Detailed geochemical map of Upper Silesia

1:25 000

Sheet **PYRZOWICE**

Editor *Agnieszka Konon*

Polish Geological Institute
National Research Institute
Warsaw 2024

Funded by
NATIONAL FUND
FOR ENVIRONMENTAL PROTECTION
AND WATER MANAGEMENT

Authors: Agnieszka Konon, Angelika Szczypczyk, Joanna Fajfer, Paulina Kostrz-Sikora, Joanna Szyborska-Kaszycka, Aleksander Biel, Katarzyna Strzemińska, Anna Pasieczna

Reviever: dr hab. inż. Urszula Aleksander-Kwaterczak, prof. AGH

Translated by: Krzysztof Leszczyński

Editing of the volume, layout and typesetting: Paweł Zawada

Cover design: Łukasz Borkowski based on the Wojciech Markiewicz series project

Cover photo: control tower at "Katowice" International Airport in Pyrzowice (Fot. Piotr Adamczyk)

The scale of the maps in the atlas is 1:35,000

ISBN 978-83-68224-59-7

Address of editorial office:
Polish Geological Institute – National Research Institute
4, Rakowiecka Street, 00-975 Warsaw, Poland

CONTENTS

SPIS TABLIC
LIST OF PLATES

INTRODUCTION

The detailed geochemical map, scale 1:25,000, sheet Pyrzowice M-34-51-C-a, is a continuation of mapping works initiated in 1996–1999 with the development of the pilot sheet Sławków M-34-63-B-b of the *Detailed Geochemical Map of Upper Silesia* (Lis, Pasieczna, 1999). By 2021, 21 sheets were compiled and published in the form of geochemical atlases. The works were financed by the National Fund for Environmental Protection and Water Management after approval of the Ministry of Climate and Environment.

The Pyrzowice sheet area is situated in the central part of the Silesian Voivodeship and covers parts of the Tarnogóra, Będzin and Lubliniec districts (poviats). A significant portion of the study area is agricultural land. The north-western, south-western and eastern parts are covered by forests. No large industrial plants that could currently represent direct pollution sources have been found in this area. The largest facility that may affect the condition of the environment is the Wojciech Korfanty International Airport "Katowice" at Pyrzowice.

The results of the geochemical studies, presented in cartographic form and accompanied by textual commentary and tabular summaries, show the present status of the quality of soils, aquatic sediments, and surface waters relative to the regional geochemical background and applicable legal norms.

The information gathered may be useful in the preparation of planning documents, including, in particular, ecophysiographic studies that are normally produced prior to the drafting of local spatial development plans and/or studies on conditions and directions of spatial development. Geochemical data may also be used to prepare strategic and sectoral documents, including environmental protection programmes, revitalization programmes (in the part presenting the condition of the environment), as well as forecasts of the environmental impact of draft strategic documents. In addition, they can be a source of information when drawing up environmental impact assessments, particularly for the reports on the environmental impact of projects. The research results on soils, sediments and waters can also be used to prepare various reports and assessments presenting the condition of the environment.

The digital version of the atlas is available at http://www.mapgeochem.pgi.gov.pl.

A number of specialists participated in the preparation of this report:
- **A. Pasieczna** – project's concept and design;
- **A. Konon** – supervision and coordination;
- **P. Kaszycki, J. Szyborska-Kaszycka** – sampling;
- **T. Kołecki, A. Konon, W. Markowski, A. Szczypczyk** – databases;
- **D. Karmasz, A. Maksymowicz, M. Janasz, A. Sztuczyńska** – leadership and coordination of analytical works;
- **Ł. Andrzejewski, P. Andrzejewski** – mechanical preparation of samples for analyses;
- **M. Białecka, R. Czerwiński, E. Kałwa** – chemical preparation of samples for analyses;
- **J. Gąsior, B. Kamińska, J. Retka, M. Stasiuk** – total organic carbon content determination by high-temperature combustion with IR detection;
- **M. Bellok, M. Białecka, R. Czerwiński, E. Kałwa, A. Maksymowicz** – pH determination;
- **J. Duszyński, D. Karmasz, D. Lech, M. Szwejkowska** – determination of mercury content by CV-AA;
- **W. Bureć-Drewniak, D. Karmasz A. Krążała, J. Kucharzyk, D. Lech** – determination of major and trace elements by ICP-OES and ICP-MS methods;
- **M. Chada, A. Grabowska, K. Jakubczak, A. Łukawska, P. Kucińska, M. Kutyna, J. Rau, A. Roguski, A Setla, P. Stefańska, K. Szewczuk** – grain size analyses;
- **A. Biel, A. Konon, A. Szczypczyk** – statistatical calculations;
- **A. Szczypczyk** – map construction;
- **A. Biel, J. Fajfer, A. Konon, P. Kostrz-Sikora, A. Pasieczna, K. Strzemińska, A. Szczypczyk, J. Szyborska-Kaszycka** – explanatory text to the Atlas.

CHARACTERISTICS OF THE MAP SHEET AREA

Geographical and administrative location. According to the physico-geographical division, the Pyrzowice M-34-51-C-a map sheet is located in the Silesian Upland macroregion, covering the areas of Tarnowskie Góry Hummock – 341.12 and Katowice Upland – 341.13 mesoregions, and in the Woźniki–Wieluń Upland macroregion, covering the area of the Upper Mała Panew Depression mesoregion – 341.28 (Richling *et al.*, 2021).

Administratively, the map sheet area belongs to three districts (poviats): tarnogórski, będziński and lubliniecki. Within the map sheet area, the tarnogórski district covers most of the Ożarowice municipality and part of the Miasteczko Śląskie municipality. The eastern and southern parts of the sheet are occupied by the będziński district, which includes the municipalities of Siewierz, Mierzęcice and Bobrowniki. In the northern part of the sheet is a small part of Woźniki municipality, within the lubliniecki district.

Surface relief, geomorphology and hydrography. Northern part of the map sheet is characterized by low relief variations. In the southern part, the relief is more diverse. This area is situated at an elevation of 280.0–397.9 m a.s.l. (in the Brynica valley and the Nowa Wieś area, respectively). The change in vertical elevation is therefore approximately 120 m. The distinctive morphological features are hills composed of Triassic limestones and dolomites, stretching in the south-eastern part of the sheet area (in the villages of Nowa Wieś, Sadowie, Siemonia and Myszkowice). To the north of these localities, the terrain descends into a broad Quaternary plain with outcrops of Triassic rocks.

The whole map sheet area lies within the Vistula River drainage basin. Its significant part is occupied by the 4th order catchment of the Brynica River, except for its south-eastern end. The northern part of the sheet is covered by the Brynica valley. The river rises at Mysłów, beyond the north-eastern border of the study area, at an elevation of 350 m a.s.l. at the foot of hills composed of Triassic rocks (Jastrząb, Mrozowski, 1997).

The river originates from minor streams and flows in a flat, marshy valley, draining heavily ameliorated agricultural areas. The major tributaries of the Brynica River are the Czeczówka and Trzonia rivers flowing in the northern part of the sheet, and the Potok Ożarowicki stream in the central part. Dopływ spod Siemoni, a tributary that crosses the south-western part of the map sheet, flows into the Kozłowa Góra reservoir located outside the sheet limits.

Built-up area and land use. Land use and housing type vary between individual regions of the study area; however, the land is largely agricultural. Non-built-up areas occupy about 78% of the sheet (Pls. 2, 3). These are represented by agricultural land (arable fields and meadows) and forests, which cover about 38 and 28% of the map sheet area, respectively. The remaining non-built-up areas include wasteland, roads and railways. Residential, industrial, and service and commerce areas occupy a small part of the map sheet. Urban development covers about 2% of the area, whereas industrial development – about 3%. Most of the villages are characterized by buildings located along the main road running through them (linear settlement, "ulicówka" in Polish). All of the villages are dominated by low-rise single-family and service buildings. An important element affecting the style of the study area is the Wojciech Korfanty International Airport "Katowice" at Pyrzowice, covering an area of 530 ha. It was established as an experimental military airport in the 1940s and has been exclusively civilian since late 1999 (Katowice Airport...). Communication with the airport is provided by the A1 motorway (Amber Motorway) running north to south, forking into the S1 motorway in the Pyrzowice area (which is the Eastern Ring Road of the Upper Silesian Industrial Region), by national road No. 78 and provincial road 913, which connect the airport with the northern area of Będzin, as well as by railway line 182 connecting Tarnowskie Góry with Zawiercie.

Economy. In the absence of large industrial plants, the economic base and source of livelihood for a large group of inhabitants of the study area is agriculture, and service and commercial activities. Alongside these, the International Airport (Międzynarodowy Port Lotniczy – MPL "Katowice") at Pyrzowice is of key importance in shaping the region's economy. In 2014, a restricted use area was established around the "Katowice" MPL (Uchwała, 2014). The airport has three passenger terminals and a cargo terminal; aircraft maintenance hangars are also part of its infrastructure. In 2023, the number of passengers served exceeded 5 million. There are plans to expand the facility over the next several years, including the construction of a main passenger terminal, a second cargo terminal, a car park with the necessary infrastructure, a new road layout, and a multimodal cargo and fuel-handling hub. A three-track unloading front will be adjacent to three tanks with a capacity of 1,000 m^3 each, and two unloading bays for tanker trucks. In the part of the hub located in the restricted area of the airport, three loading bays for airport tankers will be created. In addition, a railway siding will be constructed to connect the airport to the Central Rail Line via railway No. 182 Zawiercie–Tarnowskie Góry. These activities could have a major impact on the economic development of the region (Program inwestycyjny..., 2024).

GEOLOGICAL STRUCTURE AND MINERAL DEPOSITS

The area covered by the Pyrzowice sheet is situated in the extreme northern part of the Upper Silesian Foredeep, which is part of the exposed basement of the Variscan platform (Pożaryski *et al.*, 1992), within the Upper Silesian Coal Basin (USCB) and its northern margin (Jureczka *et al.*, 2005). The northern boundary of the USCB, which is the limit of Upper Carboniferous coal-bearing formations, runs more or less latitudinally along the line Ożarowice–Pyrzowice–Siedliska–Mierzęcice. A tectonic graben, oriented latitudinally, filled with Late Variscan Permian molasse deposits, several hundred metres thick, belonging to a larger unit – the Sławków Graben, extends in the northern margin of the USCB (Kotas, 1985; Kiersnowski, 1991).

The oldest formations occurring within the Pyrzowice map sheet area are Middle **Devonian** (Givetian) deposits represented by dark grey, greenish-grey, compact, crystalline dolomites with obliterated primary structures. They occur in the north-eastern part of the study area at depths of 50–150 m b.g.l. (Buła *et al.*, 2002; Biernat, 1955, updated by Wilanowski, Żaba, 2010; Wilanowski, Żaba, 2016). These strata dip southwards under Triassic deposits, below which they tectonically contact Lower Carboniferous rocks.

Upper in the section, there are Upper and Lower **Carboniferous** coal-bearing deposits. These are covered mainly by Permian and Triassic rocks. The Carboniferous coal-bearing deposits are very well explored by numerous boreholes drilled for the exploration of hard coal (Jureczka *et al.*, 2005).

The Lower Carboniferous (Visean) is represented by greywacke sandstones, mudstones, claystones and conglomerates, showing cyclicity characteristic of flysch deposits (Culm Formation), included in the lower Malinowice Beds. They occur mostly under the Carboniferous coal-bearing deposits or, over a much smaller area, under Permian rocks, and fragmentarily under Triassic deposits. The Culm occurs throughout the area, attaining a thickness of about 800 m (Jureczka *et al.*, 2005; Wilanowski, Żaba, 2016).

In the Pyrzowice map sheet area, there is the lowermost of the four series of the Carboniferous coal-bearing deposits, *i.e.* the Paralic Series (Namurian A), up to 900 m in thickness in the south-western part of the sheet, rapidly wedging out towards the northern boundary of the USCB (Jureczka *et al.*, 2005). The Paralic Series is composed of sandy (fine- and medium-grained sandstones) and muddy deposits with numerous interbeds of thin seams and layers of coal, coal shales, and occasionally sapropelic shales. These deposits formed under terrestrial and coastal conditions, with periodic marine ingressions, which is confirmed by the presence of marine faunal fossils in the section, in addition to numerous interbeds containing freshwater specimens. A characteristic feature of the series is its sedimentary cyclicity. Its bottom boundary is marked by the top of the Štur (XVI) marine level, and the top surface is represented by the coal seam 510 (Reden Seam). Marine, brackish and freshwater faunal fossils and common Carboniferous floral remains occur throughout the series (Wilanowski, Żaba, 2016).

Permian sandstones, conglomerates, claystones and mudstones occupy the vast majority of the sheet area, filling a tectonic graben located in the Tarnowskie Góry Trough (Sławków Graben). These rocks are covered mostly by Triassic rocks (Buła i in., 2002). At their top, there are mainly red clays with green spots, and subordinate conglomeratic sandstones and conglomerates containing small clasts. Lower in the section, there are red-green conglomerates with infrequent interbeds of sandstones, mudstones and claystones. Below, the series is composed exclusively of clay-bonded conglomerates with thin intergrowths of conglomeratic sandstones. In places, porphyry predominates among the rocks, and carbonates and quartz are also numerous. These deposits are not found at the ground surface, and they can reach a thickness of 400–450 m. A similar complex of conglomerates, filling the depressions of the Carboniferous basement that has a graben feature here with a general north-west to south-east trend, occurs in the area of the neighbouring sheets (Buła *et al.*, 2002; Biernat, 1955, updated by Wilanowski, Żaba, 2010).

The **Triassic** deposits occupy a compact area in the central and southern parts of the Pyrzowice map sheet, forming extensive, highly dismembered outcrops. The thickness of the Triassic succession is mostly 70–80 m and is constrained by the tectonics and relief of the top of Carboniferous and Permian formations (Buła *et al.*, 2002; Biernat, 1955, updated by Wilanowski, Żaba, 2010).

The lowermost Triassic in the study area is represented by the Świerklaniec Beds included in the Lower Triassic (Scythian, spanning the Induan and Olenekian stages), erosionally overlying Upper Carboniferous (southern part of the sheet area) and Permian formations. The stratotype section of the Świerklaniec Beds is located in the Świerklaniec area, about 4–5 km to the west of the map sheet. These deposits are represented by sands, clays and sandstones, subordinately conglomeratic, passing at the top into mudstones and claystones. They are of terrestrial origin and included in the Lower and Middle Buntsandstein. Over most of the study area they underlie Middle Triassic carbonates, cropping out on the surface only in the Podossa, Przełajka and Siemonia regions. The thickness of the Świerklaniec Beds is variable and varies from a dozen to more than 30 metres, locally reaching 46 m (Wilanowski, Żaba, 2016).

The Świerklaniec Beds are unconformably overlain by Lower Anisian dolomites, marls, marly claystones and limestones, previously referred to as Röt deposits (Wagner, 2008). Their succession shows a fairly well-pronounced bipartition. In the lower part, it is composed mainly of grey dolomites with interbeds of limestones and marls and locally marly dolomites and dolomitic limestones. The upper part of the Röt is represented by light yellow and grey dolomites with more frequent interbeds of grey or grey-brown, coarse-crystalline, compact limestones with small caverns. Locally, a series of cavernous limestones, characterized by numerous caverns of varying diameters, exceeding 2.0 cm in places, occurs at the top of these deposits. The thickness of the above-described rocks ranges from about 40 m in the east of the map sheet to about 60 m in its western part. Outcrops of these deposits are located mainly in the south-western part of the map sheet area, within a belt stretching between Tąpkowice and Myszkowice, and in the Siemonia region (Biernat, 1955, updated by Wilanowski, Żaba, 2010; Wilanowski, Żaba, 2016).

Upper in the section are limestones (Gogolin Beds) assigned to the Middle Triassic, which build most of the slopes and hilltops in the central and south-eastern part of the map sheet, in the Myszkowice, Mierzęcice and Najdziszów regions. The lower part of the Gogolin Beds is clearly dominated by platy limestones, while the upper part is dominated by wavy limestones, mostly silty and marly. The platy limestones are thinly to moderately layered, micritic, grey and yellow in colour and greenish in places. Locally, conglomerates and laminated marly dolomites with crinoids occur in the Gogolin Beds. The thickness of the Gogolin Beds ranges from 35 to 60 m (Biernat, 1955, updated by Wilanowski, Żaba, 2010; Wilanowski, Żaba, 2016).

Paleogene-Neogene deposits of the study area are represented by loams, muds, clays and sands and occur at the surface or under a thin cover of Quaternary sediments. Their major outcrops are found mainly in the central and eastern parts of the Pyrzowice map sheet, and minor ones are observed in its south-eastern part. These deposits accumulated mainly in karst funnels and sinkholes developed at the top of Triassic carbonates, especially in the outcrop zones of the Gogolin Limestones. Locally, there are also ochre silty loams and white fine-grained sands, as well as celadon-grey muds with variable admixtures of quartz gravels. These deposits, predominantly clay-muddy with subordinate sands and refractory clays, were previously assigned to the Lower Jurassic. Studies of karst regoliths in the Silesian Upland (Lewandowski, Ciesielczuk, 1997) indicate their Oligocene–Miocene age. The thickness of the deposits ranges up to several metres, locally exceeding 20 m (near Mierzęcice) (Biernat, 1955, updated by Wilanowski, Żaba, 2010; Wilanowski, Żaba, 2016).

Quaternary sediments cover about 65% of the map sheet area with a layer ranging in thickness from a few to several metres, up to about 30 m in fossil valleys. The most common thickness of the Quaternary cover is about 15 m. Its lithology is determined by the relief of sub-Quaternary bedrock, and its areal extent and thickness increase towards the north. Over most of the study area, it overlies Middle Triassic rocks, whereas in the south-western part of the area the cover rests upon the Upper Carboniferous paralic series and sporadically upon Miocene deposits (Biernat, 1955, updated by Wilanowski, Żaba, 2010; Wilanowski, Żaba, 2016).

South Polish Glaciation sediments occur under upper Pleistocene rocks in zones where the Quaternary covers reach large thicknesses. These include glacial tills overlying Triassic rocks, as well as glaciofluvial sands and gravels, and glacial lake muds and clays filling the bottoms of fossil valleys of watercourses (Biernat, 1955, updated by Wilanowski, Żaba, 2010; Wilanowski, Żaba, 2016).

Fluvial sands and gravels of the Mazovian Interglacial fill the Brynica River fossil valley. Typically, these are variably grained sands with admixtures of fine gravels, and with predominant gravels at the base (Biernat, 1955, updated by Wilanowski, Żaba, 2010; Wilanowski, Żaba, 2016).

Sediments of the Middle Polish glaciations compose the major part of the map sheet's surface. The oldest sediments of these glaciations in the map sheet area are yellow and yellow-brown glacial tills, generally sandy-silty, and sandy at the top. In the areas where the tills directly overlie the older bedrock, they are grey-yellow and slightly clayey. The thickness of the tills is mostly 3–6 m. Above (locally, within depressions in the glacial tills) lie ice-dammed lake clays and muds (upper series) deposited during the recession of the Odranian Glaciation ice sheet. These are grey sandy clays and muds, ranging from heavily sandy to slightly clayey, with a thickness of 2–3 m. Glaciofluvial sands and gravels (upper series), deposited during the standstill and recession of the Odranian Glaciation ice sheet, occupy about 35% of the map sheet area. These are light and dark yellow medium-grained sands or variably grained sands with admixtures of fine-grained gravels, with a thickness of about 5 m, locally approximately 10 m (Biernat, 1955, updated by Wilanowski, Żaba, 2010; Wilanowski, Żaba, 2016).

North Polish Glaciation sediments are represented by sands and gravels of overflood (accumulation) terraces in the valleys of the Brynica and Trzonia rivers and in the lower sections of the Potok Ożarowicki. They are dominated by medium- and fine-grained sands, locally with a relatively high admixture of fine-grained gravels. The thickness of these sediments generally does not exceed 15 m (Biernat, 1955, updated by Wilanowski, Żaba, 2010; Wilanowski, Żaba, 2016).

Undivided Quaternary sediments occupy a small part of the map sheet area. Slope wash loam, sands and gravels occur in the foothills and lower slopes of the Triassic hills in the central and southern parts of the map sheet. These are washed loamy-sandy sediments with sparse gravels and fragments of local rocks, about 2–4 m in thickness, locally up to 6 m. Slope wash and fluvial sands, gravels and muds fill numerous short valleys, mainly on the slopes of the Triassic hills in the central and southern parts of the area. These are variably grained sands with varying admixtures of fine-grained gravels and numerous lenses of sandy muds, and occasional clasts of local rocks, about 2–4 m thick. Aeolian sands and those forming dunes occur between Zendek, Mierzęcice and Ostrowy in the north-eastern part of the map sheet. They were deposited towards the end of the Vistulian Glaciation and at the beginning of the Holocene. The dunes are generally small, attaining a height of 5–10 m (Biernat, 1955, updated by Wilanowski, Żaba, 2010; Wilanowski, Żaba, 2016).

Holocene sediments occur only in the river valleys of the Brynica, Trzonia, Potok Ożarowicki, Czeczówka and other minor watercourses. These are mainly fluvial sands, gravels and muds of floodplain terraces, attaining a thickness of up to 8 m, alluvial muds of valley bottoms (sandy muds with a large amount of humus matter), 1.5–3.0 m thick, and peats (Biernat, 1955, updated by Wilanowski, Żaba, 2010; Wilanowski, Żaba, 2016).

Mineral deposits. In the western part of the area, mining traditions, associated with the extraction of iron ore, have been known since the early Middle Ages. The 18th century saw the development of iron ore mining, which was linked to the introduction of new metallurgical processing methods, as well as to the use of hard coal for metallurgical processes. At that time, iron ore was mined in the area of Bishop's village of Mierzęcice (the so-called Mierzęcice ore). These deposits occurred in a nested form on outcrops of Middle Triassic carbonates and originated from regolith formations (residual loams and sands) that developed as a result of karst activity, probably in Oligocene–Miocene times (Lewandowski, Ciesielczuk, 1997). Exploitation of these deposits was carried out in small shallow workings (so-called "ore pits") up to 25 m deep. In addition, in the 19th century the ore was exploited using a multi-pit system, also in small underground mines (Wójcik, Siembab, 2020).

Currently, the Pyrzowice map sheet area is very poor in terms of raw materials. As of December 31, 2022, there is one small "Pyrzowice" deposit of sands and gravels in this area (Szuflicki *et al.*, 2023). It is documented in its central part within glaciofluvial sands of the Odranian Glaciation, over an area of 2.73 ha. Right on the ground surface, there is an aggregate deposit reaching up to 10 m in thickness, with a sand point of 94.5–98.9% and a negligible (up to 0.4%) mineral dust content. The deposit remains undeveloped. Information on the parameters of the deposit and the quality parameters of the mineral product is quoted after the System of Management and Protecting of Polish Mineral Raw Materials (MIDAS).

HUMAN IMPACT (ANTHROPOPRESSION)

The map sheet area has not been heavily transformed anthropogenically. There has been no large-scale extraction of natural resources in the area, no large industrial plants, and no industrial or municipal waste dumps. Slight transformations of the relief are associated with the functioning of the International Airport "Katowice" at Pyrzowice, along with the accompanying infrastructure (*e.g.* roads and car parks). A slight impact of the development of settlements and agriculture (drainage of fields and meadows) is also discernible. However, historical and contemporary activities in the regions bordering the map sheet (*e.g.* in the areas of Miasteczko Śląskie or Tarnowskie Góry) may have a significant impact on the condition of the environment.

Atmospheric air. Pursuant to the division of Poland into zones in which assessments of the levels of substances in the air are carried out annually under the system of state environmental monitoring, the entire map sheet area lies within the Silesian zone (Ustawa, 2001). Based on the results of measurements carried out at measurement and control points located outside the map sheet area, the Silesian zone is categorized as an area characterized by above-standard concentrations of both particulate matter (both PM10 and PM2.5) and benzo(a)pyrene contained in PM10 (Roczna ocena, 2023). The main source of emissions of these pollutants is the municipal sector, represented by individual, low-efficiency and non-environmental heat supply equipment and installations. The presence of particulate matter in the air is also due to linear emissions from vehicular traffic – its impact is observed mainly in areas crossed by heavy traffic roads. Pollutants are released as a result of the abrasion of road surfaces, tyres and vehicle linings (Uchwała, 2023; Roczna ocena, 2023).

Surface water and groundwater. The hydrographic network in the map sheet area is poorly developed. It is represented by the Brynica River and its tributaries: minor watercourses and numerous drainage ditches in its northern, north-western, central and south-western parts. There are no natural or anthropogenic surface water bodies. The Brynica River flows in a natural (largely meandering) channel, across a flat wetland valley, through an area of meadows and arable fields (Czekaj, Skrzypczyk, 2017) in the north of the map sheet, leaving the area near Kolonia Oparowe. Its left-bank tributaries are the Trzonia, Czeczówka and Potok Ożarowicki streams (Konfederak, 2021). The riverbed (in its northern part) is located within a cone of depression of the Bibiela deep-water intakes (located outside the sheet boundary), which contributes up to 20% of water escape from the river channel (Pazgan, 2022). The 12.07 km long Trzonia River, whose headwaters are located outside the map sheet area, flows into the Brynica in its northern part. The watercourse channel is regulated and lined with fascine and concrete slabs (locally). Its valley is drained by numerous drainage ditches (Konfederak, 2021). The Czeczówka River flows through land used for agriculture, drained by ditches (Pazgan, 2022), and flows into the Brynica River downstream of the Trzonia. It is 6.25 km in length (Wójcik, 2024). The Potok Ożarowicki flows latitudinally through a flat and marshy valley that locally reaches a width of about 1,000 m. It crosses agricultural land (Konfederak, 2021) and flows into the Brynica River just outside the western boundary of the map sheet. The watercourse is 5.84 km in length (Wójcik, 2024). A tributary of the Potok Ożarowicki, the Rów z Siedlisk ditch, joins it near Ożarowice. The Dopływ spod Siemoni stream, as well as numerous drainage ditches, drains the south-western part of the map sheet area. It flows through forested areas and flows directly into the Kozłowa Góra reservoir (located outside the map area). In general, the surface watercourses within the study area are short and characterized by flow rates varying from a few to a few tens of dm^3/s. At estuarine cross-sections, they reach a maximum rate of several hundred dm^3/s (Czekaj, Skrzypczyk, 2017).

The quality of the surface waters flowing across the map sheet area was assessed as poor (Rozporządzenie, 2022). Confirmation of the poor water status is also provided by the environmental assessment carried out for the four Surface Water Bodies (three fluvial and one limnic) located within the sheet limits. All the four SWBs are considered to be at risk of failing to meet the environmental objectives set out for the Vistula River Basin Management Plan (Rozporządzenie, 2022). A factor contributing to the poor water quality status is surface runoff of rainwater from paved areas, roads, squares, car parks and roof surfaces, fertilization of agricultural land, and atmospheric deposition of benzo(a)pyrene, the source of which is emissions from fossil fuel combustion and road transport (Rozporządzenie, 2022; Karty charakterystyk, 2024).

The map sheet area is situated in the Silesian Triassic hydrogeological region (XII) (Paczyński, Sadurski, 2007), and within the boundaries of GWB 111 (covering the whole sheet area except for its south-eastern region) and GWB 112 (south-eastern region), according to the characterization of the Groundwater Bodies (CBDG database). Usable groundwater is found in Middle and Lower Triassic marly-dolomitic and calcareous deposits represented by the Muschelkalk and Röt. These are fractured-karst aquifers that merge over large areas into the aquifer complex of Triassic carbonates. On the other hand, the pore aquifer of Lower Triassic sandstones (Lower Triassic – Świerklaniec Beds), occurring in the regions of Ożarowice, Mierzęcice and Siemonia (and Dąbie, outside the map sheet area), is usable only on a local scale (Różkowski, 1997). The quality of the waters is assessed as poor due to the impact exerted by the municipal economy and agricultural activity (some areas have no sewage system). In the south-eastern region of the map sheet, the general condition of groundwater is assessed good (Karty charakterystyk, 2023).

The map sheet area is located within the range of two Major Groundwater Reservoirs: MGR No. 327 (Lubliniec–Myszków) and MGR No. 454 (Olkusz–Zawiercie). The range of MGR No. 327 covers a strip stretching from its northern part through the central area to its southern part, except for the south-western and south-central-eastern extremes of the map sheet. MGR No. 327 is composed of Middle Triassic (Muschelkalk) dolomitic-calcareous rocks, and the groundwater occurs in a fracture-karst aquifer. Within the map sheet boundaries, the aquifer is unconfined and has no established protection areas. The groundwater quality falls into classes II and III. Potential threats to the water quality are mainly anthropogenic factors (found outside the sheet boundaries in the Tarnowskie Góry region) and areas of intensive farming (Mikołajków, Sadurski, 2017).

At the south-central-eastern edge of the map sheet, there is a small part of Major Groundwater Reservoir No. 454. It is composed of Lower and Middle Triassic calcareous, dolomitic and marly rocks included in the Muschelkalk, Röt, and Middle and Lower Buntsandstein (these deposits occur on a local scale and are of little economic significance). This MGR has no established protection areas. Due to the major impact of Zn and Pb ore mining (including the formation of an extensive cone of depression, the disappearance of springs, and the change in the nature of surface watercourses from drainage to infiltration), creation of a protection area of 426.3 km^2 has been proposed. The area will also include degraded water areas covering acreage of approximately 167 km^2. Most of the waters are of quality classes I–III and their chemical status is good. Locally, the waters of the reservoir are categorized into classes IV–V (in urban-industrial and agricultural areas) (Mikołajków, Sadurski, 2017).

Treatment plants. At the western end of the map sheet, within the administrative boundaries of the Ożarowice municipality, the Ożarowice Sewage Treatment Plant is located. It is a mechanical-biological installation that receives wastewater from the following municipalities: Ożarowice (villages: Niezdara, Tąpkowice, Ossy, Ożarowice, Zendek, Pyrzowice and Celiny), Mierzęcice (villages: Mierzęcice, Mierzęcice Osiedle, Nowa Wieś, Zawada, Toporowice, Przeczyce, Boguchwałowice, Sadowie and Najdziszów) and Miasteczko Śląskie (villages: Brynica and Bibiela). The facility also receives wastewater from "Katowice" International Airport at Pyrzowice (in the past, "Katowice" airport discharged wastewater to its own treatment plant, which has been decommissioned), but does not receive industrial wastewater. The average capacity of the treatment plant is 2,500 m^3/day. Treated wastewater is discharged to the Brynica River (km 35+096) (Oczyszczalnia…, Uchwała..., 2021).

Soils. The factors which significantly affect the diversity of the soil cover in the map sheet area are the geological structure of bedrock, relief, hydrographic conditions, and climate. Podzolic and pseudo-podzolic soils, developed on sandy bedrock and poor in nutrients, are the main soil types in the municipalities of Ożarowice and Bobrowniki and are also characteristic for the northern part of the Mierzęcice municipality. Another common soil type is black earths – genetically related to sandy loam deposits – which formed under conditions of high moisture with the participation of meadow vegetation, and are found in the central part of the map sheet (Ożarowice municipality). Brown rendzina is the dominant soil type in the Mierzęcice municipality and locally in the Ożarowice municipality (near the village of Celiny). They were formed from the weathering cover of limestones which have a high content of iron that is responsible for the grey-brown or brown colour of the soil. Brown soil complexes also locally occur in the map sheet area (*e.g.* around the hills in the Ożarowice municipality), whereas organic soils are found in the valleys of watercourses (Bula, Wieland, 2007; Program..., 2016; Wach i in., 2020; Program..., 2021; Studium..., 2021).

The condition of soils is dependent mainly on anthropogenic factors, including their agricultural use and construction investments aimed at the development of technical and engineering and communication infrastructure.

RESEARCH SCOPE AND METHODS

The research carried out between 2021 and 2024 included the study of published and archival materials, delineation of the soil sampling grid on topographic maps at a scale of 1:10,000, sampling and determination of geographical coordinates at their locations, measurements of pH and specific electrolytic conductivity of surface water in the field, chemical analyses of the samples, creation of field and laboratory databases, statistical calculations of the results of chemical analyses, development of a topographic base, development of a geological map and geochemical maps, and interpretation of the results. The workflow sequence is illustrated in the schematic diagram below (Fig. 1).

FIELDWORK

Soils were sampled using a 60 mm diameter hand auger in a regular 250×250 m grid (16 samples/km^2). The location of sampling sites is documented by maps showing both the housing type and land use (Pls. 2, 3). A total of 1289 samples were collected from a depth of 0.0–0.3 m and 1270 samples from a depth of 0.8–1.0 m (or from a shallower depth in case of shallower-seated bedrock). Each sample (weighing approximately 500 g) was placed in a linen bag labelled with the appropriate number, and pre-dried on wooden pallets in a field storage facility.

Samples of surface waters and aquatic sediments (379 and 368 samples, respectively) were collected, at the same locations, from rivers, streams, ditches, canals, lakes, and settling and natural ponds. The differences in the number of samples taken were dependent on the possibility to sample them (lack of material resulting, for example, from the periodic drying up of watercourses or the concreting of their channels). The distance between the sampling sites in the watercourses and water bodies was approximately 250 m. The locations of the sampling sites correspond to those depicted in the plates (starting with Plates 7 and 9, respectively), showing the content of individual elements in surface waters and aquatic sediments.

Surface water samples were taken directly from the water body/watercourse using a syringe. In case of unsafe approach, the water was collected with a bucket. The electrical conductivity (EC) and pH of the waters were measured in the field using a pH meter/conductivity meter (Elmetron CPC-105) with automatic temperature compensation, assuming a reference temperature of 25°C. After collection, the waters were filtered in the field through Milipore 0.45 µm filters, poured into 30 cm^3 bottles, and acidified with nitric acid (V) to the pH<2. The bottles were labelled with the appropriate numbers. Sediment samples of approximately 500 g (grain size as fine as possible) were collected from the banks of water bodies and watercourses using a bucket, and then placed in 500 cm^3 plastic containers labelled with the appropriate numbers.

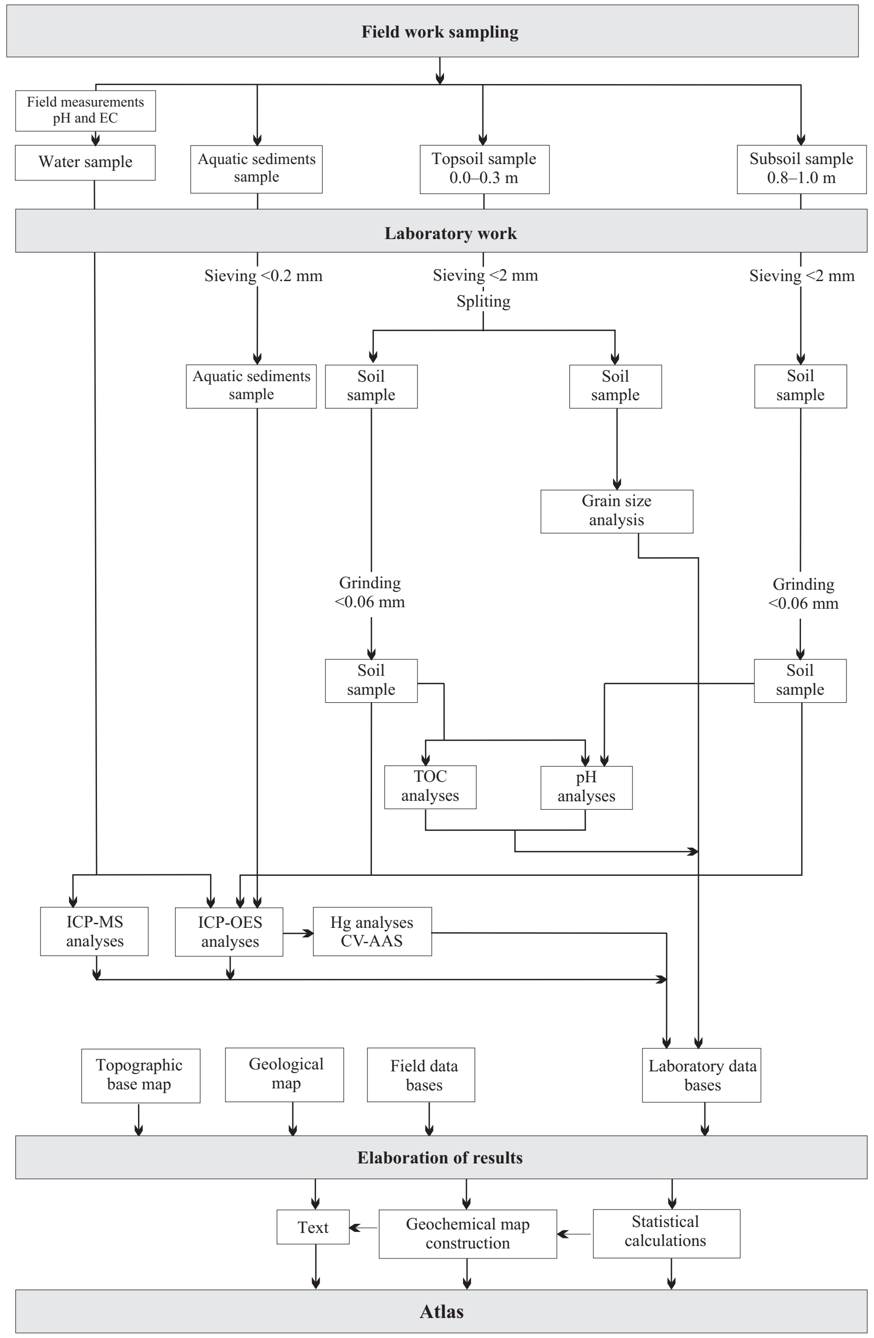

Fig. 1. Scheme of the work performed

All sampling sites were marked on topographic maps at a scale of 1:10,000, and their locations were determined using GPS technology, with an accuracy of ±2–5 m. The device used allows recording additional information (*e.g.* sample number, pH and EC values of the waters, data on housing types and land use, and lithology of the samples), as well as results of geographical coordinate measurements. Prior to the field trips, the sampling grid had been uploaded into the memory of the GPS device in the form of shapefile spatial data. For added security, all field data were also recorded on specially prepared field sheets (Fig. 2).

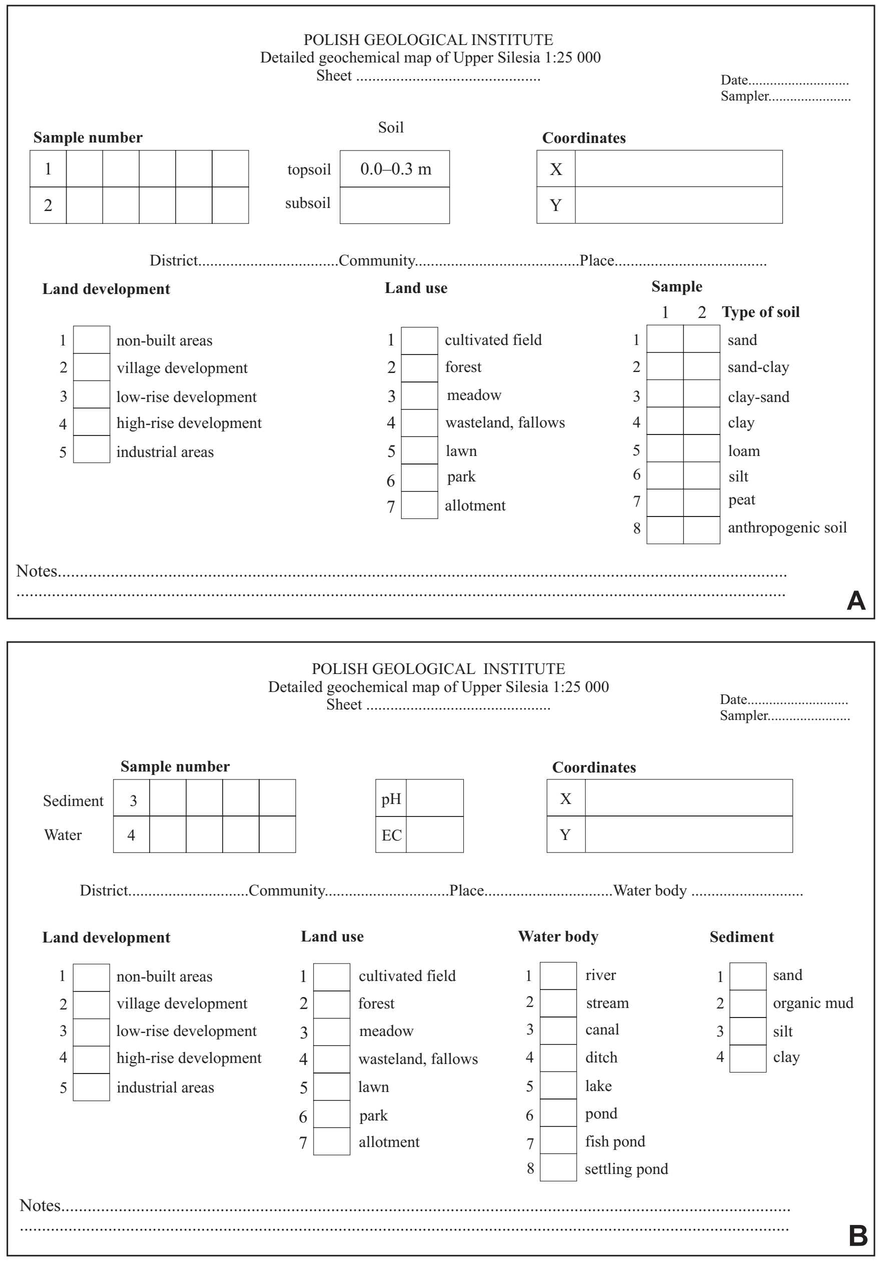

Fig. 2. Field sampling sheets for soils (A) and sediments and surface waters (B)

LABORATORY WORK

Sample preparation for testing, determinations of physico-chemical parameters, and chemical analyses were carried out at the chemical laboratory of PGI-NRI.

Sample preparation. After transport to the laboratory, soil samples were dried at room temperature and sieved through 2 mm mesh nylon sieves. Each soil sample from a depth of 0.0–0.3 m (topsoil), after sieving and quartering, was divided into two subsamples: one for chemical analysis and the other for grain size analysis. Each soil sample from a depth of 0.8–1.0 m (subsoil), after sieving and quartering, was destined for chemical analysis (Fig. 1). Soil samples prepared for chemical analysis were grinded to a <0.06 mm fraction in agate ball mills. Sediment samples were dried at room temperature and then sieved through 0.2 mm mesh nylon sieves. The <0.2 mm fraction, after quartering, was destined for chemical analysis (Fig. 1).

Chemical analyses. Soil and sediment samples were dissolved using aqua regia (1 g sample to a final mineralizate of 50 g) for 1 hour at a temperature of 95°C in a thermostated heating block.

Determinations of Ag, Al, As, Ba, Ca, Cd, Co, Cr, Cu, Fe, Mg, Mn, Ni, P, Pb, S, Sr, Ti, V and Zn in soils and sediments were performed by inductively coupled plasma optical emission spectrometry (ICP-OES). Analyses of Hg content in soil and sediment samples were carried out by cold vapour atomic absorption spectrometry (CV-AAS) in a flow-injection system. The pH of soils was determined by a potentiometric method in 1:5 (weight fraction) suspension of soil in water ($pH-H_2O$), and the total organic carbon (TOC) content of soils was determined by high-temperature combustion with IR detection. Determinations of B, Ba, Ca, Cr, Fe, K, Mg, Mn, Na, P, Si, S, Sr, Ti and Zn in surface waters were carried out by inductively coupled plasma atomic emission spectrometry (ICP-OES), while the contents of Ag, Al, As, Be, Cd, Co, Cu, Li, Mo, Ni, Pb, Sb, Se, Tl, U and V by inductively coupled plasma mass spectrometry (ICP-MS). A summary of the analytical methods and the determination limits of the elements are shown in Table 1.

Quality control of the determinations was performed by analysis of duplicate samples (5% of the total number of samples), analysis of reference materials with certified content of the elements tested (2% of the total number of samples), and analysis of internal control samples confirming correct instrumental measurements (5% of the total number of samples). The purity of reagents and vessels was controlled by "reagent blanks" and "procedural blanks".

The expanded uncertainty of the research results (assuming the probability level of 95% and the coverage factor k = 2) of water, soil and sediment samples does not exceed 25%, except for the expanded uncertainty of the results of boron concentration in water samples in the range of 0.01–0.10 mg/dm^3, mercury content in soil and sediment samples, and total organic carbon content in soil samples, which is 30%.

Grain size analyses of soils sampled from a depth of 0.0–0.3 m were carried out at the Soil and Rock Laboratory Testing Centre, Department of Engineering Geology, PGI-NRI, Warsaw. Determination of grain composition was performed by sieve (granulometric) analysis according to an in-house procedure developed on the basis of Standard PN-88/B-04481 (1988, p. 4.1). After oxidation of organic matter (using 30% solution of hydrogen peroxide – perhydrol), the samples were washed through a 0.02 mm sieve and the residue was sieved dry through a column of sieves with mesh sizes of 1 mm, 0.1 mm and 0.02 mm, and then the resulting fractions of 1– 2 mm, 0.1–1.0 mm and <0.02 mm were weighed.

The results of the grain size analyses (after conversion to percentages) are presented in the grain class maps: 0.1–1.0 mm – sand fraction, 0.02–0.1 mm – silt fraction, and <0.02 mm – clay fraction (Pls. 4–6).

Tabela 1
Table

Metody analityczne i granice oznaczalności

Analytical methods and determination limits

Pierwiastek/ związek *Element/ compound*	Metoda analityczna *Analytical method*	Granica oznaczalności *Determination limit*	Jednostka *Unit*	Metoda analityczna *Analytical method*	Granica oznaczalności *Determination limit*	Jednostka *Unit*
	Gleby, osady *Soils, aquatic sediments*			Wody powierzchniowe *Surface water*		
Ag	ICP-OES	1	[mg/kg]	ICP-MS	0,05	[μg/dm^3]
Al	ICP-OES	0,01	[%]	ICP-MS	0,5	[μg/dm^3]
As	ICP-OES	3	[mg/kg]	ICP-MS	2	[μg/dm^3]
B	nie oznaczono/ *not indicated*			ICP-OES	0,01	[mg/dm^3]
Ba	ICP-OES	1	[mg/kg]	ICP-OES	0,001	[mg/dm^3]
Be	nie oznaczono/ *not indicated*			ICP-MS	0,05	[μg/dm^3]
C_{org} (TOC)	*	0,02	[%]	nie oznaczono/ *not indicated*		
Ca	ICP-OES	0,01	[%]	ICP-OES	0,1	[mg/dm^3]
Cd	ICP-OES	0,5	[mg/kg]	ICP-MS	0,05	[μg/dm^3]
Co	ICP-OES	1	[mg/kg]	ICP-MS	0,05	[μg/dm^3]
Cr	ICP-OES	1	[mg/kg]	ICP-OES	0,003	[mg/dm^3]
Cu	ICP-OES	1	[mg/kg]	ICP-MS	0,05	[μg/dm^3]
Fe	ICP-OES	0,01	[%]	ICP-OES	0,01	[mg/dm^3]
Hg	CV-AAS	0,02	[mg/kg]	nie oznaczono/ *not indicated*		
K	nie oznaczono/ *not indicated*			ICP-OES	0,5	[mg/dm^3]
Li				ICP-MS	0,3	[μg/dm^3]
Mg	ICP-OES	0,01	[%]	ICP-OES	0,1	[mg/dm^3]
Mn	ICP-OES	2	[mg/kg]	ICP-OES	0,001	[mg/dm^3]
Mo	nie oznaczono/ *not indicated*			ICP-MS	0,05	[μg/dm^3]
Na				ICP-OES	0,5	[mg/dm^3]
Ni	ICP-OES	1	[mg/kg]	ICP-MS	0,5	[μg/dm^3]
P	ICP-OES	0,002	[%]	ICP-OES	0,05	[mg/dm^3]
Pb	ICP-OES	2	[mg/kg]	ICP-MS	0,05	[μg/dm^3]
S	ICP-OES	0,003	[%]	nie oznaczono/ *not indicated*		
Sb	nie oznaczono/ *not indicated*			ICP-MS	0,05	[μg/dm^3]
Se				ICP-MS	2	[μg/dm^3]
Si				ICP-OES	0,1	[mg/dm^3]
Sr	ICP-OES	1	[mg/kg]	ICP-OES	0,002	[mg/dm^3]
Ti	ICP-OES	5	[mg/kg]	ICP-OES	0,002	[mg/dm^3]
Tl	nie oznaczono/ *not indicated*			ICP-MS	0,05	[μg/dm^3]
U				ICP-MS	0,05	[μg/dm^3]
V	ICP-OES	1	[mg/kg]	ICP-MS	1	[μg/dm^3]
Zn	ICP-OES	1	[mg/kg]	ICP-OES	0,003	[mg/dm^3]

ICP-OES – emisyjna spektrometria atomowa ze wzbudzeniem w plazmie indukcyjnie sprzężonej
Inductively Coupled Plasma Optical Emission Spectrometry

ICP-MS – spektrometria mas z jonizacją w plazmie indukcyjnie sprzężonej
Inductively Coupled Plasma-Mass Spectrometry

CV-AAS – absorpcyjna spektrometria atomowa z generowaniem zimnych par rtęci
Cold Vapour Atomic Absorption Spectrometry

* – wysokotemperaturowe spalanie z detekcją IR
High-temperature combustion with IR detection

DATABASES AND GEOCHEMICAL MAP CONSTRUCTION

Databases. Separate datasets (spreadsheets) have been created for:
- soils from a depth of 0.0–0.3 m,
- soils from a depth of 0.8–1.0 m,
- sediments,
- surface waters.

The datasets for soils, sediments and surface waters include: numbers of samples, results of measurements of geographic coordinates at sampling sites, field observations (type of housing, land use, soil types – for sampled soils, type of water body, type of sediment – for sampled sediments and surface waters), administrative location of sampling sites – district, municipality, locality, date and the name of sampler, and results of chemical analyses.

The data were placed in separate tables (for soils, sediments and surface waters) of a special geodatabase in the Central Geological Database (CBDG) running in the Oracle environment. These tables were used to develop mono-elemental geochemical maps. The geodatabase stores descriptive data (metadata), results of chemical analyses of samples, and geometrical data comprising the graphical part of the study.

Statistical calculations. The research results stored in the databases were used to separate subsets for statistical calculations according to different environmental criteria, for example in terms of elemental content of industrial soils, forest soils, urban soils, and sediments and waters of individual watercourses and water bodies, as well as for the construction of geochemical maps. Calculations of statistical parameters were performed (using Statistica software) for both entire sets and subsets of soils, sediments, and surface waters provided they numbered 10 or more samples. If the contents of elements were lower than their limits of quantification of the analytical method, a value equal to half of this limit was taken for statistical calculations. The arithmetic mean, geometric mean, and median were calculated and the minimum and maximum values were presented. In case of elements for which the percentage of results below the limit of quantification exceeded 50%, the calculation of selected measures of descriptive statistics was abandoned and only the minimum and maximum values were presented. Statistical parameters for individual elements and indices are summarized in Tables 2–5 and shown in the geochemical maps (Pls. 7–62).

When interpreting the results, the median values were used as a measure of the geochemical background for the individual elements. The median is a statistical parameter that better characterizes the content, compared to the arithmetic mean, as it is less affected by extreme values. Other statistical parameters (variance, standard deviation) are not suitable for characterizing a population with an undefined distribution.

Topographic base. VMap L2 data (vector format) at a scale of 1:50,000 in the PL-1992 rectangular coordinate system and other supporting materials were used to develop the topographic base of the 1:25,000 geochemical maps. The topographic map includes the following vector information layers:
- relief,
- hydrography (rivers, streams, ditches, and bodies of stagnant water),
- road network (with breakdown by class),
- railway network,
- built-up area type (rural, urban and industrial),
- forests,
- industrial areas (industrial facilities, mine workings, spoil heaps, and settling ponds).

Geological Map. The Detailed Geological Map of Poland 1:50,000 sheet Wojkowice M-34-51-C (Biernat 1955; updated by Wilanowski, Żaba, 2010) was used to present the geological structure of the study area. The vector images of the map sheet, created as a result of digitization, were combined with the topographic base to construct the geological map at the scale of 1:25,000 (Pl. 1).

Map construction. The following maps were produced for the Pyrzowice sheet (Pls. 2–63):
- land development,
- land use,
- content of total organic carbon, and of the sand, silt and clay fractions in soils at a depth of 0.0–0.3 m,
- pH in soils at depths of 0.0–0.3 and 0.8–1.0 m,
- contents of Ag, Al, As, Ba, Ca, Cd, Co, Cr, Cu, Fe, Hg, Mg, Mn, Ni, P, Pb, S, Sr, Ti, V and Zn in soils at depths of 0.0–0.3 and 0.8–1.0 m, and in sediments,
- pH and EC and the contents of Ag, Al, As, B, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Ni, P, Pb, SO_4^{2-}, Sb, Se, SiO_2, Sr, Ti, Tl, U, V and Zn in surface waters,
- assessment of topsoil (0.0–0.3 m) contamination according to the permissible cadmium content.

The maps were developed in ArcGIS 10.8, which is a software package from ESRI for working with maps and spatial data. The software enables to create new or modify existing maps, and to analyse, visualize and manage spatial data in geodatabases. The housing type and land use, as well as the distribution of elements in sediments and surface waters, are presented as point maps.

An isoline (areal) method of mapping was chosen to represent the distribution of grain size classes in soils, their pH and the content of chemical elements, due to its clarity and legibility. The geochemical isoline maps were constructed using the deterministic Inverse Distance Weighted method (IDW). This method produces a result for a given grid by averaging the values from the nearest points, with closer points having a greater influence on the interpolated value. This influence is the inverse of the distance of a given point raised to a power set by the mapper. The advantage of the method is the possibility to determine the distance and location of the points used in the interpolation process.

Maps of distribution of grain size classes, soil pH, and elemental contents in soils were constructed for a set of results of chemical analyses for the Pyrzowice, Siewierz, Wojkowice and Siemianowice Śląskie sheets at a scale of 1:25,000. One spatial analysis of the above-mentioned map sheets was made for each map to prevent discrepancies at their boundaries. The resulting monoelemental maps were combined with the topographic base within the boundaries of the respective sheet.

Soil's pH is presented according to the scale adopted in soil science, with a subdivision into very acidic (pH < 5.0), acidic (pH 5.0–6.0), slightly acidic (pH 6.1–6.7), neutral (pH 6.8–7.4) and alkaline (pH > 7.4) soils (Bednarek *et al.*, 2004). The spatial distribution of selected elements in soils is presented using a geometric progression to determine distribution classes.

Geochemical maps of sediments and surface waters of the Pyrzowice sheet were compiled separately. They were constructed as circular cartodiagrams, assigning their respective diameters to individual content classes, arranged mostly in geometric progression.

In drawing up an example map of classification of surface soils (Pl. 63), according to the permissible content of cadmium, the results of geochemical tests are related to permissible contents of risk-causing substances, according to soil groups specified in the Regulation of the Minister of Environment (Rozporządzenie..., 2016).

For the purpose of publishing, the geochemical maps are combined in pairs, *i.e.* the geochemical map of soils from 0.0–0.3 m depth and the geochemical map of sediments are presented on one plate, and the adjacent plate presents the geochemical map of soils from 0.8–1.0 m depth and the geochemical map of surface waters. This method of presentation allows direct comparison of geochemical images of different environments. Guided by convenience of use, the maps (annotated with a linear scale) are printed in a reduced format (A3), the scale of the print being 1:35,000. This procedure did not result in omission of any detail of the content of the maps.

Tabela 2
Table

Parametry statystyczne zawartości pierwiastków chemicznych i odczynu gleb (0,0–0,3 m)

Statistical parameters of chemical elements contents and acidity of topsoils (0.0–0.3 m)

Gleby *Soils*	Parametry *Parameters*	Ag	Al	As	Ba	C_{org}	Ca	Cd	Co	Cr	Cu	Fe	Hg	Mg	Mn	Ni	P	Pb	S	Sr	Ti	V	Zn	pH
		[mg/kg]	[%]	[mg/kg]		[%]		[mg/kg]				[%]	[mg/kg]	[%]	[mg/kg]		[%]	[mg/kg]	[%]	[mg/kg]				[–]
	Granica oznaczalności *Determination limit*	1	0,01	3	1	0,02	0,01	0,5	1	1	1	0,01	0,02	0,01	2	1	0,002	2	0,003	1	5	1	1	2,00
	a	<1	0,04	<3	8	0,06	<0,01	<0,5	<1	<1	1	0,03	<0,02	<0,01	2	<1	0,003	5	<0,003	<1	7	<1	5	3,66
Gleby ogółem	b	14	3,01	601	1269	54,42	15,20	35,1	30	223	478	10,80	2,44	9,06	3913	77	0,487	4907	0,594	224	277	77	8159	9,43
Total soils	c	–	0,38	10	86	3,72	0,46	3,1	3	7	10	0,73	0,05	0,14	299	6	0,036	118	0,034	11	41	11	255	6,43
n = 1289	d	–	0,31	6	67	2,20	0,12	2,0	1	5	8	0,49	0,04	0,04	133	4	0,029	89	0,022	7	38	8	145	6,32
	e	–	0,29	6	64	1,88	0,11	2,1	2	5	8	0,46	0,04	0,04	189	3	0,030	83	0,020	6	38	7	141	6,51
	a	1	0,04	2	8	0,06	0,01	0,3	1	1	1	0,03	0,01	0,01	2	1	0,003	7	0,002	1	7	1	5	3,66
Tereny bez zabudowy	b	8	3,01	367	965	54,42	7,58	23,5	30	223	478	10,80	2,44	2,77	3913	77	0,476	2277	0,552	224	240	77	3495	9,43
Non-built-up areas	c	1	0,37	10	86	4,12	0,37	3,0	2	7	9	0,69	0,05	0,10	276	5	0,035	114	0,036	10	39	10	225	6,22
n = 1004	d	1	0,29	6	67	2,34	0,10	2,0	1	5	7	0,45	0,04	0,03	111	3	0,028	88	0,022	6	36	8	130	6,11
	e	1	0,28	5	63	1,93	0,08	2,0	1	4	7	0,40	0,04	0,03	151	3	0,029	81	0,019	5	37	7	123	6,21
	a	<1	0,11	<3	15	0,15	<0,01	<0,5	<1	2	2	0,13	<0,02	<0,01	5	<1	0,006	5	<0,003	1	11	2	20	4,50
Tereny z zabudową wiejską	b	9	1,43	324	1269	38,78	15,20	35,1	19	29	228	7,62	0,30	9,06	3024	31	0,487	1078	0,594	120	277	62	4359	9,17
Village areas	c	–	0,42	11	88	2,45	0,67	3,9	3	8	14	0,83	0,05	0,22	384	8	0,043	124	0,030	13	48	12	357	7,08
n = 223	d	–	0,36	7	70	1,86	0,23	2,5	2	6	10	0,63	0,04	0,07	247	5	0,037	97	0,022	9	44	10	216	7,03
	e	–	0,34	7	72	1,88	0,23	2,5	3	6	10	0,64	0,04	0,07	308	5	0,036	95	0,021	8	44	9	219	7,19
	a	<1	0,18	<3	26	0,91	0,03	0,6	<1	3	5	0,33	<0,02	0,02	41	2	0,016	18	0,011	4	35	5	67	4,66
Tereny z zabudową miejską	b	<1	0,92	24	250	6,78	3,87	9,6	6	27	50	1,51	0,17	1,18	825	18	0,106	256	0,079	81	86	26	1098	8,38
Urban areas	c	–	0,41	9	111	2,20	0,90	3,7	3	8	14	0,71	0,05	0,28	340	7	0,033	118	0,027	16	55	12	380	7,43
n = 22	d	–	0,38	8	98	1,89	0,50	2,9	2	7	12	0,65	0,05	0,15	273	6	0,030	106	0,025	12	54	10	291	7,38
	e	–	0,35	8	101	1,76	0,63	3,0	2	7	12	0,63	0,05	0,16	273	6	0,028	112	0,025	11	51	9	276	7,67
	a	<1	0,17	<3	20	0,30	0,02	0,5	<1	3	4	0,23	<0,02	0,02	39	2	0,009	26	0,006	2	26	3	56	5,88
Tereny przemysłowe	b	14	0,80	601	215	5,97	13,01	32,4	13	43	26	5,19	0,15	7,46	1506	36	0,076	4907	0,126	73	182	47	8159	9,27
Industrial areas	c	–	0,36	23	59	1,63	1,36	2,9	3	8	9	0,94	0,04	0,64	394	7	0,026	194	0,024	13	51	11	387	7,69
n = 40	d	–	0,33	7	50	1,33	0,48	1,7	2	6	8	0,68	0,03	0,19	268	5	0,023	74	0,018	9	46	9	167	7,65
	e	–	0,32	6	51	1,27	0,39	1,6	2	6	9	0,69	0,03	0,16	286	6	0,022	63	0,017	8	43	10	152	7,86
	a	<1	0,08	<3	16	0,27	<0,01	<0,5	<1	1	2	0,10	<0,02	<0,01	8	<1	0,012	17	0,005	1	16	3	23	5,11
Pola uprawne	b	<1	1,26	53	249	5,29	7,49	35,1	19	25	32	3,13	0,21	4,56	1517	35	0,206	602	0,049	41	111	49	1983	8,48
Cultivated fields	c	–	0,44	9	68	1,43	0,52	3,2	3	8	10	0,79	0,04	0,22	433	8	0,039	103	0,017	8	45	13	273	7,12
n = 132	d	–	0,38	6	60	1,26	0,18	2,2	3	6	9	0,63	0,03	0,08	325	5	0,035	83	0,016	6	43	11	187	7,08
	e	–	0,36	7	65	1,27	0,16	2,2	3	6	9	0,63	0,03	0,07	389	5	0,036	78	0,016	6	43	11	197	7,19
	a	<1	0,04	<3	8	0,06	<0,01	<0,5	<1	<1	1	0,03	<0,02	<0,01	2	<1	0,003	9	<0,003	<1	8	<1	5	3,66
Lasy	b	<1	3,01	40	450	54,42	4,38	15,4	25	27	34	2,95	0,39	1,39	1542	33	0,176	645	0,307	57	195	37	904	8,46
Forests	c	–	0,26	5	80	5,42	0,11	2,1	–	4	7	0,39	0,06	0,03	91	3	0,022	112	0,032	5	36	6	101	5,23
n = 357	d	–	0,21	4	61	2,99	0,04	1,4	–	3	6	0,28	0,04	0,01	35	2	0,017	86	0,021	4	34	5	70	5,15
	e	–	0,20	4	57	2,75	0,03	1,4	–	3	6	0,26	0,04	0,01	28	2	0,017	82	0,018	3	35	5	66	5,13
	a	<1	0,07	<3	13	0,26	<0,01	<0,5	<1	1	2	0,09	<0,02	<0,01	5	<1	0,005	7	0,003	1	7	1	21	4,82
Łąki	b	2	1,73	367	965	43,32	7,58	31,1	30	34	37	10,80	0,30	1,99	3255	57	0,487	2277	0,594	224	240	73	2824	8,46
Meadows	c	–	0,43	12	94	3,54	0,40	3,3	3	7	9	0,88	0,05	0,10	332	6	0,044	114	0,039	13	39	12	266	6,60
n = 355	d	–	0,34	6	72	2,23	0,15	2,3	2	5	8	0,55	0,04	0,05	173	4	0,036	86	0,024	8	36	9	167	6,56
	e	–	0,32	6	66	1,94	0,14	2,2	2	5	7	0,47	0,04	0,04	202	3	0,034	81	0,021	7	35	8	156	6,62
	a	<1	0,08	<3	15	0,28	0,01	<0,5	<1	1	2	0,04	<0,02	<0,01	2	<1	0,006	9	0,003	1	7	2	22	4,39
Nieużytki, ugory	b	14	1,55	601	463	41,12	15,20	32,4	16	223	478	5,19	2,44	9,06	3913	77	0,197	4907	0,424	115	182	77	8159	9,43
Barren lands	c	–	0,44	15	89	3,52	0,76	3,9	3	9	14	0,89	0,06	0,24	405	8	0,042	135	0,041	15	45	13	372	6,94
n = 343	d	–	0,37	8	71	2,10	0,23	2,6	2	6	9	0,64	0,04	0,07	234	5	0,036	97	0,025	9	40	10	211	6,88
	e	–	0,36	7	66	1,77	0,20	2,4	2	6	9	0,64	0,04	0,06	298	5	0,033	87	0,021	8	41	10	207	6,92
	a	<1	0,12	<3	16	0,15	0,02	<0,5	<1	2	3	0,15	<0,02	0,01	17	1	0,006	5	<0,003	2	14	2	20	4,96
Trawniki	b	2	0,89	66	1269	8,31	5,35	33,8	15	37	86	1,77	0,15	2,53	1560	22	0,108	526	0,163	120	277	32	3794	8,62
Lawns	c	–	0,38	9	91	2,00	0,85	3,6	3	8	13	0,75	0,04	0,27	385	7	0,037	113	0,025	16	53	11	337	7,51
n = 97	d	–	0,35	7	69	1,68	0,41	2,4	2	7	10	0,63	0,03	0,12	262	6	0,032	90	0,021	11	48	9	224	7,47
	e	–	0,35	7	66	1,76	0,42	2,4	2	7	10	0,69	0,04	0,10	288	6	0,030	97	0,021	10	49	9	221	7,65

Tabela 2 cd.
Table 2 cont.

Gleby *Soils*	Parametry *Parameters*	Ag	Al	As	Ba	C_{org}	Ca	Cd	Co	Cr	Cu	Fe	Hg	Mg	Mn	Ni	P	Pb	S	Sr	Ti	V	Zn	pH
		[mg/kg]	[%]	[mg/kg]		[%]		[mg/kg]				[%]	[mg/kg]	[%]	[mg/kg]		[%]	[mg/kg]	[%]	[mg/kg]				[–]
	Granica oznaczalności *Determination limit*	1	0,01	3	1	0,02	0,01	0,5	1	1	1	0,01	0,02	0,01	2	1	0,002	2	0,003	1	5	1	1	2,00
Gleby piaszczyste *Sandy soils* n = 1055	a	<1	0,04	<3	8	0,06	<0,01	<0,5	<1	<1	1	0,03	<0,02	<0,01	2	<1	0,003	5	<0,003	<1	7	<1	5	3,67
	b	2	1,72	367	1269	48,92	5,31	31,1	30	223	162	5,64	0,27	2,84	3255	57	0,161	2277	0,594	115	240	62	3794	9,25
	c	–	0,31	7	77	2,69	0,25	2,5	2	5	8	0,55	0,04	0,08	248	4	0,030	100	0,024	7	39	8	190	6,30
	d	–	0,26	5	61	1,96	0,09	1,7	1	4	7	0,40	0,03	0,03	108	3	0,026	80	0,019	5	36	7	117	6,20
	e	–	0,26	5	58	1,77	0,07	1,8	1	4	7	0,38	0,04	0,03	147	3	0,027	78	0,018	5	37	6	113	6,35
Gleby gliniaste *Clay soils* n = 98	a	<1	0,22	<3	38	0,42	0,06	0,6	1	4	6	0,32	<0,02	0,03	95	3	0,012	24	0,008	4	21	6	122	5,53
	b	<1	1,73	201	370	15,26	7,58	35,1	16	37	39	10,80	0,25	4,56	2246	77	0,476	569	0,171	165	169	49	2031	8,35
	c	–	0,86	23	103	2,53	1,33	6,3	7	16	18	1,80	0,07	0,35	694	19	0,054	153	0,031	21	59	25	609	7,45
	d	–	0,81	16	93	2,17	0,72	4,9	6	15	17	1,58	0,06	0,19	599	17	0,046	132	0,027	16	58	23	492	7,43
	e	–	0,86	15	91	2,22	0,72	4,6	7	16	18	1,57	0,06	0,15	580	17	0,046	116	0,029	15	59	24	474	7,41
Gleby torfiaste *Peaty soils* n = 77	a	<1	0,15	<3	44	2,10	0,02	0,9	<1	2	4	0,14	0,04	<0,01	6	1	0,015	44	0,025	3	7	2	42	3,66
	b	<1	3,01	137	512	54,42	4,98	15,4	20	25	58	8,15	2,44	1,10	3913	24	0,487	645	0,552	224	195	77	1064	7,83
	c	–	0,67	19	192	20,50	0,92	6,9	3	10	16	1,39	0,18	0,09	313	8	0,099	238	0,181	36	38	21	391	5,73
	d	–	0,56	14	163	14,00	0,44	5,6	2	9	14	0,99	0,14	0,06	143	6	0,081	196	0,132	23	34	17	307	5,63
	e	–	0,56	14	159	13,25	0,45	6,1	2	10	15	0,95	0,14	0,06	196	7	0,094	228	0,122	23	34	18	324	5,88
Gleby antropogeniczne *Anthropogenic soils* n = 59	a	<1	0,11	<3	18	0,29	0,01	<0,5	<1	2	2	0,14	<0,02	0,03	45	1	0,006	23	0,006	2	22	2	28	5,42
	b	14	0,95	601	270	8,31	15,20	32,4	12	150	478	5,19	0,17	9,06	2431	36	0,132	4907	0,229	92	277	39	8159	9,43
	c	–	0,47	35	87	2,15	2,17	4,1	4	13	27	1,18	0,05	0,93	554	10	0,033	227	0,035	24	69	15	649	8,02
	d	–	0,44	12	72	1,65	1,13	2,6	3	9	14	0,98	0,04	0,38	410	8	0,029	113	0,026	17	60	13	314	7,99
	e	–	0,46	10	67	1,68	1,35	2,5	3	8	11	1,02	0,04	0,47	474	9	0,029	94	0,024	19	53	14	249	8,04
Tło geochemiczne / *Geochemical background*																								
Gleby Europy [1] *Soils of Europe*	e	0,27 n = 840	5,82 n = 845	6,00 n = 837*	65,0 n = 837*	1,73 n = 819	0,659 n = 845	0,145 n = 840	7,00 n = 837*	22,00 n = 837*	12,0 n = 837*	1,96 n = 837*	0,037 n = 833	0,46 n = 845	382 n = 837*	14,0 n = 837*	0,056 n = 845	15,0 n = 837*	0,023 n = 837*	89,0 n = 845	3426 n = 845	33,0 n = 837*	48,0 n = 837*	5,51 n = 818
Gleby Polski [2] *Soils of Poland* n = 10 840**	e	<1	nd.	<5	32	nd.	0,18	<0,5	2	4	5	0,51	<0,05	0,06	217	4	0,034	13	0,012	8	26	7	35	6,1
Gleby regionu śląsko-krakowskiego [3] *Soils of Cracow-Silesia Region* n = 1564**	e	<1	nd.	<5	54	nd.	0,22	1,3	3	5	7	0,63	0,08	0,07	257	5	0,030	44	0,015	10	28	9	104	6,7
Dopuszczalne zawartości pierwiastków powodujących ryzyko z podziałem na grupy gruntów [4] / *Permissible contents of risk-causing substances by land groups* [4]																								
I grupa *Group I*		nd.	nd.	25	400	nd.	nd.	2	50	200	200	nd.	5	nd.	nd.	150	nd.	200	nd.	nd.	nd.	nd.	500	nd.
II grupa *Group II*		nd.	nd.	10–50	200–600	nd.	nd.	2–5	20–50	150–500	100–300	nd.	2–5	nd.	nd.	100–300	nd.	100–500	nd.	nd.	nd.	nd.	300–1000	nd.
III grupa *Group III*		nd.	nd.	50	1000	nd.	nd.	10	100	500	300	nd.	10	nd.	nd.	300	nd.	500	nd.	nd.	nd.	nd.	1000	nd.
IV grupa *Group IV*		nd.	nd.	100	1500	nd.	nd.	15	200	1000	600	nd.	30	nd.	nd.	500	nd.	600	nd.	nd.	nd.	nd.	2000	nd.

a – minimum *minimum*; b – maksimum *maximum*; c – średnia arytmetyczna *arithmetic mean*; d – średnia geometryczna *geometric mean*; e – mediana *median*; n – liczba próbek *number of samples*; [1] Salminen, 2005; [2] Lis, Pasieczna, 1995a; [3] Lis, Pasieczna, 1995b; [4] Rozporządzenie Ministra Środowiska, 2016

„–” nie obliczono w przypadku, gdy odsetek wyników poniżej granicy oznaczalności przekraczał 50% *not calculated in the case when the percentage of the results below determination limit exceeded 50%*; nd. – nie dotyczy *not applicable*; * ekstrakcja wodą królewską *aqua regia digestion*; ** ekstrakcja kwasem solnym *hydrochloric acid digestion*

Tabela 3
Table

Parametry statystyczne zawartości pierwiastków chemicznych i odczynu gleb (0,8–1,0 m)

Statistical parameters of chemical elements contents and acidity of subsoils (0.8–1.0 m)

Gleby *Soils*	Parametry *Parameters*	Ag	Al	As	Ba	Ca	Cd	Co	Cr	Cu	Fe	Hg	Mg	Mn	Ni	P	Pb	S	Sr	Ti	V	Zn	pH
		[mg/kg]	[%]	[mg/kg]		[%]	[mg/kg]				[%]	[mg/kg]	[%]	[mg/kg]		[%]	[mg/kg]	[%]	[mg/kg]				[–]
	Granica oznaczalności *Determination limit*	1	0,01	3	1	0,01	0,5	1	1	1	0,01	0,02	0,01	2	1	0,002	2	0,003	1	5	1	1	2,00
Gleby ogółem	a	<1	0,03	<3	4	<0,01	<0,5	<1	<1	<1	0,01	<0,02	<0,01	<2	<1	<0,002	<2	<0,003	<1	6	<1	2	3,82
Total soils	b	17	3,12	688	1720	26,95	90,0	126	66	711	13,02	0,30	10,82	9582	143	0,568	1779	1,897	539	458	134	5267	9,48
n = 1270	c	–	0,48	–	45	1,59	–	4	8	10	0,90	–	0,55	296	9	0,015	45	0,019	16	47	13	194	7,27
	d	–	0,33	–	25	0,08	–	2	4	5	0,37	–	0,06	60	4	0,009	10	0,005	4	41	7	43	7,21
	e	–	0,30	–	21	0,04	–	1	4	5	0,36	–	0,03	48	3	0,009	9	0,004	3	40	6	31	7,31
Tereny bez zabudowy	a	<1	0,03	<3	4	<0,01	<0,5	<1	<1	<1	0,01	<0,02	<0,01	<2	<1	<0,002	<2	<0,003	<1	8	<1	2	3,82
Non-built-up areas	b	15	3,12	618	1720	26,95	78,7	86	66	711	13,02	0,30	10,51	9582	134	0,568	1499	1,897	539	235	134	4585	9,48
n = 991	c	–	0,47	–	44	1,48	–	4	8	9	0,85	–	0,52	277	9	0,014	36	0,017	14	46	13	168	7,17
	d	–	0,32	–	24	0,07	–	1	4	5	0,33	–	0,05	50	3	0,008	9	0,005	4	40	6	38	7,11
	e	–	0,28	–	20	0,03	–	1	4	5	0,29	–	0,03	37	3	0,007	7	0,004	2	39	5	25	7,19
Tereny z zabudową wiejską	a	<1	0,07	<3	6	<0,01	<0,5	<1	<1	<1	0,04	<0,02	<0,01	3	<1	<0,002	<2	<0,003	<1	6	1	4	5,06
Village areas	b	12	2,56	475	423	20,65	90,0	126	51	346	7,82	0,30	10,82	5327	143	0,101	1779	1,294	321	458	72	5267	9,21
n = 219	c	–	0,57	11	46	1,92	–	6	9	12	1,10	0,04	0,58	379	13	0,018	72	0,019	22	51	15	293	7,56
	d	–	0,40	4	28	0,14	–	2	6	7	0,54	0,02	0,07	106	5	0,012	16	0,005	6	44	9	69	7,52
	e	–	0,33	3	25	0,08	–	2	5	6	0,56	0,02	0,04	90	5	0,012	16	0,005	4	45	10	58	7,58
Tereny z zabudową miejską	a	<1	0,10	<3	10	<0,01	<0,5	<1	1	2	0,05	<0,02	<0,01	8	<1	<0,002	<2	<0,003	1	20	2	3	7,01
Urban areas	b	<1	1,27	51	622	14,34	6,2	16	20	65	4,06	0,19	7,30	1508	44	0,193	218	0,068	291	198	45	1006	8,82
n = 21	c	–	0,37	–	74	2,26	–	3	6	12	0,68	–	0,60	278	8	0,028	49	0,013	29	53	10	218	7,91
	d	–	0,30	–	34	0,18	–	1	4	7	0,35	–	0,07	76	3	0,014	17	0,006	7	46	7	59	7,89
	e	–	0,32	–	22	0,09	–	1	4	4	0,33	–	0,04	72	3	0,013	14	0,004	4	42	6	45	7,83
Tereny przemysłowe	a	<1	0,11	<3	10	<0,01	<0,5	<1	<1	2	0,06	<0,02	<0,01	7	<1	0,003	<2	<0,003	<1	21	2	11	5,48
Industrial areas	b	17	1,34	688	192	17,19	9,2	22	20	481	5,34	0,11	10,06	3085	25	0,084	1535	1,423	90	132	45	5142	9,11
n = 39	c	–	0,45	27	44	2,22	1,2	4	7	21	1,08	0,04	1,15	342	8	0,016	106	0,067	16	51	13	275	7,84
	d	–	0,38	6	34	0,31	0,7	2	6	8	0,67	0,03	0,18	137	6	0,013	29	0,010	7	46	10	86	7,79
	e	–	0,37	6	35	0,29	0,5	2	7	7	0,86	0,03	0,17	213	7	0,015	33	0,009	7	46	12	82	8,14
Pola uprawne	a	<1	0,06	<3	4	<0,01	<0,5	<1	<1	1	0,03	<0,02	<0,01	3	<1	<0,002	<2	<0,003	<1	10	<1	4	5,06
Cultivated fields	b	<1	2,56	98	622	24,25	61,1	126	51	65	6,41	0,29	10,39	3999	143	0,261	651	0,072	436	198	72	5267	9,16
n = 129	c	–	0,69	12	56	3,67	2,5	7	12	13	1,36	0,05	1,45	513	16	0,023	71	0,011	30	54	21	306	7,79
	d	–	0,52	7	36	0,43	0,8	3	8	9	0,86	0,03	0,21	233	9	0,016	26	0,007	11	49	15	110	7,74
	e	–	0,54	9	33	0,34	0,7	4	9	11	0,99	0,04	0,15	387	11	0,020	28	0,008	12	51	19	119	7,88
Lasy	a	<1	0,03	<3	4	<0,01	<0,5	<1	<1	<1	0,01	<0,02	<0,01	<2	<1	<0,002	<2	<0,003	<1	8	<1	3	3,82
Forests	b	<1	2,46	35	153	11,82	15,6	86	51	49	6,38	0,21	6,91	4731	125	0,133	274	0,215	51	235	61	3273	8,87
n = 357	c	–	0,33	–	20	–	–	–	5	5	0,47	–	0,10	91	5	0,008	10	0,006	3	43	7	51	6,55
	d	–	0,24	–	15	–	–	–	3	3	0,18	–	0,02	18	2	0,005	4	0,003	2	36	4	17	6,49
	e	–	0,19	–	13	–	–	–	2	3	0,14	–	0,02	12	2	0,005	4	0,003	1	34	3	12	6,59
Łąki	a	<1	0,03	<3	5	<0,01	<0,5	<1	<1	<1	0,01	<0,02	<0,01	2	1	<0,002	<2	<0,003	<1	11	1	2	3,93
Meadows	b	3	3,12	178	1720	26,95	78,7	78	56	70	11,85	0,30	8,09	9582	134	0,568	1779	1,897	539	193	134	4386	9,48
n = 348	c	–	0,51	–	59	1,55	–	4	8	9	0,99	–	0,40	311	11	0,016	46	0,024	20	45	14	207	7,41
	d	–	0,34	–	30	0,11	–	2	4	5	0,38	–	0,05	62	4	0,009	10	0,005	5	40	7	44	7,36
	e	–	0,30	–	26	0,05	–	1	4	5	0,36	–	0,04	49	3	0,008	9	0,005	3	40	7	35	7,46
Nieużytki, ugory	a	1	0,03	<3	6	<0,01	<0,5	<1	<1	<1	0,02	<0,02	<0,01	2	<1	<0,002	<2	<0,003	<1	6	<1	3	5,19
Barren lands	b	15	2,21	618	1078	20,12	30,1	37	66	711	13,02	0,30	10,51	7372	92	0,327	1217	1,294	313	458	70	4867	9,21
n = 336	c	–	0,54	14	54	2,15	–	5	9	13	1,10	0,04	0,78	407	11	0,018	64	0,029	18	50	16	277	7,55
	d	–	0,38	5	31	0,17	–	2	5	7	0,50	0,03	0,08	98	5	0,011	16	0,006	6	43	9	67	7,51
	e	–	0,40	4	28	0,10	–	2	6	7	0,64	0,03	0,06	89	6	0,011	18	0,006	5	44	11	54	7,55
Trawniki	a	<1	0,10	<3	8	<0,01	<0,5	<1	<1	<1	0,05	<0,02	<0,01	5	<1	0,003	<2	<0,003	<1	11	1	6	5,80
Lawns	b	17	2,04	688	407	20,65	90,0	58	32	481	4,19	0,25	10,82	2967	76	0,079	1535	1,423	321	210	55	5142	9,11
n = 95	c	–	0,45	14	43	2,19	–	4	8	13	0,83	0,03	0,80	335	9	0,018	67	0,026	20	51	12	240	7,81
	d	–	0,35	4	29	0,19	–	2	5	6	0,52	0,02	0,09	128	5	0,014	21	0,006	6	45	8	78	7,77
	e	–	0,32	3	26	0,10	–	2	5	6	0,52	0,02	0,05	179	4	0,014	24	0,005	4	46	9	77	7,83

Tabela 3 cd.
Table 3 cont.

Gleby *Soils*	Parametry *Parameters*	Ag	Al	As	Ba	Ca	Cd	Co	Cr	Cu	Fe	Hg	Mg	Mn	Ni	P	Pb	S	Sr	Ti	V	Zn	pH
		[mg/kg]	[%]	[mg/kg]		[%]	[mg/kg]				[%]	[mg/kg]	[%]	[mg/kg]		[%]	[mg/kg]	[%]	[mg/kg]				[–]
	Granica oznaczalności *Determination limit*	1	0,01	3	1	0,01	0,5	1	1	1	0,01	0,02	0,01	2	1	0,002	2	0,003	1	5	1	1	2,00
Gleby piaszczyste *Sandy soils* n = 797	a	<1	0,03	<3	4	<0,01	<0,5	<1	<1	<1	0,01	<0,02	<0,01	<2	<1	<0,002	<2	<0,003	<1	8	<1	2	3,82
	b	9	1,68	271	775	18,98	24,3	126	44	198	8,06	0,19	8,95	3999	143	0,261	1217	0,797	291	198	48	4462	9,20
	c	–	0,25	–	23	0,22	–	–	3	4	0,33	–	0,10	90	3	0,008	16	–	3	38	5	52	7,06
	d	–	0,20	–	16	0,02	–	–	2	3	0,17	–	0,02	21	2	0,005	4	–	2	34	3	19	7,01
	e	–	0,19	–	14	0,02	–	–	2	3	0,15	–	0,02	16	2	0,005	4	–	2	33	3	15	7,11
Gleby gliniaste *Clay soils* n = 417	a	<1	0,11	<3	7	<0,01	<0,5	<1	1	2	0,11	<0,02	0,01	8	2	0,003	<2	<0,003	1	15	1	10	4,61
	b	3	3,12	178	1720	26,95	90,0	86	56	70	13,02	0,30	10,82	9582	134	0,568	1779	0,182	539	235	81	5267	9,48
	c	–	0,93	15	82	3,98	3,3	9	16	16	1,95	0,06	1,32	679	22	0,026	85	0,014	37	61	27	426	7,64
	d	–	0,81	9	55	0,81	1,0	6	14	14	1,47	0,05	0,31	354	16	0,019	38	0,009	17	56	23	176	7,55
	e	–	0,83	10	52	0,80	0,8	6	14	14	1,43	0,05	0,19	457	16	0,020	34	0,010	16	56	24	150	7,95
Gleby torfiaste *Peaty soils* n = 16	a	<1	0,12	<3	27	0,13	<0,5	<1	3	5	0,18	<0,02	0,04	17	2	0,019	14	0,043	9	17	7	23	3,93
	b	<1	1,91	47	260	4,22	4,7	22	22	35	2,15	0,25	0,30	529	39	0,327	645	1,897	62	48	134	465	6,67
	c	–	0,63	15	122	1,74	2,4	5	11	14	0,99	0,14	0,14	133	11	0,079	113	0,558	32	33	29	180	5,91
	d	–	0,47	9	97	1,32	1,9	3	9	12	0,75	0,12	0,12	90	9	0,063	63	0,341	29	31	22	146	5,86
	e	–	0,46	9	133	1,69	2,3	3	10	12	0,69	0,15	0,13	82	10	0,063	55	0,348	32	34	22	168	6,07
Gleby antropogeniczne *Anthropogenic soils* n = 40	a	<1	0,18	<3	16	0,01	<0,5	<1	2	3	0,06	<0,02	0,02	8	<1	0,007	11	0,006	2	6	3	24	5,88
	b	17	1,99	688	333	16,02	14,0	23	66	711	4,19	0,13	9,41	1778	40	0,081	1535	1,423	153	458	55	5142	9,21
	c	–	0,50	56	69	3,88	2,8	5	11	50	1,20	0,04	1,70	481	10	0,023	181	0,118	33	74	16	602	8,32
	d	–	0,43	11	56	1,90	1,5	3	8	14	0,89	0,04	0,68	325	8	0,020	81	0,028	21	58	13	225	8,29
	e	–	0,42	8	54	2,12	1,8	3	8	11	0,82	0,04	0,84	377	7	0,018	70	0,018	22	56	13	239	8,38

a – minimum *minimum* b – maksimum *maximum* c – średnia arytmetyczna *arithmetic mean* d – średnia geometryczna *geometric mean* e – mediana *median* n – liczba próbek *number of samples* „–" nie obliczono w przypadku, gdy odsetek wyników poniżej granicy oznaczalności przekraczał 50% *not calculated in the case when the percentage of the results below determination limit exceeded 50%*

Tabela 4
Table 4

Parametry statystyczne zawartości pierwiastków chemicznych w osadach wodnych

Statistical parameters of chemical elements contents in aquatic sediments

Osady wodne *Aquatic sediments*	Parametry *Parameters*	Ag	Al	As	Ba	Ca	Cd	Co	Cr	Cu	Fe	Hg	Mg	Mn	Ni	P	Pb	S	Sr	Ti	V	Zn
		[mg/kg]	[%]	[mg/kg]		[%]	[mg/kg]				[%]	[mg/kg]	[%]	[mg/kg]		[%]	[mg/kg]	[%]	[mg/kg]			
	Granica oznaczalności *Determination limit*	1	0,01	3	1	0,01	0,5	1	1	1	0,01	0,02	0,01	2	1	0,002	2	0,003	1	5	1	1
Osady wodne (wszystkie próbki)	a	<1	0,02	<3	1	0,03	<0,5	<1	<1	<1	0,05	<0,02	0,01	20	<1	<0,002	6	0,009	1	<5	<1	24
Aquatic sediments (all samples)	b	138	2,35	2974	967	33,66	9695,0	131	471	8056	37,61	9,15	7,13	23 810	1307	0,902	27 190	13,780	1925	493	62	69 330
n = 368	c	2	0,73	109	161	3,26	63,8	9	25	137	2,78	0,31	0,63	1407	31	0,115	1163	0,588	97	98	20	4938
	d	1	0,61	30	123	1,40	12,7	7	19	45	2,11	0,15	0,34	692	20	0,074	430	0,264	46	83	18	1714
	e	<1	0,65	26	127	1,23	11,7	7	19	40	2,09	0,14	0,34	631	20	0,075	394	0,246	39	88	19	1469
Strumienie i rowy bez nazwy	a	<1	0,05	<3	1	0,03	1,0	<1	2	2	0,28	<0,02	0,01	35	3	0,003	27	0,019	2	<5	2	123
Streams and ditches (no name)	b	138	2,35	2974	575	16,30	9695,0	49	88	1539	37,61	1,11	7,13	23 810	475	0,530	27 190	13,780	434	458	57	69 330
n = 239	c	3	0,75	140	182	1,89	125,0	8	22	68	2,85	0,19	0,29	1403	30	0,113	1353	0,529	40	86	20	3870
	d	<1	0,63	32	138	0,90	14,1	6	19	38	2,09	0,12	0,31	633	21	0,082	408	0,175	29	71	18	1493
	e	<1	0,65	23	162	0,79	11,4	7	19	33	1,99	0,12	0,29	618	20	0,083	317	0,146	30	73	20	1165
Sadzawki	a	<1	0,11	<3	10	0,02	<0,5	<1	2	<1	0,12	<0,02	0,01	7	1	0,006	5	0,004	1	20	3	9
Small water pools	b	<1	1,35	31	269	8,92	54,6	85	19	118	3,86	0,21	5,84	1049	70	0,082	581	1,226	40	113	24	4549
n = 19	c	–	0,48	8	80	0,72	6,9	8	8	22	0,70	0,06	0,37	184	10	0,025	135	0,218	11	48	9	557
	d	–	0,38	5	47	0,18	1,6	2	6	9	0,46	0,03	0,06	71	6	0,019	65	0,068	6	43	7	131
	e	–	0,47	7	47	0,16	1,6	2	8	9	0,43	0,02	0,04	62	5	0,018	86	0,052	7	39	8	100
Zlewnia Brynicy do zb. Kozłowa	a	1	0,10	<3	3	<0,01	<0,5	<1	1	1	0,04	<0,02	<0,01	6	<1	0,003	4	0,006	<1	9	1	7
Góra	b	4	1,26	292	742	15,51	105,8	48	40	117	4,70	0,38	4,66	2891	61	0,420	753	1,795	232	283	57	9185
Catchment of the Brynica River to the	c	–	0,54	21	113	1,37	7,6	7	8	13	1,31	0,06	0,39	419	10	0,069	106	0,262	24	38	14	579
Kozłowa Góra reservoir	d	–	0,46	11	79	0,45	4,5	4	7	9	0,88	0,04	0,13	145	7	0,045	63	0,153	13	32	10	345
n = 90	e	–	0,49	11	80	0,44	4,5	4	7	9	1,07	0,04	0,11	150	7	0,039	63	0,131	11	30	12	358
Brynica	a	<1	0,16	<3	19	0,08	1,0	1	2	1	0,39	<0,02	0,02	20	2	0,013	7	0,021	3	19	3	119
Brynica River	b	<1	1,11	33	217	1,05	16,2	19	14	18	4,70	0,07	0,45	2817	18	0,129	97	0,665	17	43	23	1427
n = 29	c	–	0,45	11	84	0,44	4,1	7	6	6	1,36	0,03	0,17	399	7	0,042	36	0,160	8	30	9	432
	d	–	0,40	9	72	0,34	3,4	5	5	5	1,14	0,02	0,12	239	6	0,036	31	0,117	8	29	8	367
	e	–	0,38	10	73	0,29	3,7	5	5	5	1,06	0,03	0,10	227	6	0,035	28	0,112	7	30	7	377
Zlewnia Trzoni	a	<1	0,10	<3	14	0,05	<0,5	<1	1	<1	0,11	<0,02	0,01	7	<1	0,005	5	0,021	2	12	3	9
Catchment of the Trzonia Stream	b	<1	1,69	100	661	2,90	94,2	19	20	32	17,35	0,22	1,22	3024	18	2,108	268	0,924	103	84	52	4150
n = 43	c	–	0,64	22	117	0,48	9,1	5	7	9	2,60	0,06	0,09	371	5	0,173	72	0,192	16	37	14	559
	d	–	0,53	14	75	0,28	5,3	3	6	6	1,38	0,04	0,05	191	4	0,080	49	0,121	10	34	11	364
	e	–	0,60	17	64	0,23	6,2	4	7	5	1,47	0,04	0,05	248	4	0,086	43	0,131	9	35	11	438
Trzonia	a	<1	0,17	4	33	0,08	1,3	2	2	1	0,54	<0,02	0,02	145	1	0,017	15	0,021	4	17	4	112
Trzonia Stream	b	<1	0,99	22	124	0,33	11,6	13	11	13	4,72	0,07	0,08	884	7	0,119	80	0,226	11	54	22	838
n = 18	c	–	0,54	14	63	0,20	5,1	5	6	4	1,87	0,03	0,05	411	4	0,066	36	0,084	8	37	11	408
	d	–	0,48	12	59	0,19	4,2	5	5	4	1,60	0,02	0,04	348	4	0,058	32	0,068	7	36	9	348
	e	–	0,51	14	62	0,21	4,2	5	5	4	1,59	0,04	0,05	322	5	0,061	34	0,072	8	36	9	342
Zlewnia Czeczówki	a	<1	0,08	<3	7	0,03	<0,5	<1	1	2	0,10	<0,02	<0,01	4	1	0,004	5	0,016	2	10	3	25
Catchment of the Czeczówka Stream	b	10	2,38	81	301	6,48	69,3	147	21	56	12,61	0,31	3,79	19331	26	0,231	799	1,172	84	103	66	4621
n = 50	c	–	0,64	20	109	1,08	10,2	11	9	17	2,02	0,07	0,38	1062	9	0,065	135	0,250	18	41	16	742
	d	–	0,49	12	77	0,50	4,7	4	7	12	1,04	0,04	0,14	208	7	0,043	84	0,139	12	37	12	396
	e	–	0,49	13	99	0,67	4,8	4	9	17	1,08	0,05	0,16	274	8	0,048	86	0,152	13	39	13	490
Czeczówka	a	<1	0,08	<3	13	0,03	1,0	<1	1	2	0,10	<0,02	<0,01	4	1	0,006	10	0,020	2	<5	3	81
Czeczówka Stream	b	1	2,34	81	301	6,48	57,2	147	21	56	12,61	0,31	3,79	19331	26	0,190	799	1,172	68	51	41	4621
n = 22	c	–	0,74	25	105	1,17	12,4	16	9	19	2,99	0,09	0,48	1456	10	0,071	153	0,372	19	35	16	974
	d	–	0,55	15	85	0,49	5,9	4	8	14	1,38	0,05	0,14	170	7	0,051	89	0,224	13	28	13	503
	e	–	0,55	17	99	0,67	5,9	6	10	20	1,21	0,07	0,17	134	9	0,059	93	0,191	14	42	16	598

Tabela 4 cd.
Table 4 cont.

Osady wodne *Aquatic sediments*	Parametry *Parameters*	Ag	Al	As	Ba	Ca	Cd	Co	Cr	Cu	Fe	Hg	Mg	Mn	Ni	P	Pb	S	Sr	Ti	V	Zn
		[mg/kg]	[%]	[mg/kg]		[%]	[mg/kg]				[%]	[mg/kg]	[%]	[mg/kg]		[%]	[mg/kg]	[%]	[mg/kg]			
	Granica oznaczalności *Determination limit*	1	0,01	3	1	0,01	0,5	1	1	1	0,01	0,02	0,01	2	1	0,002	2	0,003	1	5	1	1
Zlewnia Potoku Ożarowickiego *Catchment of the Potok Ożarowicki Stream* n = 108	a	1	0,09	2	10	0,02	<0,5	<1	2	1	0,14	<0,02	0,01	9	1	0,007	7	0,016	1	17	3	12
	b	21	1,76	1129	623	9,09	125,2	69	68	483	7,55	0,60	5,84	6980	50	0,577	2727	1,941	66	241	69	3877
	c	–	0,59	46	177	1,82	10,5	8	14	34	1,87	0,10	0,66	944	12	0,104	260	0,276	24	52	22	785
	d	–	0,50	18	142	1,05	6,1	6	11	20	1,38	0,06	0,27	473	9	0,075	163	0,167	19	46	18	506
	e	–	0,53	19	160	1,10	6,9	6	12	23	1,40	0,08	0,30	507	11	0,087	175	0,198	21	45	20	578
Potok Ożarowicki *Potok Ożarowicki Stream* n = 22	a	<1	0,14	4	41	0,40	1,7	2	3	8	0,37	<0,02	0,11	119	3	0,021	37	0,045	6	30	5	139
	b	2	1,76	181	358	3,14	14,7	15	68	114	3,75	0,30	1,43	3159	50	0,233	562	1,808	47	68	58	1382
	c	–	0,68	47	159	1,41	7,0	7	19	35	1,65	0,12	0,53	762	14	0,089	198	0,338	21	46	20	684
	d	–	0,56	30	137	1,16	5,7	6	14	28	1,32	0,07	0,42	542	11	0,071	154	0,211	18	45	17	561
	e	–	0,61	30	145	1,04	6,4	7	16	30	1,31	0,09	0,43	527	13	0,082	157	0,186	21	45	20	640
Zlewnia zb. Kozłowa Góra *Catchment of the Kozłowa Góra reservoir* n = 75	a	<1	0,06	<3	14	0,02	<0,5	<1	2	<1	0,08	<0,02	0,01	10	<1	0,004	6	0,004	2	17	3	23
	b	1	2,84	178	1621	1,75	59,5	243	31	99	26,48	0,23	0,78	61941	157	0,424	861	2,028	64	118	67	4875
	c	–	0,64	22	217	0,43	14,1	23	10	21	3,41	0,08	0,09	3242	20	0,081	172	0,275	18	50	17	991
	d	–	0,46	10	127	0,27	6,7	7	8	12	1,45	0,06	0,06	461	11	0,044	103	0,124	13	46	12	485
	e	–	0,57	13	150	0,32	10,2	8	10	15	1,63	0,08	0,06	511	13	0,054	137	0,163	16	45	13	669
Rów z Siedlisk *Rów z Siedlisk Ditch* n = 11	a	<1	0,23	3	41	0,39	0,5	2	4	4	0,44	<0,02	0,20	217	3	0,016	24	0,017	5	32	6	80
	b	<1	0,84	35	248	6,44	9,0	10	27	49	7,55	0,14	3,51	3489	20	0,125	241	0,691	57	142	31	933
	c	–	0,46	19	110	2,80	4,5	5	13	24	2,01	0,07	1,42	795	11	0,073	134	0,248	24	59	16	515
	d	–	0,43	16	98	2,30	3,8	5	12	20	1,56	0,06	1,12	566	10	0,062	117	0,143	21	53	14	441
	e	–	0,45	19	93	2,49	4,8	5	13	24	1,58	0,07	1,20	524	10	0,082	143	0,201	22	49	14	537
Tło geochemiczne / *Geochemical background*																						
Osady strumieniowe Europy[1] *Stream sediments of Europe*[1]	e	nd.	5,50 n = 799	6,00 n = 794*	87,5 n = 794*	1,74 n = 801	0,29 n = 797	8,00 n = 794*	22,0 n = 794*	15,0 n = 794*	1,97 n = 794*	0,038 n = 797	0,72 n = 801	453 n = 794*	17,0 n = 794*	0,057 n = 801	14,0 n = 794*	0,0502 n = 794	124 n = 801	3798 n = 801	29,0 n = 794*	59,5 n = 794*
Osady Polski[2] *Sediments of Poland*[2] n = 12 778**	e	<1	nd.	<5	54	0,86	<0,5	3	5	7	0,80	0,05	0,11	274	6	0,059	13	0,040	20	30	7	62
Osady regionu śląsko-krakowskiego[3] *Sediments of Cracow-Silesia region*[3] n = 1459**	e	1	nd.	6	98	0,71	2,5	4	9	15	1,07	0,06	0,13	292	11	0,066	59	0,052	24	42	12	259

a – minimum *minimum* b – maksimum *maximum* c – średnia arytmetyczna *arithmetic mean* d – średnia geometryczna *geometric mean* e – mediana *median* n – liczba próbek *number of samples* [1] Salminen, 2005 [2] Lis, Pasieczna, 1995a [3] Lis, Pasieczna, 1995b

„–" nie obliczono w przypadku, gdy odsetek wyników poniżej granicy oznaczalności przekraczał 50% *not calculated in the case when the percentage of the results below determination limit exceeded 50%* nd. – nie dotyczy *not applicable* * ekstrakcja wodą królewską *aqua regia digestion* ** ekstrakcja kwasem solnym *hydrochloric acid digestion*

Tabela 5
Table

Parametry statystyczne przewodności elektrolitycznej właściwej, odczynu i zawartości pierwiastków chemicznych w wodach powierzchniowych

Statistical parameters of electrolytic conductivity, acidity and chemical elements contents in surface water

Wody powierzchniowe *Surface water*	Parametry *Paramters*	EC	pH	Ag	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K	Li	Mg	Mn	Mo	Na	Ni	P	Pb	SO_4^{2-}	Sb	Se	SiO_2	Sr	Ti	Tl	U	V	Zn
		[mS/cm]	[–]	[µg/dm³]			[mg/dm³]		[µg/dm³]	[mg/dm³]	[µg/dm³]		[mg/dm³]	[µg/dm³]	[mg/dm³]		[µg/dm³]	[mg/dm³]		[µg/dm³]	[mg/dm³]	[µg/dm³]	[mg/dm³]	[µg/dm³]	[mg/dm³]	[µg/dm³]		[mg/dm³]			[µg/dm³]			[mg/dm³]
	Granica oznaczalności *Determination limit*	brak *none*	brak *none*	0,05	0,5	2	0,01	0,001	0,05	0,1	0,05	0,05	0,003	0,05	0,01	0,5	0,3	0,1	0,001	0,05	0,5	0,5	0,05	0,05	1	0,05	2	0,1	0,003	0,002	0,05	0,05	1	0,003
Wody powierzchniowe (wszystkie próbki) *Surface water (all samples)* n = 379	a	0,10	3,71	<0,05	0,9	<2	<0,01	0,028	<0,05	4,5	<0,05	<0,05	<0,003	0,20	<0,01	<0,5	<0,3	0,8	<0,001	<0,05	1	<0,5	<0,05	<0,05	2	<0,05	<2	0,5	0,023	<0,002	<0,05	<0,05	<1	<0,003
	b	2,61	8,56	0,11	3946,9	36	0,60	0,787	0,86	332,9	25,58	225,43	0,008	10,08	127,35	31,5	33,9	211,2	37,474	5,19	265,9	42,7	0,57	53,22	840	2,14	3	26,9	0,869	0,029	1,19	9,74	31	2,904
	c	0,56	6,86	–	272,4	–	0,05	0,146	–	61,0	0,90	3,30	–	1,65	2,84	4,2	3,4	17,0	0,810	0,78	13,5	3,7	–	2,16	69	0,34	–	10,0	0,149	–	0,13	0,70	–	0,136
	d	0,48	6,80	–	47,1	–	0,04	0,128	–	48,4	0,13	0,69	–	1,31	0,32	3,1	2,5	11,8	0,167	0,42	8,6	2,7	–	0,49	43	0,26	–	9,0	0,123	–	0,09	0,28	–	0,030
	e	0,52	7,09	–	25,6	–	0,04	0,129	–	57,0	0,08	0,67	–	1,25	0,33	3,3	2,7	14,7	0,134	0,46	8,9	2,5	–	0,37	55	0,25	–	9,0	0,116	–	0,09	0,33	–	0,025
Strumienie i rowy bez nazwy *Streams and ditches (without a name)* n = 240	a	0,10	3,71	0,03	0,9	1	0,01	0,028	0,03	4,9	0,03	0,03	0,002	0,25	0,01	0,3	0,2	1,0	0,001	0,03	1,0	0,3	0,03	0,03	2	0,03	1	0,5	0,023	0,001	0,03	0,03	1	0,002
	b	2,61	8,56	0,11	3946,9	30	0,60	0,787	0,86	332,9	25,58	225,43	0,006	10,08	127,35	31,5	33,9	211,2	37,474	5,19	265,9	33,7	0,44	38,46	840	2,14	3	26,9	0,869	0,021	1,19	9,74	31	2,904
	c	0,53	6,73	–	355,6	–	0,06	0,152	–	58,1	1,12	3,98	–	1,83	3,12	4,1	3,4	15,5	0,899	0,77	13,2	4,1	–	2,61	69	0,36	–	10,9	0,145	–	0,15	0,67	–	0,165
	d	0,43	6,66	–	68,4	–	0,05	0,130	–	43,5	0,19	0,88	–	1,45	0,38	2,8	2,3	10,1	0,175	0,38	7,7	3,0	–	0,70	41	0,28	–	9,8	0,115	–	0,09	0,22	–	0,047
	e	0,45	6,98	–	59,4	–	0,05	0,130	–	45,5	0,15	1,04	–	1,39	0,40	2,8	2,2	10,6	0,181	0,40	7,8	2,7	–	0,56	47	0,27	–	9,5	0,107	–	0,09	0,17	–	0,038
Sadzawki *Small water pools* n = 20	a	0,14	5,52	<0,05	3,5	<2	0,02	0,036	<0,05	4,5	<0,05	<0,05	<0,003	0,21	<0,01	1,0	0,5	0,8	<0,001	<0,05	1,2	<0,5	<0,05	0,12	3	<0,05	<2	0,7	0,038	<0,002	<0,05	<0,05	<1	<0,003
	b	0,91	7,86	0,06	690,2	36	0,10	0,414	0,60	114,6	10,03	11,38	0,008	6,65	119,58	21,6	10,0	32,4	3,842	3,88	32,8	42,7	0,43	53,22	81	1,95	2	21,1	0,161	0,029	0,43	1,86	11	0,362
	c	0,42	7,01	–	85,6	–	0,05	0,140	–	42,8	–	1,47	–	1,41	7,18	4,6	2,9	11,1	0,703	0,50	10,3	4,0	–	3,58	28	0,32	–	7,1	0,101	–	–	0,31	–	0,035
	d	0,37	6,99	–	32,6	–	0,05	0,107	–	33,5	–	0,46	–	0,88	0,41	3,2	2,2	7,9	0,171	0,22	6,9	1,6	–	0,81	19	0,22	–	5,1	0,092	–	–	0,12	–	0,008
	e	0,40	7,01	–	31,7	–	0,05	0,121	–	40,3	–	0,87	–	0,78	0,65	2,6	2,3	9,5	0,341	0,19	6,2	1,4	–	0,65	18	0,23	–	6,7	0,106	–	–	0,13	–	0,006
Zlewnia Brynicy do zb. Kozłowa Góra *Catchment of the Brynica River to the Kozłowa Góra reservoir* n = 94	a	0,10	3,87	<0,05	5,9	<2	<0,01	0,045	<0,05	4,9	<0,05	<0,05	<0,003	0,56	<0,01	<0,5	0,9	1,0	0,009	<0,05	1,0	0,9	<0,05	<0,05	11	0,07	<2	0,5	0,034	<0,002	<0,05	<0,05	<1	0,004
	b	1,97	8,56	<0,05	3095,9	30	0,60	0,363	0,53	332,9	25,58	23,18	0,004	7,79	39,06	31,5	10,0	211,2	1,655	5,19	66,3	19,2	0,39	26,54	840	2,14	3	22,5	0,864	0,010	0,61	3,46	31	2,904
	c	0,48	6,64	–	470,9	–	0,05	0,132	0,10	52,7	1,46	2,04	–	1,77	1,58	4,1	3,8	14,8	0,190	0,76	10,5	4,1	–	2,62	76	0,35	–	11,0	0,174	–	0,14	0,45	–	0,212
	d	0,40	6,53	–	92,6	–	0,04	0,120	0,05	39,8	0,16	0,93	–	1,40	0,41	3,4	3,2	9,1	0,122	0,39	7,1	3,4	–	0,57	54	0,27	–	9,8	0,135	–	0,09	0,20	–	0,043
	e	0,46	7,11	–	57,8	–	0,04	0,121	<0,05	53,1	0,07	0,75	–	1,11	0,39	3,5	3,2	10,9	0,113	0,61	8,7	3,0	–	0,34	61	0,23	–	9,4	0,140	–	0,08	0,19	–	0,032
Brynica *Brynica River* n = 31	a	0,34	6,73	<0,05	10,7	<2	0,02	0,054	<0,05	42,5	<0,05	0,14	<0,003	0,63	0,15	2,2	1,3	4,3	0,054	0,11	7,2	1,7	<0,05	<0,05	22	0,12	<2	6,7	0,093	<0,002	<0,05	0,07	<1	0,004
	b	0,64	7,66	<0,05	87,8	<2	0,05	0,134	<0,05	70,4	0,48	0,93	–	1,54	0,68	5,0	3,4	18,6	0,172	1,06	16,0	3,7	0,05	0,92	72	0,27	<2	9,4	0,205	<0,002	0,10	0,78	<1	0,084
	c	0,53	7,32	–	23,4	–	0,03	0,107	–	62,1	–	0,40	–	0,99	0,32	3,8	2,7	13,6	0,101	0,67	12,2	2,6	–	0,21	60	0,19	–	8,6	0,166	–	0,07	0,51	–	0,017
	d	0,52	7,32	–	20,9	–	0,03	0,103	–	61,5	–	0,35	–	0,96	0,29	3,7	2,6	12,2	0,096	0,53	11,8	2,5	–	0,15	57	0,19	–	8,5	0,160	–	0,07	0,42	–	0,011
	e	0,56	7,39	–	18,7	–	0,03	0,118	–	65,9	–	0,35	0,003	0,95	0,30	4,2	3,1	16,0	0,105	0,81	12,3	2,6	–	0,12	68	0,19	–	9,0	0,191	–	0,08	0,64	–	0,009
Zlewnia Trzoni *Catchment of the Trzonia Stream* n = 44	a	0,13	3,71	<0,05	0,9	<2	<0,01	0,041	<0,05	7,2	<0,05	<0,05	<0,003	0,20	<0,01	<0,5	0,5	1,2	0,005	<0,05	1,5	0,7	<0,05	<0,05	2	0,06	<2	1,4	0,040	<0,002	<0,05	<0,05	<1	<0,003
	b	0,97	8,30	<0,05	2939,4	14	0,14	0,384	0,33	83,1	5,77	8,22	<0,003	4,62	57,83	9,6	7,4	25,9	5,879	2,11	29,7	4,2	0,23	16,65	97	1,19	<2	21,2	0,282	0,008	0,30	0,64	6	0,539
	c	0,46	7,00	–	210,7	–	0,04	0,130	–	47,1	–	1,65	–	1,02	3,40	2,7	2,0	14,9	0,965	0,40	7,0	1,6	–	1,28	28	0,25	–	8,9	0,117	–	–	0,17	–	0,061
	d	0,42	6,94	–	42,4	–	0,03	0,113	–	42,9	–	0,93	–	0,76	0,95	2,0	1,8	12,6	0,350	0,25	5,3	1,5	–	0,40	16	0,20	–	8,1	0,109	–	–	0,12	–	0,022
	e	0,47	7,17	–	25,7	–	0,04	0,100	–	46,3	–	1,12	–	0,72	1,04	2,0	1,8	16,2	0,394	0,25	4,4	1,5	–	0,35	21	0,18	–	8,5	0,110	–	–	0,15	–	0,026
Trzonia *Trzonia Stream* n = 18	a	0,36	7,06	<0,05	2,9	<2	<0,01	0,082	<0,05	36,1	<0,05	<0,05	<0,003	0,20	0,02	0,6	1,2	10,1	0,040	0,06	2,2	1,0	<0,05	<0,05	2	0,08	<2	3,3	0,090	<0,002	<0,05	<0,05	<1	<0,003
	b	0,66	8,30	<0,05	41,8	3	0,04	0,294	<0,05	78,4	0,55	8,22	<0,003	1,86	3,91	5,1	2,3	22,4	5,879	0,48	7,2	2,0	0,08	0,83	63	0,29	<2	9,2	0,171	<0,002	0,19	0,52	<1	0,067
	c	0,49	7,27	–	17,9	–	0,03	0,126	–	53,7	–	2,09	–	0,75	1,36	2,3	1,9	18,2	1,640	0,26	5,1	1,4	–	0,24	22	0,16	–	7,5	0,128	–	–	0,22	–	0,017
	d	0,49	7,27	–	15,7	–	0,02	0,116	–	52,8	–	1,13	–	0,61	0,76	1,9	1,8	18,0	0,874	0,23	4,8	1,4	–	0,16	12	0,15	–	7,3	0,125	–	–	0,18	–	0,010
	e	0,49	7,20	–	17,4	–	0,03	0,100	–	52,0	–	1,22	–	0,55	0,82	2,0	1,9	18,5	0,851	0,25	4,8	1,5	–	0,16	8	0,16	–	7,9	0,119	–	–	0,16	–	0,010
Zlewnia Czeczówki *Catchment of the Czeczówka Stream* n = 50	a	0,14	4,00	<0,05	3,5	<2	0,01	0,028	<0,05	4,9	<0,05	<0,05	<0,003	0,31	<0,01	0,7	0,5	1,4	0,015	<0,05	1,2	<0,5	<0,05	<0,05	7	0,10	<2	0,7	0,023	<0,002	<0,05	<0,05	<1	<0,003
	b	1,54	7,88	<0,05	2507,9	33	0,34	0,478	0,45	241,4	20,06	225,43	<0,003	9,33	127,35	21,6	33,9	78,5	13,014	4,69	53,4	18,1	0,34	37,93	810	1,39	<2	26,9	0,869	0,008	1,19	9,74	8	2,128
	c	0,70	6,94	–	326,6	4	0,06	0,152	–	78,5	1,03	9,50	–	2,07	6,08	5,0	4,1	25,8	1,003	1,14	9,1	4,4	–	2,75	121	0,34	–	10,1	0,211	–	0,21	1,21	–	0,259
	d	0,61	6,87	–	46,0	2	0,04	0,124	–	60,6	0,14	1,00	–	1,64	0,36	3,7	2,7	18,0	0,197	0,56	5,5	3,1	–	0,36	67	0,27	–	8,4	0,158	–	0,14	0,50	–	0,046
	e	0,74	7,28	–	22,5	2	0,04	0,142	–	83,1	0,08	1,37	–	1,61	0,21	4,1	3,5	27,8	0,139	0,81	4,5	2,7	–	0,24	69	0,26	–	8,9	0,158	–	0,17	1,05	–	0,028
Czeczówka *Czeczówka Stream* n = 22	a	0,14	4,00	<0,05	4,5	<2	0,01	0,064	<0,05	7,8	<0,05	0,08	<0,003	0,72	0,02	0,7	1,0	1,4	0,027	<0,05	1,7	1,3	<0,05	<0,05	7	0,10	<2	6,7	0,044	<0,002	<0,05	<0,05	<1	0,004
	b	1,20	7,45	<0,05	2507,9	33	0,08	0,387	0,45	174,9	20,06	67,80	<0,003	5,32	85,50	8,5	7,8	47,6	8,194	1,79	19,4	18,1	0,11	23,07	573	1,39	<2	20,9	0,643	0,008	0,87	7,20	8	2,128
	c	0,66	6,63	–	523,4	–	0,04	0,151	0,10	70,6	1,68	8,11	–	1,63	6,21	3,9	4,2	25,7	0,769	0,80	6,8	4,7	–	2,79	112	0,30	–	11,0	0,196	–	0,21	1,19	–	0,400
	d	0,57	6,51	–	47,5	–	0,04	0,140	0,05	51,9	0,12	1,41	–	1,40	0,60	3,1	3,8	16,5	0,175	0,49	5,4	3,4	–	0,24	77	0,22	–	10,4	0,149	–	0,15	0,49	–	0,066
	e	0,77	7,23	–	20,8	–	0,04	0,149	0,03	79,5	0,05	2,41	–	1,19	0,77	3,6	4,2	31,0	0,108	0,81	5,9	2,6	–	0,11	72	0,18	–	8,6	0,175	–	0,17	1,14	–	0,034

Tabela 5 **cd.**
Table 5 cont.

Wody powierzchniowe *Surface water*	Parametry *Paramters*	EC	pH	Ag	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K	Li	Mg	Mn	Mo	Na	Ni	P	Pb	SO_4^{2-}	Sb	Se	SiO_2	Sr	Ti	Tl	U	V	Zn
		[mS/cm]	[–]	[µg/dm^3]			[mg/dm^3]		[µg/dm^3]	[mg/dm^3]	[µg/dm^3]		[mg/dm^3]	[µg/dm^3]	[mg/dm^3]		[µg/dm^3]	[mg/dm^3]		[µg/dm^3]	[mg/dm^3]	[µg/dm^3]	[mg/dm^3]	[µg/dm^3]	[mg/dm^3]	[µg/dm^3]		[mg/dm^3]			[µg/dm^3]			[mg/dm^3]
	Granica oznaczalności *Determination limit*	brak *none*	brak *none*	0,05	0,5	2	0,01	0,001	0,05	0,1	0,05	0,05	0,003	0,05	0,01	0,5	0,3	0,1	0,001	0,05	0,5	0,5	0,05	0,05	1	0,05	2	0,1	0,003	0,002	0,05	0,05	1	0,003
Zlewnia Potoku Ożarowickiego *Catchment of the Potok Ożarowicki Stream* n = 112	a	0,14	5,52	<0,05	0,9	<2	<0,01	0,040	<0,05	4,5	<0,05	<0,05	<0,003	0,51	<0,01	<0,5	<0,3	0,8	<0,001	0,06	2,2	<0,5	<0,05	<0,05	3	<0,05	<2	1,8	0,043	<0,002	<0,05	<0,05	<1	<0,003
	b	2,61	7,85	0,06	690,2	36	0,11	0,394	0,60	190,1	13,26	25,55	0,008	6,65	119,58	25,3	9,3	57,8	18,526	4,45	265,9	42,7	0,57	53,22	284	1,95	–	22,9	0,600	0,029	0,87	4,15	11	0,985
	c	0,77	7,02	–	43,1	–	0,04	0,155	–	83,9	0,51	1,26	–	1,59	2,24	5,3	2,8	22,6	0,634	1,08	23,1	2,7	–	1,13	85	0,37	–	8,6	0,148	–	0,14	1,26	–	0,053
	d	0,70	7,01	–	18,4	–	0,03	0,144	–	75,5	0,09	0,24	–	1,42	0,09	3,4	2,0	19,1	0,091	0,72	16,9	1,9	–	0,35	68	0,28	–3	8,0	0,133	–	0,12	0,83	–	0,018
	e	0,77	7,07	–	18,2	–	0,03	0,147	–	84,2	0,06	0,21	–	1,36	0,05	3,9	1,9	22,1	0,070	0,81	21,0	1,8	–	0,29	71	0,29		8,4	0,139	–	0,11	1,34	–	0,014
Potok Ożarowicki *Potok Ożarowicki Stream* n = 23	a	0,66	5,94	<0,05	10,4	<2	0,02	0,089	<0,05	62,2	<0,05	<0,05	<0,003	0,95	0,01	1,8	0,8	14,3	0,021	0,08	19,7	1,1	<0,05	0,11	79	0,14	<2	2,9	0,128	<0,002	0,08	<0,05	<1	0,006
	b	1,07	7,72	<0,05	64,5	6	0,05	0,190	0,14	101,9	5,09	3,99	<0,003	3,46	0,80	8,7	6,1	29,6	2,618	1,92	39,2	11,9	0,07	1,60	177	0,96	<2	10,0	0,429	<0,002	0,18	1,58	<1	0,270
	c	0,82	6,91	–	24,1	3	0,03	0,150	–	85,3	–	0,51	–	1,58	0,10	4,8	3,6	23,7	0,279	1,33	26,0	2,9	–	0,40	115	0,46	–	7,8	0,189	–	0,12	1,10	–	0,039
	d	0,82	6,89	–	22,2	2	0,03	0,149	–	84,4	–	0,12	–	1,48	0,05	4,4	3,3	23,3	0,060	1,03	25,5	2,2	–	0,26	112	0,41	–	7,5	0,176	–	0,11	0,90	–	0,018
	e	0,81	7,01	–	21,3	3	0,03	0,148	–	91,2	–	0,08	–	1,37	0,03	4,8	3,7	24,6	0,036	1,41	23,9	1,8	–	0,19	111	0,45	–	8,7	0,150	–	0,10	1,32	–	0,012
Zlewnia zb. Kozłowa Góra *Catchment of the Kozłowa Góra reservoir* n = 77	a	0,12	4,90	<0,05	5,3	<2	0,02	0,046	<0,05	6,8	<0,05	0,06	<0,003	0,21	<0,01	0,5	<0,3	1,1	0,002	<0,05	2,3	1,0	<0,05	<0,05	2	0,11	<2	2,2	0,032	<0,002	<0,05	<0,05	<1	<0,003
	b	1,30	7,82	0,11	3946,9	21	0,12	0,787	0,86	98,9	15,75	64,63	0,006	10,08	38,57	10,4	11,7	23,3	37,474	3,90	66,3	33,7	0,39	38,46	107	1,72	<2	21,1	0,285	0,021	0,44	2,68	15	1,348
	c	0,35	6,75	–	336,1	–	0,06	0,155	–	34,7	1,03	4,75	–	1,63	2,85	3,2	4,0	7,1	1,609	0,37	9,3	5,5	–	2,92	31	0,32	–	11,5	0,098	–	0,09	0,17	–	0,127
	d	0,31	6,71	–	81,9	–	0,06	0,126	–	29,9	0,21	1,49	–	1,25	0,75	2,8	3,2	5,9	0,364	0,23	7,1	4,1	–	0,86	23	0,27	–	10,6	0,091	–	0,06	0,09	–	0,039
	e	0,33	6,95	–	72,5	–	0,06	0,119	–	34,2	0,17	1,64	–	1,12	0,76	2,8	3,0	6,4	0,402	0,23	6,9	3,4	–	0,90	27	0,27	–	10,5	0,101	–	0,07	0,10	–	0,040
Rów z Siedlisk *Rów z Siedlisk Ditch* n = 16	a	0,44	6,93	<0,05	6,7	<2	0,03	0,086	<0,05	43,3	<0,05	0,18	<0,003	0,84	0,02	6,8	2,7	14,1	0,043	0,97	11,2	1,5	<0,05	<0,05	45	0,13	<2	5,9	0,092	<0,002	<0,05	0,53	<1	<0,003
	b	1,10	7,76	<0,05	31,7	9	0,07	0,164	<0,05	110,2	0,14	1,00	<0,003	2,12	0,88	10,9	9,3	45,5	1,031	2,39	39,6	3,3	0,57	1,53	137	0,56	<2	9,8	0,245	<0,002	0,28	2,10	<1	0,015
	c	0,82	7,29	–	16,5	–	0,05	0,124	–	85,2	–	0,43	–	1,40	0,20	9,0	6,2	32,8	0,251	1,57	23,5	2,4	–	0,44	93	0,32	–	8,2	0,165	–	0,13	1,43	–	0,006
	d	0,79	7,28	–	15,6	–	0,05	0,121	–	80,4	–	0,35	–	1,34	0,10	8,9	5,8	30,1	0,144	1,52	21,2	2,3	–	0,19	86	0,28	–	8,0	0,156	–	0,12	1,28	–	0,004
	e	0,93	7,33	–	15,5	–	0,05	0,130	–	99,4	–	0,28	–	1,24	0,08	9,1	6,8	37,0	0,101	1,46	26,7	2,4	–	0,13	106	0,27	–	8,8	0,171	–	0,14	1,68	–	0,006
Wartości graniczne wskaźników jakości wód powierzchniowych z grupy specyficznych substancji zanieczyszczających[1)] *Limit values for surface water quality indicators from the group of specific pollutants [1)]*																																		
I i II klasa[1)] *Classes I and II [1)]*		nd.	nd.	≤5	≤400	≤50	≤2	≤0,5	≤0,8	nd.	nd.	≤50	≤0,05	≤50	nd.	nd.	nd.	nd.	nd.	≤40	nd.	nd.	nd.	nd.	nd.	≤2	≤20	nd.	nd.	≤0,05	≤2	nd.	≤50	≤1
Środowiskowe normy jakości dla wskaźników stanu chemicznego jednolitych części wód powierzchniowych[2)] *Environmental quality standards for chemical status indicators of uniform part of the surface water[2)]*																																		
Maksymalne dopuszczalne stężenie[2)] *Maximum allowable concentration[2)]*		nd.	nd.	nd.	nd.	nd.	nd.	nd.	nd.	nd.	0,45 (klasy 1 i 2) *(class 1 and 2)*; 0,6 (klasa 3) *(class 3)*; 0,9 (klasa 4) *(class 4)*; 1,5 (klasa 5) *(class 5)*	nd.	nd.	nd.	nd.	nd.	nd.	nd.	nd.	nd.	nd.	34	nd.	14	nd.	nd.	nd.	nd.	nd.	nd.	nd.	nd.	nd.	nd.

a – minimum *minimum* b – maksimum *maximum* c – średnia arytmetyczna *arithmetic mean* d – średnia geometryczna *geometric mean* e – mediana *median* n – liczba próbek *number of samples* „–" nie obliczono w przypadku, gdy odsetek wyników poniżej granicy oznaczalności przekraczał 50% *not calculated in the case when the percentage of the results below determination limit exceeded 50%* nd. – nie dotyczy *not applicable*

[1)] Zgodnie z załącznikiem nr 26 do rozporządzenia Ministra Infrastruktury (Rozporządzenie…, 2021)
In accordance with Annex 26 of the Regulation of the Minister of Infrastructure

[2)] Zgodnie z załącznikiem nr 14 do rozporządzenia Ministra Infrastruktury (Rozporządzenie…, 2021)
In accordance with Annex 14 of the Regulation of the Minister of Infrastructure

RESEARCH RESULTS

SOILS

Soil is one of the main elements of the environment and the most superficial part of the Earth's crust. Its origin is related to the effects of weathering, biological and microbiological factors. It is characterized by filtering and buffering properties that prevent trace elements from excessive penetration into other environmental components. In the soil, some compounds and toxic substances undergo processes of decomposition into less toxic or non-toxic substances under certain environmental conditions (Kabata-Pendias, Pendias, 1999).

Grain size composition. The study adopted the division of soil particles into grain size groups according to the standard BN-78/9180-11, which was in force until 2008. Reference to this standard results from the need to maintain it for the continuation of the project that has been carried out continuously for several years in accordance with the instruction for the compilation of The Detailed Geochemical Map of Upper Silesia, scale 1:25,000. The grain size analysis involved the following grain size groups: 1.0–0.1 mm (sand fraction), 0.10–0.02 mm (silt fraction) and <0.02 mm (clay fraction) (Pls. 4–6). Changing the ranges of grain size groups in accordance with the guidelines of the Polish Soil Association (Klasyfikacja..., 2008) would make it difficult to compare the grain size composition with data from map sheets developed earlier.

Grain size composition is genetically related to the bedrock lithology. The soils of the northern part of the map sheet developed on Quaternary glacial sands and gravels. In that area, the sand fraction predominates. An increased proportion of the silt and clay fractions was found in samples taken from soils developed on Triassic carbonates (south-eastern part) (Pls. 4–6).

The pH. The pH of the topsoil layer (0.0–0.3 m) depends largely on the nature of its management. In forested areas, very acidic (pH<5.0) or acidic (pH 5.0–6.0) soils predominate (Pl. 7). Slightly acidic (pH 6.1–6.7), neutral (pH 6.8–7.4) or alkaline (pH > 7.4) soils are typically found in soils of wastelands and fallows, cultivated fields, and grasslands. These soils occur mainly on outcrops of Triassic carbonates. A significant area of alkaline soils (pH > 7.4) is located in the central part of the map sheet and in a strip between the villages of Tąpkowice and Sadowie. The pH of the subsoil layer (depth 0.8–1.0 m) is closely dependent on geological factors. Alkaline soils (pH > 7.4) predominate on the outcrops of Triassic carbonates. Neutral soils (pH 6.8–7.4) are genetically related to the occurrence of Quaternary glacial sands and gravels (Pl. 8).

Geochemistry. The concentrations of elements analysed in soil samples collected from the map sheet area occasionally exceed the geochemical background value of the Silesian-Cracow region, determined by Lis and Pasieczna (1995b; Tab. 2). Taking into account median values calculated for all topsoil samples, exceedances were recorded for arsenic (by 240%), barium (119%), cadmium (162%), copper (114%), lead (189%), sulphur (133%), titanium (136%) and zinc (136%).

The spatial distribution of the contents of individual elements in the soils shows a clear relationship with the bedrock geology (Pl. 1), especially in the subsoil layer (0.8–1.0 m). It is observed in the southern part of the study area, where outcrops of Triassic carbonates, especially limestones and dolomites, occur. The elements whose higher contents in the soils are related largely to the bedrock geology are aluminium, barium, calcium, cadmium, cobalt, chromium, iron, magnesium, manganese, nickel, lead, strontium, vanadium and zinc.

The influence of bedrock lithology is also observed when analysing the proportion of total organic carbon (TOC) in the topsoil layer. Soils that formed on Triassic alkaline carbonates are characterized by a lower content of total organic carbon (<3%). This applies mainly to the central part of the map sheet, the areas extending south of Dąbrówka and Zendek, and the southern part of the study area. Naturally elevated total organic carbon contents (6–24%) are found in soils of wet river valleys filled with alluvial muds and peats in the northern and western parts of the map sheet, which may be controlled by humidity conditions (Rawls *et al.*, 2003). In areas of higher organic carbon content (>24%), simultaneously elevated contents of arsenic, barium, calcium, cadmium, copper, mercury, phosphorus, lead, sulphur, strontium, vanadium and zinc were found. The content of C_{org} in soils is also influenced by the way of their use. The median content of this component in forest soils is 2.75%, while in soils of arable field it is 1.27%.

The spatial distributions of cadmium, lead and zinc contents are similar. Elevated concentrations of these elements (cadmium >8 mg/kg, lead > 250 mg/kg, zinc >1,000 mg/kg) in both soil levels were found in outcrop areas of Triassic deposits (mainly in the south-eastern part of the map sheet). These are also observed in the valleys of watercourses.

A point anomaly of lead (4,907 mg/kg) occurs north-east of Pyrzowice near the village of Siedliska. It is found in the topsoil layer of anthropogenic soil. High levels of silver (14 mg/kg), arsenic (601 mg/kg), calcium (4.04%), cadmium (32.4 mg/kg), iron (5.19%) and zinc (8,159 mg/kg) are also recorded at this site.

In the vicinity of Celiny (near the motorway), in anthropogenic soil too, geochemical anomalies of copper (>80 mg/kg) are present in both soil levels sampled. They show maximum concentrations of this element (478 mg/kg in soil from 0.0–0.3 m depth, and 711 mg/kg in the deeper layer) recorded in the entire map sheet area. Elevated contents of silver, arsenic, cadmium, calcium, magnesium, sulphur and lead are also observed here.

High arsenic concentrations (>10 mg/kg and in places 20 mg/kg) in soils from the topsoil level, especially in the southern part of the study area, may be related to the significant proportion of silt and clay fractions in these soils (Pls. 5, 6). The highest concentrations of this metal are thought to occur in soils containing higher levels of the clay fraction and in organic soils (Kabata-Pendias, Pendias, 1999; Lombi *et al.*, 2000; Karczewska *et al.*, 2010). Arsenic anomalies in the topsoil layer are found along the valleys of the Brynica, Trzonia, and Potok Ożarowicki and its left-hand tributary near the village of Ogrodzonki. These are floodplains covered by meadows. The valleys are lined largely with Holocene alluvial muds. Relatively high concentrations of arsenic (>160 mg/kg) are observed in the vicinity of the Pyrzowice motorway junction and near Siedliska.

Barium anomalies in the topsoil layer, above 120 mg/kg, were found in the valleys of the Brynica River, the watercourse flowing from the western boundaries of the Katowice International Airport to Kolonia Oparowe, the Potok Ożarowicki, and Dopływ spod Siemoni, in the airport area, and near Kolonia Folwarczna. The influence of bedrock lithology on the spatial distribution of barium content is evident at the 0.8–1.0 m depth level and coincides with the outcrops of Triassic carbonates. Point anomalies of barium were found in the vicinity of Kolonia za Przysiekami, in the fork of the Czeczówka River and its right-hand tributary, and in the area of the "Katowice" International Airport. At these locations, the concentrations of this element exceed 480 mg/kg.

The distribution of iron content in the topsoil layer of the northern part of the map sheet shows similarity to the geochemical pattern of other elements, such as arsenic, barium, cadmium, phosphorus, strontium and zinc. Increased contents of these elements relative to the background value of the Silesian–Cracow region were found in soils of the valleys of the Brynica and Trzonia, a watercourse draining from the western boundaries of the "Katowice" International Airport, and the Potok Ożarowicki and its left-hand tributary flowing from near the village of Ogrodzonki.

A point anomaly of mercury in soils from the 0.0–0.3 m depth level was found along the railway line between Siedliska and the village of Łubne, where its maximum concentration for the map sheet area is 2.44 mg/kg. A transport depot, serving domestic and international truck traffic, and a company that trades scrap metal and batteries, are located at this site. Within the mercury anomaly, an elevated copper concentration, above 20 mg/kg, is also observed.

The spatial distribution of calcium content, especially at a depth of 0.8–1.0 m, is related to the bedrock lithology and coincides with the outcrops of Triassic carbonates. Magnesium shows anomalies in the topsoil layer in the central part of the map sheet and in the regions of Sączów and Siemonia. In samples collected from 0.8–1.0 m depth, elevated contents of this element (>1%) were found south of Zendek, between Kolonia pod Brynicą and Siedliska, and near Sączów and Siemonia.

The contents of phosphorus indicate its anthropogenic origin, especially in the topsoil layer. Higher contents of this element are found in extensive areas used for agriculture than in those covered by forests. The median phosphorus content is 0.036% in arable fields, 0.034% in grasslands, 0.033% in wasteland and fallow land, and 0.017% in forests. This is related most likely to the fertilization of soils with phosphates and possible uncontrolled discharge of municipal wastewater. In addition, phosphorus contents in excess of 0.120% were measured in soil samples of stream valleys in the northern part of the map sheet. Distinct geochemical anomalies of phosphorus were also found in the north-eastern part of the area, near the village of Zendek, and in the north-eastern corner of the map sheet.

The widespread occurrence of arsenic, cadmium, lead and zinc compounds in soils, from which they can migrate into the water, is the cause of many diseases of humans in different countries around the world (Kabata-Pendias, Mukherjee, 2007; Kabata-Pendias, Szteke, 2015). Due to the ease of accumulation and harmful effects of excess of these elements on plants and soil microorganisms, and consequently on human health, the amount of the map sheet area contaminated to varying degrees with these elements has been estimated (Tab. 6). Soils contaminated by arsenic cover only a small area within the map sheet. Its harmful concentration (>100 mg/kg) was found in the area occupied by 0.70% of soils from both the

Tabela 6
Table

Udział obszarów zajmowanych przez gleby o różnych zawartościach arsenu, kadmu, cynku i ołowiu na głębokości 0,0–0,3 m i 0,8–1,0 m

The share of areas occupied by soils with different arsenic, cadmium, lead and zinc content in topsoil (0.0–0.3 m) and subsoil (0.8–1.0 m)

Pierwiastek *Element*	Zawartość *Content* [mg/kg]	Gleba *Soil* 0,0–0,3 m		0,8–1,0 m	
		[km²]	[%]*	[km²]	[%]*
As	<10	64,07	77,66	66,78	80,95
	10–25	13,76	16,68	10,72	12,99
	25–50	3,26	3,95	3,12	3,78
	50–100	0,83	1,01	1,30	1,58
	>100	0,58	0,70	0,58	0,70
Cd	<2	40,45	49,03	71,33	86,46
	2–5	29,38	35,61	6,76	8,19
	5–10	8,70	10,55	2,34	2,84
	10–15	2,69	3,26	0,65	0,79
	>15	1,28	1,55	1,43	1,73
Pb	<100	51,59	62,53	74,77	90,64
	100–200	21,19	25,68	4,09	4,96
	200–500	8,77	10,63	2,40	2,91
	500–600	0,51	0,62	0,39	0,47
	>600	0,45	0,54	0,85	1,02
Zn	<300	63,30	76,73	70,48	85,43
	300–500	8,64	10,47	4,09	4,96
	500–1000	7,68	9,31	4,35	5,28
	1000–2000	2,37	2,87	2,08	2,52
	>2000	0,51	0,62	1,50	1,81

* 82,5 km² = 100%

Tabela 7
Table

Ocena zanieczyszczenia gleb z głębokości 0,0–0,3 m ze względu na zawartości wybranych pierwiastków potencjalnie toksycznych

Assessment of topsoil (0.0–0.3 m) contamination according to the content of selected potentially toxic elements

Pierwiastek *Element*		Grupa I *Group I*	Grupa II* *Group II*	Grupa III *Group III*	Grupa IV *Group IV*	Pozostałe** *Other*
As	1	<25	<10	<50	<100	>100
	2	1216	1001	1267	1280	9
	3	94,34%	77,66%	98,29%	99,30%	0,70%
Ba	1	<400	<200	<1000	<1500	>1500
	2	1280	1202	1288	1289	0
	3	99,30%	93,25%	99,92%	100,00%	0,00%
Cr	1	<200	<150	<500	<1000	>1000
	2	1288	1288	1289	1289	0
	3	99,92%	99,92%	100,00%	100,00%	0,00%
Zn	1	<500	<300	<1000	<2000	>2000
	2	1124	989	1244	1281	8
	3	87,20%	76,73%	96,51%	99,38%	0,62%
Cd	1	<2	<2	<10	<15	>15
	2	632	632	1227	1269	20
	3	49,03%	49,03%	95,19%	98,45%	1,55%
Co	1	<50	<20	<100	<200	>200
	2	1289	1286	1289	1289	0
	3	100,00%	99,77%	100,00%	100,00%	0,00%
Cu	1	<200	<100	<300	<600	>600
	2	1287	1286	1288	1289	0
	3	99,84%	99,77%	99,92%	100,00%	0,00%
Ni	1	<150	<100	<300	<500	>500
	2	1289	1289	1289	1289	0
	3	100,00%	100,00%	100,00%	100,00%	0,00%
Pb	1	<200	<100	<500	<600	>600
	2	1137	806	1274	1282	7
	3	88,21%	62,53%	98,84%	99,46%	0,54%
Hg	1	<5	<2	<10	<30	>30
	2	1289	1288	1289	1289	0
	3	100,00%	99,92%	100,00%	100,00%	0,00%

1 – dopuszczalne zawartości substancji powodujących ryzyko z podziałem na grupy gruntów przyjęte za Rozporządzeniem Ministra Środowiska z dnia 1 września 2016 r.
permissible contents of substances causing risk, divided into soil groups, adopted according to the Regulation of the Minister of Environment of September 1, 2016

2 – liczba próbek spełniających kryteria dla poszczególnych grup gruntów
number of samples meeting the criteria for individual soil groups

3 – udział procentowy próbek (w stosunku do całkowitej liczby *n*) spełniających kryteria dla poszczególnych grup gruntów
percentage of samples (in relation to the total number n) meeting the criteria for individual soil groups

* – wartości przyjęte dla grupy II-1 (wartości najniższe)
values adopted for group II-1 (lowest values)

** – nie spełniające wymogów dla żadnej z grup
not meeting the requirements for any of the groups

topsoil layer and at a depth of 0.8–1.0 m. In the 0.0–0.3 m depth layer, the area occupied by soils contaminated with cadmium (>15 mg/kg) is 1.55%, with lead (>600 mg/kg) – 0.54%, and with zinc (>2,000 mg/kg) – 0.62%. At a depth of 0.8–1.0 m, there is an increase in the proportion of soils contaminated with these elements: to 1.73% for cadmium, to 1.02% for lead, and to 1.81% for zinc, which may indicate a relationship between these metals and the bedrock geology, as well as their long-term downward migration.

In order to assess the degree of contamination of soils from the 0.0–0.3 m depth layer with toxic element, reference was made to the limit values provided in the Regulation of the Minister of the Environment on the manner of conducting the assessment of contamination of the Earth surface (Rozporządzenie..., 2016). According to the contents of arsenic, barium, chromium, zinc, cadmium, cobalt, copper, nickel, lead and mercury, the requirements for groups I–III (residential and other built-up areas, including built-up agricultural land, arable land and forests) are met by 95.19 to 100% of the analysed soil samples. The requirements for soil group IV (industrial land, mining areas, communication land) were met by 0.08 to 3.26% of the samples. The remaining percentage of soil samples (0.54 to 1.55%) does not meet the requirements for any of the categories (Tab. 7). An example of the assessment of soil quality (in cartographic form) as regards the permissible cadmium content (Rozporządzenie..., 2016) is presented in the map of the distribution of the content of this element (Pl. 63). This analysis does not take into account the stages and method of research on soil contamination, set out in Rozporządzenie (2016).

AQUATIC SEDIMENTS

Most of the heavy metals and other toxic substances harmful to living organisms and to the environment, which are supplied to surface waters, are deposited in aquatic sediments. Among inorganic pollutants accumulated in alluvial deposits, heavy metals, such as cadmium, mercury and chromium, pose a particular risk (Bojakowska, Gliwicz, 2003; Helios-Rybicka *et al*., 2005; Siebielec *et al*., 2015). Trace elements and other substances, which are subject to environmental studies, are incorporated into the geochemical cycle largely as a result of human economic activities, and their high contents are associated with numerous sources of pollution. The point sources of pollution include controlled and uncontrolled discharges of municipal wastewater, wastewater generated from the dewatering of pits during extraction and processing of raw materials, as well as wastewater from industrial production and that generated by agricultural activity. Deposition from the atmosphere (*e.g.* lead, mercury), and surface runoff from urbanized and agricultural areas, associated with large areal impacts, which is responsible for pollution by arsenic, mercury and pesticides, are indicated as non-point sources of pollution (Bojakowska, 2001).

Within the map sheet boundaries, sediments of watercourses and water bodies were studied within the following catchments: Brynica River to the Kozłowa Góra reservoir, Trzonia and Czeczówka streams, Potok Ożarowicki stream, Przeczyce reservoir, Kozłowa Góra reservoir, and Brynica River from the Szarlejka to Rawa (Fig. 3). In characterizing the study results, reference was made to the geochemical background values for the Silesian-Cracow region (according to Lis, Pasieczna, 1995b), and to the *Probable Effect Concentration* (PEC) values determined by MacDonald *et al.* (2000), above which harmful effects of the element on aquatic organisms are observed. The PEC index takes on the following values: arsenic – 33 mg/kg, cadmium – 4.98 mg/kg, chromium – 111 mg/kg, copper – 149 mg/kg, lead – 128 mg/kg, mercury – 1.06 mg/kg, nickel – 48.6 mg/kg, and zinc – 459 mg/kg.

The study area included in **the catchment of the Brynica River to the Kozłowa Góra reservoir** is located in the north-western part of the map sheet. It covers

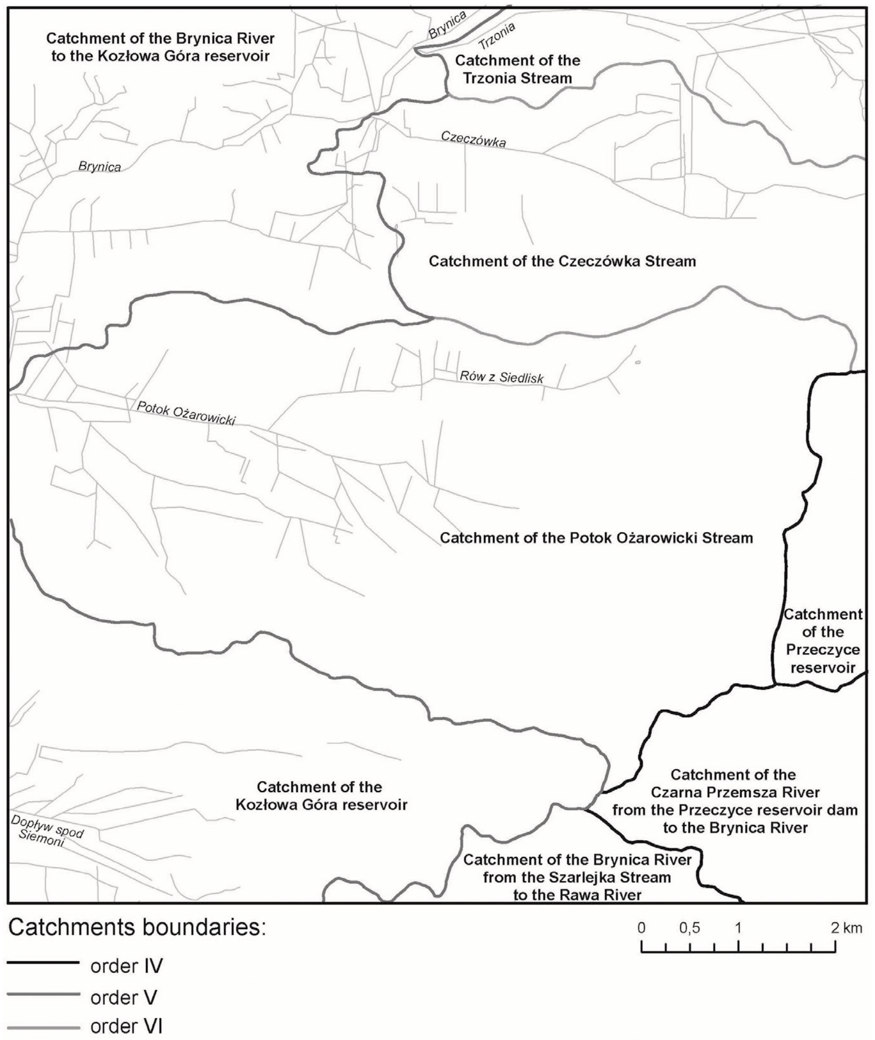

Fig. 3. Location of watercourses and catchments (after Hydroportal)

mostly forests, meadows, and arable fields. Most of the aquatic sediment samples were collected for study from forests and meadows, with smaller numbers taken from wasteland and fallow land. Within the map sheet, the catchment area is covered mainly by Pleistocene glacial sands and gravels; the valley bottoms of the Brynica River and its tributaries are lined by Quaternary deposits of floodplain terraces. Sediments of overflood terraces occur along the watercourse valleys, whereas Holocene alluvial muds of valley bottoms are found in the valley of a stream flowing between the villages of Kolonia Niwy and Kolonia Oparowe. In the southern part of the catchment and in a small area near the western edge of the map sheet, Triassic limestones are exposed.

Comparing the calculated median values for sediment samples from the studied catchment to the geochemical background values of the Silesian–Cracow region (according to Lis, Pasieczna, 1995b), exceedances were observed for arsenic (by 183%), lead (107%), sulphur (252%) and zinc (138%) (Tab. 4). These elements can be transported by watercourses from polluted catchments. Very high lead contaminations (>6,400 mg/kg) in aquatic sediments were found during an earlier study (Lis, Pasieczna, 1995a, b) north-east of Zendek. The maximum contents of calcium (15.51 %), strontium (232 mg/kg) and titanium (283 mg/kg) determined in the catchment sediments concurrently represent the highest concentrations of these elements in the whole map sheet area. One of the probable sources of these elements in the aquatic sediments is surface runoff.

Within the catchment area, exceedances of the PEC index for arsenic, cadmium, nickel, lead and zinc are recorded. The highest number of samples exceeding the PEC threshold was determined for arsenic (nearly half of the samples) and zinc (35 samples).

Catchment of the Trzonia Stream. The catchment covers a small, north-eastern part of the Pyrzowice map sheet. In terms of land use, it is dominated by grassland, forests, arable fields and wastelands. Surface deposits of the catchment are represented mainly by Pleistocene glacial sands and gravels, Pleistocene sediments of overflood terraces, and Triassic carbonates exposed in the central part of the catchment area. The Trzonia valley bottom is composed of Quaternary sands, gravels and muds of floodplain terraces, while the valleys of the Trzonia's left-hand tributaries are lined by Holocene alluvial muds. Over small areas of the catchment, Quaternary aeolian sands are also found.

The medians greater than the regional background levels were observed for arsenic (by 283%), cadmium (248%), iron (137%), phosphorus (130%), sulphur (252%) and zinc (169%) (Tab. 4). Analysis of the results shows that some of the samples contained higher amounts of arsenic, cadmium, lead and zinc in relation to their PEC values. The greatest number of exceedances was recorded for cadmium (more than half of the samples).

Catchment of the Czeczówka Stream. The catchment covers the north-eastern part of the map sheet between Pyrzowice and Dąbrówka and the village of Ostrowy. "Katowice" International Airport is also located within the catchment area. The catchment area is represented mainly by grassland (meadows) and forests, and to a lesser extent by wastelands, fallow land and arable fields. Glaciofluvial sands and gravels are the main lithologies found at the surface. Triassic limestones are exposed in its southern part, and Triassic dolomites, marls and marly claystones occur over a small area in the north. The Czeczówka Stream valley is filled with Quaternary alluvial muds and sediments of floodplain terraces.

The geochemical background of the Silesian–Cracow region (Tab. 4), expressed by median values, is exceeded in the case of arsenic (by 217%), cadmium (192%), copper (113%), magnesium (123%), lead (146%), sulphur (292%) and zinc (189%). The concentrations of arsenic, cadmium, lead and zinc of some of the samples were higher than their PEC thresholds. The greatest number of samples (nearly half) showing values exceeding the threshold was found for cadmium and zinc.

Catchment of the Potok Ożarowicki Stream. This catchment covers the largest area of the Pyrzowice map sheet (approx. 30.39 km^2) and is located in its central part. The area is represented almost entirely by agricultural land (arable fields, meadows), as well as by wasteland and fallow land. Small areas are occupied by residential, industrial and service functions (car parks at the International Airport "Katowice" in Pyrzowice). Forests occur in the northeast and over small areas scattered in the central and northern parts of the catchment. The northern and central parts of the catchment area are covered by Pleistocene glaciofluvial sands and gravels, while the southern area is composed of Triassic carbonates. The valleys of the Potok Ożarowicki, its left-hand tributaries, and partly of the Rów z Siedliska ditch are covered by Quaternary sediments of floodplain terraces and Holocene alluvial muds of valley bottoms.

Sediments of the catchment of the Potok Ożarowicki Stream show the highest concentrations of silver (21 mg/kg), arsenic (1,129 mg/kg), chromium (68 mg/kg), copper (483 mg/kg), mercury (0.60 mg/kg) and lead (2,727 mg/kg) recorded in the map sheet area. The medians of most of the analysed elements indicate that the regional geochemical background values are exceeded. This is particularly true for arsenic, for which an exceedance of 317% was recorded, barium (163%), calcium (155%), cadmium (276%), cobalt (150%), chromium (133%), copper (153%), iron (131%), mercury (133%), magnesium (231%), manganese (174%), phosphorus (132%), lead (297%), sulphur (381%), titanium (107%), vanadium (167%) and zinc (223%). Analysis of the results shows that more than half of the sediment samples contain higher amounts of cadmium, lead and zinc than the PEC limits.

Catchment of the Kozłowa Góra reservoir is located in the south-western part of the Pyrzowice map sheet. This catchment encompasses localities such as Przełajka, Podsączów, Łubianki, Kalinowa and Siemonia. The land use structure of the catchment includes agricultural land (meadows, arable fields), wasteland and fallow land, as well as forests. The central and south-western parts of the catchment area are composed of Pleistocene glaciofluvial sands and gravels, while in the eastern and northern parts, Triassic carbonates are exposed. In addition, Triassic sands, sandstones, clays, claystones and mudstones occur in these areas.

For most of the elements determined (arsenic, barium, cadmium, cobalt, chromium, iron, mercury, manganese, nickel, lead, sulphur, titanium, vanadium and zinc), the median values are higher than the geochemical background of the region (Tab. 4). The greatest levels of iron (26.48%), manganese (61,941 mg/kg) and nickel (157 mg/kg) in the sediments of the catchment are also the maximum ones for the map sheet area. More than half of the sediment samples show exceedances of the PEC for cadmium, lead and zinc. In the case of arsenic and nickel, the number of samples with exceeded concentration limits was lower.

Catchment of the Przeczyce reservoir. The analysed portion of the catchment occupies the eastern area of the map sheet. It is a small area where the villages of Łubne, Mierzęcice and Sadowe Pierwsze are located. A single sample of pond sediment was collected from the catchment. The elemental concentrations were below the regional geochemical background level. There was no exceedance of the PEC value for any of the elements determined.

Catchment of the Brynica River from the Szarlejka Stream to the Rawa Stream. This is a small area covering part of the villages of Siemonia and Twardowice in the south of the map sheet. During fieldwork, a single sediment sample was taken from a stream close to its source. The geochemical background of the region was exceeded for chromium (by 111%), arsenic (117%) and titanium (293%). The concentrations of cadmium (2.2 mg/kg), lead (69 mg/kg) and zinc (202 mg/kg) were higher than their PEC thresholds.

SURFACE WATERS

The greatest threat to the surface water quality in the Silesian Voivodeship is posed by industry, the discharge of untreated sewage, pollution resulting from agricultural activity and from fishponds, and the dumping of waste. All these have a significant impact on both human health and the proper functioning of aquatic ecosystems (Stan środowiska..., 2020). In the course of the study, the contents of selected chemical components, specific electrolytic conductivity, and pH were determined in water samples. The ranges of their values and the statistical parameters are presented in Table 5. For comparison, it also includes the values of surface water quality indicators used in Poland (Rozporządzenie..., 2021).

Within the map sheet boundaries, water samples were analysed from the following catchment: Brynica River to the Kozłowa Góra reservoir, Trzonia Stream, Czeczówka Stream, Potok Ożarowicki Stream, Przeczyce reservoir, Kozłowa Góra reservoir and Brynica River from the Szarlejka Stream to the Rawa River (Fig. 3).

Catchment of the Brynica River to the Kozłowa Góra reservoir. The pH values of the catchment's waters range from 3.87 to 8.56, attaining a maximum for the entire map sheet area of 8.56. Low pH values, often below pH 5.00, were found in the watercourses of forested areas, indicating their acidity resulting from the presence of high organic matter contents. The waters of the Brynica River are alkaline, with pH ranging from 7.00 to 8.00. This may be due to surface runoff of rainwater from agricultural land, and the presence of high calcium concentrations in the bedrock (Pls. 20, 21) In the case of four water samples taken from a stream flowing out of the airport area, the pH values are in excess of 8.00. This may be related to the operation and maintenance of the airport itself (Polkowska, Błaś, 2010; Kowalska, Grabowski, 2023).

Surface waters in this catchment are characterized by an electrolytic conductivity between 0.10 and 1.97 mS/cm. Noticeable is the high EC value (1.97 mS/cm) measured north of Kolonia za Przysiekami, at the junction of forest roads. At the same location, the sulphate content was determined at 708 mg/dm^3, magnesium 211.2 mg/dm^3, calcium 121.1 mg/dm^3 and cadmium 1.44 µg/dm^3. Noteworthy are the zinc and cadmium contents in surface waters of forested areas in this catchment. The low pH of waters in these areas may cause remobilization of the metals from aquatic sediments and hinder their binding by the solid phase constituents in case of new emissions of pollutants. The zinc concentrations range from 0.005 mg/dm^3 to 2.904 mg/dm^3, and the cadmium concentrations are from <0.05 µg/dm^3 to 25.58 µg/dm^3. Samples of the waters also show elevated concentrations of aluminium (maximum 3,095.9 µg/dm^3).

Catchment of the Trzonia Stream. The pH values range between 3.71 and 8.30, with the minimum value also being the minimum in the entire map sheet area, measured in a forested, wetland area. The maximum value in the catchment (pH 8.30) was measured at the northern edge of the map sheet, and the sample was taken from a ditch with stagnant water, draining meadows. The specific electrolytic conductivity of the waters was between 0.13 and 0.97 mS/cm (median 0.47 mS/cm). Of particular note in this respect are the Trzonia waters showing significant amounts of sulphate (up to 97 mg/dm^3) and magnesium (up to 25.9 mg/dm^3), which may be a consequence of surface runoff from agricultural areas.

Elevated levels of lead, phosphorus and cadmium were found predominantly at the eastern edge of the map sheet. Higher calcium contents for the catchment area were found in the Trzonia waters near the built-up area of the village of Zendek.

Catchment of the Czeczówka Stream. The pH of the catchment waters ranges from 4.00 to 7.88. The lowest pH values were found in the upper reaches of the Czeczówka Stream and in its tributaries draining from the vicinity of the rural housing of Ostrowy. The specific electrolytic conductivity of the waters is in the range of 0.14–1.54 mS/cm. A high EC value of 1.33 mS/cm was found in water samples taken from ditches draining from the airport area. This is most likely related to the maintenance of the airport apron (Polkowska, Błaś, 2010; Kowalska, Grabowski, 2023). About 75% of the water samples are characterized by high sulphate concentrations (up to 810 mg/dm^3). In addition, high magnesium concentrations (up to 78.5 mg/dm^3) were determined in almost all water samples except for the forested areas at the eastern edge of the map sheet. Its median concentration is 27.8 mg/dm^3. In a large proportion of the water samples, significant calcium concentrations (up to 241.4 mg/dm^3) were also found.

Water samples collected from the upper reaches of the Czeczówka Stream and from the watercourses draining from the housing area of Ostrowy show higher zinc concentrations (up to 2.128 mg/dm^3) in relation to the limits defined for surface water quality classes I and II (Rozporządzenie..., 2021), which coincide with low pH values. Some of the samples with elevated zinc concentrations are also characterized by high amounts of cadmium (up to 20.06 µg/dm^3).

Phosphorus enrichment (from 0.27 to 0.34 mg/dm^3) was observed in samples collected from a small tributary of the Czeczówka River, draining from the housing area of the vicinity of the village of Ostrowy. Noticeable are high levels of cobalt. Their maximum in the map sheet (225.43 µg/dm^3) was found in a water sample taken from a ditch flowing out of the airport area. In the wetlands located west of Ostrowy, the concentrations of copper are above 8 µg/dm^3, and of manganese above 3.2 µg/dm^3, which may be associated with the impact of agricultural activity in these areas.

Catchment of the Potok Ożarowicki Stream. The pH of the catchment waters ranges from 5.52 to 7.85. The lowest pH values were measured in samples from unnamed ditches in the lower part of the catchment of the Potok Ożarowicki Stream. The basin's lowest pH value was determined in a sample from a small vegetated pond near Nowowiejska Street in Pyrzowice. This is most likely related to the presence of organic matter in this pond, which contributes to acidification of its water. The low pH values found in the waters of watercourses in the western part of the catchment may be due to the presence of Quaternary peats in their valleys. Previous studies of the Potok Ożarowicki waters, carried out in 2018, showed that the waters were of substandard quality with regard to pH (Program..., 2021).

The specific electrolytic conductivity varies between 0.14 and 2.61 mS/cm, and these are the highest levels recorded in the map sheet. The maximum EC value was determined in the waters of a concreted unnamed ditch near the S1 expressway. Significant levels of calcium (190.1 mg/dm^3), magnesium (41.7 mg/dm^3) and sulphate (274 mg/dm^3) were also found in the same sample. This may partly be related to the maintenance of the expressway surface and possible surface runoff from agricultural areas. High EC levels (up to 1.10 mS/cm) were determined in the waters of the Rów z Siedlisk ditch, which is a right-hand tributary of the Potok Ożarowicki stream and drains the built-up areas of Pyrzowice and Ożarowice. In addition, EC values of up to 1.48 mS/cm were found in the waters from ditches draining the villages of Tąpkowice and Podtąpkowice. High phosphorus concentrations (0.21 to 0.44 mg/dm^3) were also determined at these locations, which may be due to water and sewage management.

A water sample taken from a vegetated pond near Nowowiejska Street in Pyrzowice showed 690.2 µg/dm^3 of aluminium, 42.7 µg/dm^3 of nickel, and 53.22 µg/dm^3 of lead. At this site, a very high cadmium concentration (10.03 µg/dm^3) was also determined.

Elevated amounts of cadmium were also found in water samples taken from the Potok Ożarowicki stream. Its concentrations decrease downstream. High cadmium concentrations were observed also in the western part of the map sheet. A sample taken from an unnamed ditch showed the catchment's maximum concentration of this element (13.26 µg/dm^3).

Catchment of the Kozłowa Góra reservoir. The pH of the basin's waters ranges from 4.90 to 7.82. It is noticeable that its low pH values are associated with high aluminium concentrations (up to 3,946.9 µg/dm^3). The lowest pH values were found in the waters of the ditch crossing a forested area in the south-western part of the map sheet. High aluminium concentrations (up to 2,151.8 µg/dm^3) were also recorded in these waters. This may be due to the properties of the element itself, which is easily sorbed by aquatic sediments and subsequently leached by surface waters as their pH decreases (Kabata-Pendias, Pendias, 1999). Elevated levels of cadmium and zinc were also observed in waters with low pH values. The cadmium concentrations showed similar trends to those of sulphate, whose concentrations in the catchment's waters were recorded in the range of 2–107 mg/dm^3.

The EC of the water samples varies between 0.12 and 1.30 mS/cm, but most samples have a relatively low specific electrolytic conductivity. The maximum value (1.30 mS/cm) was determined in a sample near the southern edge of the map sheet in a forested area. Elevated levels of copper (10.08 µg/dm^3 – maximum value in the map sheet), lead (38.46 µg/dm^3 – maximum value in the catchment) and phosphorus (0.39 mg/dm^3) were found in a sample from the ditch crossing the south-western part of the map sheet.

A slight exceedance of the cobalt limit for water quality classes I and II (Rozporządzenie..., 2021) was found in a water sample collected from a ditch being a right-hand tributary of the Dopływ spod Siemoni stream. The concentration of this element is 64.63 µg/dm^3. The waters of the same watercourse also show excessive concentrations of beryllium (0.86 µg/dm^3) and barium (0.787 mg/dm^3) with respect to the limits indicated in Rozporządzenie... (2021).

Catchment of the Przeczyce reservoir. Within the catchment, a single surface water sample was collected from a pond located south of the housing area of the village of Łubne. The water has a pH of 7.86 and an EC of 0.51 mS/cm. The sample contained 18.7 mg/dm^3 of magnesium and 53 mg/dm^3 of sulphate. The sample was taken from an area used for agricultural purposes (meadows). The other elements analysed do not exceed the limits for water quality classes I and II (Rozporządzenie..., 2021).

Catchment of the Brynica River from the Szarlejka Stream to the Rawa Stream. The water quality of the catchment waters within the map sheet area is based on the description of a single sample taken from the source of the Jaworznik Stream. At that site, the pH of the waters is 6.62 and the specific electrolytic conductivity is 0.63 mS/cm. Relatively high levels of aluminium (2,516.2 µg/dm^3), cadmium (1.82 µg/dm^3) and lead (27.30 µg/dm^3) were measured for the water.

SUMMARY AND CONCLUSIONS

1. The chemistry of soils in the map sheet area is dependent on the lithology of parent rocks, their grain size composition, as well as the way of their use. The relationship between the elemental contents and the occurrence of Triassic carbonates is clearly visible in the case of aluminium, barium, calcium, cadmium, cobalt, chromium, iron, magnesium, manganese, nickel, lead, strontium, vanadium and zinc. Soils abundant in the sand fraction are generally depleted in the elements studied, while soils abundant in the silt and clay fractions are characterized by higher contents of these elements.
2. The pH of the soils is related to the bedrock lithology and the way they are used. Soils that developed from Triassic carbonates are characterized by alkaline or neutral pH. Soils genetically associated with Quaternary sands and gravels have neutral or acidic pH values. In forested areas, the topsoil layer is dominated by very acidic or acidic pH. Alkaline or neutral pH is typical of wasteland and fallow soils, as well as arable fields.
3. Anthropogenic factors shaping the chemistry of soils in the map sheet area are agricultural and service activity, as well as water and sewage management. The median contents of arsenic, barium, cadmium, copper, iron, lead, sulphur, titanium and zinc are higher than the geochemical background values of the Silesian–Cracow region. In the studied soils, minor anomalies of silver, arsenic, barium, cadmium, chromium, copper, mercury, phosphorus, lead and zinc are also observed.
4. The average contents of individual elements in the aquatic sediments are generally higher or equal to the geochemical background values of the Silesian–Cracow region. The highest exceedances in case of arsenic, cadmium, manganese, lead and zinc contents were recorded in the central part of the map sheet (catchment of the Potok Ożarowicki Stream), while in case of barium, sulphur and cobalt – in its south-western part (catchment of the Kozłowa Góra reservoir).
5. Sediments of all catchments within the map sheet area, apart from the catchment of the Przeczyce reservoir, show exceeded PEC thresholds for cadmium, lead and zinc.
6. The waters studied are mainly neutral and alkaline. High values of electrolytic conductivity (>1 mS/cm) were typically measured in some watercourses in the catchments of the Potok Ożarowicki stream, Brynica River (downstream to the Kozłowa Góra reservoir) and Czeczówka. Waters enriched in cadmium, cobalt and zinc occur in the northern, north-eastern and south-western parts of the map sheet.

REFERENCES

BAZA CBDG https://dm.pgi.gov.pl/ (dostęp 19.12.2023 r.).

BEDNAREK R., DZIADOWIEC H., POKOJSKA U., PRUSINKIEWICZ Z., 2004 – Badania ekologiczno-gleboznawcze. Państw. Wyd. Nauk., Warszawa.

BIERNAT S., 1955 – Szczegółowa Mapa Geologiczna Polski 1:50 000, ark. Wojkowice. Inst. Geol., Warszawa.

BN-78/9180-11. Gleby i utwory mineralne. Podział na frakcje i grupy granulometryczne. Norma branżowa, 1978, PKN, Warszawa.

BOJAKOWSKA I., 2001 – Kryteria oceny zanieczyszczenia osadów wodnych. *Przegląd Geologiczny*, **49**: 213–218.

BOJAKOWSKA I., GLIWICZ T., 2003 – Wyniki geochemicznych badań osadów wodnych Polski w latach 2000–2002: 46–81. Bibl. Monitoringu Środowiska, Warszawa.

BULA R., WIELAND Z., 2007 – Opracowanie ekofizjograficzne do projektu zmiany Planu Zagospodarowania Przestrzennego Województwa w zakresie zaktualizowania i uszczegółowienia zapisów dotyczących przyjętego zadania o znaczeniu ponadlokalnym pn. Rozbudowa MPL „Katowice" w Pyrzowicach; https://planzagospodarowania.slaskie.pl/content/1288255872 (dostęp 21.02.2024).

BUŁA Z., HABRYN R., KUREK S., KRIEGER W., MARKOWIAK M., WOŹNIAK P., 2002 – Atlas geologiczny paleozoiku bez permu w strefie kontaktu bloków górnośląskiego i małopolskiego w skali 1:200 000. Państw. Inst. Geol., Warszawa.

CZEKAJ J., SKRZYPCZYK M., 2017 – D.T2.1.4 Descriptive documentation of pilot actions and related issues (PA2.2). INTERREG CENTRAL EUROPA-PROLINE-CE; http://proline-ce.fgg.uni-lj.si/externalapp/content/deliverables/T2/PROLINE-CE_T2_DT214_PA22_PL_Koz%C5%82owaG%C3%B3ra.pdf (dostęp 01.03.2024).

HELIOS-RYBICKA E., ADAMIEC E., ALEKSANDER-KWATERCZAK U., 2005 – Distribution of heavy metals in the Odra River system: *Water-suspended matter-sediments. Limnologica*, **35**: 185–198.

HYDROPORTAL https://wody.isok.gov.pl/imap_kzgw/ (dostęp 12.09.2024).

JASTRZĄB M., MROZOWSKI M., 1997 – Brynica jaka jest jaka będzie. Biblioteka „Echa Czeladzi". Wydaw. Urząd Miasta Czeladź.

JURECZKA J., DOPITA M., GAŁKA M., KRIEGER W., KWARCIŃSKI J., MARTINEC P., 2005 – Atlas geologiczno-złożowy polskiej i czeskiej części Górnośląskiego Zagłębia Węglowego. Państw. Inst. Geol., Warszawa.

KABATA-PENDIAS A., MUKHERJEE A., 2007 – Trace elements from soil to human. Springer-Verlag, Berlin Heidelberg.

KABATA-PENDIAS A., PENDIAS H., 1999 – Biogeochemia pierwiastków śladowych. Wydaw. Nauk. PWN, Warszawa.

KABATA-PENDIAS A., SZTEKE B., 2015 – Trace elements in abiotic and biotic environments. Taylor and Francis Group, CRC Press.

KARCZEWSKA A., LEWIŃSKA K., AGATA M., KRYSIAK A., 2010 – Soil Pollution by Arsenic within the Allotment Gardens in Zloty Stok. *Ecol.Chem. Enineering* A. **17 (8)**: 927–933.

KARTY CHARAKTERYSTYK, 2023 – Karty charakterystyk JCWPd; http://karty.apgw.gov.pl:4200/jcw-podziemne (dostęp 07.12.2023).

KARTY CHARAKTERYSTYK, 2024 – Karty charakterystyk JCWP; http://karty.apgw.gov.pl:4200/jcw-powierzchniowe (dostęp 01.03.2024).

KATOWICE AIRPORT – https://www.katowice-airport.com/pl (dostęp 01.08.2024).

KIERSNOWSKI H., 1991 – Litostratygrafia permu północno-wschodniego obrzeżenia Górnośląskiego Zagłębia Węglowego – nowa propozycja. *Przegląd Geologiczny*, **39**, 4: 198–203.

KLASYFIKACJA UZIARNIENIA GLEB I UTWORÓW MINERALNYCH, 2008 – Polskie Towarzystwo Gleboznawcze; https://www1.up.poznan.pl/glinbar/wp-content/uploads/2015/03/Uziarnienie_PTG_2008.pdf (dostęp 20.08.2024).

KONFEDERAK A., 2021 – Program Ochrony Środowiska dla Gminy Ożarowice na lata 2021–2024 z perspektywą do roku 2028; https://www.bip.ozarowice.pl/res/serwisy/pliki/27112918?version=1.0 (dostęp 01.03.2024).

KOTAS A., 1985 – Uwagi o ewolucji strukturalnej GZW. [W:] Mat. Konf. Tektonika GZW. UŚ, Sosnowiec: 17–46.

KOWALSKA D., GRABOWSKI P., 2023 – Środki odladzające stosowane na lotniskach z uwzględnieniem ich wpływu na środowisko, IV Konferencja „Dni Betonu – Tradycja i Nowoczesność", Wisła, 9–11 października.

LEWANDOWSKI J., CIESIELCZUK J., 1997 – Przyczynek do powstania regolitów krasowych Wyżyny Śląskiej. *Geologia*, **14**: 139–152.

LIS J., PASIECZNA A., 1995a – Atlas geochemiczny Polski w skali 1:2 500 000. Państw. Inst. Geol., Warszawa.

LIS J., PASIECZNA A., 1995b – Atlas geochemiczny Górnego Śląska w skali 1:200 000. Państw. Inst. Geol., Warszawa.

LIS J., PASIECZNA A., 1999 – Szczegółowa mapa geochemiczna Górnego Śląska w skali 1:25 000, ark. Sławków. Państw. Inst. Geol., Warszawa.

LOMBI E., SLETTEN R.S., WENZEL W.W., 2000 – Sequentially extracted arsenic from different size fractions of contaminated soils. *Water Air Soil Pollution*, **124**: 319–332.

MACDONALD D.D., INGERSOL C.G., BERGER T.A., 2000 – Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems, environmental contamination and toxicology. *Archives of Environmental Contamination and Toxicology*, **39**: 20–31, DOI: 10.1007/s002440010075.

MIDAS (System Gospodarki i Ochrony Bogactw Naturalnych Państwowego Instytutu Geologicznego-PIB); http://geoportal.pgi.gov.pl/midas-web.

MIKOŁAJKÓW J., SADURSKI A. (red.), 2017 – Charakterystyka głównych i lokalnych zbiorników wód podziemnych. PIG-PIB, Warszawa; https://www.pgi.gov.pl/psh/materialy-informacyjne-psh/informatory-psh/4719-informator-psh-2017-gzwp/file.html.

OCZYSZCZALNIA ŚCIEKÓW OŻAROWICE – http://osozarowice.pl/ (dostęp 21.02.2024).

PACZYŃSKI B., SADURSKI A. (red.), 2007 – Hydrogeologia regionalna Polski, t. I, Wody słodkie. Państw. Inst. Geol., Warszawa.

PAZGAN M., 2022 – Prognoza oddziaływania na środowisko – uchwalenia miejscowego planu zagospodarowania przestrzennego dla sołectwa Tąpkowice w jego granicach administracyjnych. Wektor. Doradztwo ekonomiczne i środowiskowe Pazgan Michał, Tychy; https://www.bip.ozarowice.pl/res/serwisy/pliki/29672396?version=1.0 (dostęp 01.03.2024).

PN-88/B-04481 – Grunty budowlane. Badania próbek gruntu. Polska norma. 1988, PKNMiJ, Warszawa.

POLKOWSKA Ż., BŁAŚ M., 2010 – Obecność wybranych grup związków w wodach spływających z płyty lotniska. *Stan i antropogeniczne zmiany jakości wód w Polsce. State and Anttropogenic Changes of Water Quality in Poland*, **6**: 29–40.

POŻARYSKI W., GROCHOLSKI A., TOMCZYK H., KARNKOWSKI P., MORYC W., 1992 – Mapa tektoniczna Polski w epoce waryscyjskiej. *Przegląd Geol*ogiczny, **40**: 643–651.

PROGRAM INWESTYCYJNY KATOWICE AIRPORT 2024–2028; https://blog.katowice-airport.com/program-inwestycyjny-katowice-airport-2024-2028/ (dostęp 22.03.2024).

PROGRAM OCHRONY ŚRODOWISKA dla Gminy Bobrowniki na lata 2017–2020 z uwzględnieniem perspektywy na lata 2021–2024, 2016; https://archiwum-bobrowniki.bip.net.pl/c1676.html (dostęp 21.02.2024).

PROGRAM OCHRONY ŚRODOWISKA dla Gminy Ożarowice na lata 2021–2024 z perspektywą do roku 2028, 2021; https://www.bip.ozarowice.pl/res/serwisy/pliki/26253803?version=1.0 (dostęp 21.02.2024).

RAWLS W.J., PACHEPSKY Y.A., RITCHIE J.C., SOBECKI T.M., BLOODWORTH H., 2003 – Effect of soil organic carbon on soil water retention, *Geoderma*, **116**, 1/2: 61–76; https://doi.org/10.1016/S0016-7061(03)00094-6.

RICHLING A., SOLON J., MACIAS A., BALON J., BORZYSZKOWSKI J., KISTOWSKI M. (red.), 2021 – Regionalna geografia fizyczna Polski. Bogucki Wydaw. Naukowe, Poznań.

ROCZNA OCENA JAKOŚCI POWIETRZA w województwie śląskim. Raport wojewódzki za rok 2022, 2023 – Główny Inspektorat Ochrony Środowiska, Departament Monitoringu Środowiska. Regionalny Wydział Monitoringu Środowiska w Katowicach. Katowice; https://powietrze.gios.gov.pl/pjp/rwms/publications/card/1877 (dostęp 05.12.2023).

ROZPORZĄDZENIE MINISTRA INFRASTRUKTURY z dnia 25 czerwca 2021 r. w sprawie klasyfikacji stanu ekologicznego, potencjału ekologicznego i stanu chemicznego oraz sposobu klasyfikacji stanu jednolitych części wód powierzchniowych, a także środowiskowych norm jakości dla substancji priorytetowych (Dz.U. 2021 poz. 1745).

ROZPORZĄDZENIE MINISTRA INFRASTRUKTURY z dnia 4 listopada 2022 r. w sprawie Planu gospodarowania wodami na obszarze dorzecza Wisły (Dz.U. 2023 poz. 300).

ROZPORZĄDZENIE MINISTRA ŚRODOWISKA z dnia 1 września 2016 r. w sprawie sposobu prowadzenia oceny zanieczyszczenia powierzchni ziemi (Dz.U. 2016 poz. 1395).

RÓŻKOWSKI A. (red.), 1997 – Objaśnienia do mapy hydrogeologicznej Polski w skali 1:50 000, Arkusz Wojkowice (0911). Państw. Inst. Geol. Warszawa; https://bazadata.pgi.gov.pl/data/hydro/mhp/gupw/txt/mhpgupw0911objasnienia.pdf (dostęp 01.03.2024).

SALMINEN R. (red.), 2005 – Geochemical atlas of Europe, Part I. Geological Survey of Finland, Espoo.

SIEBIELEC S., SIEBIELEC G., SMRECZAK B., 2015 – Zanieczyszczenia osadów dennych rzek i zbiorników wodnych. *Studia i raporty IUNG-PIB*, **46**: 163–181.

STAN ŚRODOWISKA w województwie śląskim. Raport 2020, 2020 – Główny Inspektorat Ochrony Środowiska. Departament Monitoringu Środowiska. Regionalny Wydział Monitoringu Środowiska w Katowicach; https://www.gios.gov.pl/images/dokumenty/pms/raporty/stan_srodowiska_2020_slaskie.pdf (dostęp 20.12.2023).

STUDIUM UWARUNKOWAŃ i kierunków zagospodarowania przestrzennego Gminy Mierzęcice. Tekst ujednolicony. Cz. I. Diagnoza stanu istniejącego, 2021 – Załącznik Nr 1 do uchwały Nr XXVIII/229/2021 Rady Gminy Mierzęcice z dnia 29 września 2021 r.; https://www.mierzecice.pl/images/Studium/Tekst%20Studium%202021.pdf (dostęp 22.02.2024).

SZUFLICKI M., MALON A., TYMIŃSKI M. (red.), 2023 – Bilans zasobów złóż kopalin w Polsce wg stanu na 31 XII 2022 r. Państw. Inst. Geol., Warszawa.

UCHWAŁA NR IV/53/12/2014 Sejmiku Województwa Śląskiego z dnia 25 sierpnia 2014 r. w sprawie utworzenia obszaru ograniczonego użytkowania dla Międzynarodowego Portu Lotniczego „Katowice" w Pyrzowicach (Dz. Urz. Woj. Śląskiego poz. 4405); https://dzienniki.slask.eu/WDU_S/2014/4405/akt.pdf (dostęp 22.03.2024).

UCHWAŁA NR VI/62/8/2023 Sejmiku Województwa Śląskiego z dnia 20 listopada 2023 r. w sprawie przyjęcia aktualizacji „Programu ochrony powietrza dla województwa śląskiego" przyjętego uchwałą Nr VI/21/12/2020 Sejmiku Województwa Śląskiego z dnia 22 czerwca 2020 r. (Dz. Urz. Woj. Śląskiego poz. 8625); https://dzienniki.slask.eu/WDU_S/2023/8625/akt.pdf (dostęp 12.02.2024).

UCHWAŁA NR XXII.393.2021 Rady Gminy Ożarowice z dnia 11 lutego 2021 r. w sprawie wyznaczenia obszaru i granic aglomeracji Ożarowice (Dz. Urz. Woj. Śląskiego poz. 1160); https://dzienniki.slask.eu/WDU_S/2021/1160/akt.pdf (dostęp 21.02.2024).

USTAWA z dnia 27 kwietnia 2001 r. Prawo ochrony środowiska (Dz.U. poz. 54 t.j.).

WACH J., HAWRO-KRAJKA M., WACH M., 2020 – Prognoza oddziaływania na środowisko projektu miejscowego planu zagospodarowania przestrzennego sołectwa Celiny w jego granicach administracyjnych (gmina Ożarowice); https://www.bip.ozarowice.pl/res/serwisy/pliki/27424691?version=1.0 (dostęp 22.02.2024).

WAGNER R. (red.) 2008 – Tabela stratygraficzna Polski. Państw. Inst. Geol. Warszawa.

WILANOWSKI S., ŻABA M., 2016 – Objaśnienia do Szczegółowej Mapy Geologicznej Polski w skali 1:50 000, ark. Wojkowice (911). Państw. Inst. Geol. Warszawa.

WILANOWSKI S., ŻABA M., 2010 – Szczegółowa Mapa Geologiczna Polski, 1:50 000, reambulacja, ark. Wojkowice. Państw. Inst. Geol., Warszawa.

WÓJCIK A.J., SIEMBAB M., 2020 – Górnictwo triasowych rud żelaza w Księstwie Siewierskim w XVIII wieku. *Hereditas Minariorum*, **6**: 115–124

WÓJCIK A.R., 2024 – Sprawozdanie z działań podejmowanych na terenie Nadzoru Wodnego na obszarach powiatów: będzińskiego, tarnogórskiego, olkuskiego, lublinieckiego, myszkowskiego, zawierciańskiego, m. Bytom, m. Chorzów, m. Dabrowa Górnicza, m. Katowice, m. Mysłowice, m. Piekary Śląskie, m. Ruda Śląska, m. Siemianowice Śląskie, m. Sosnowiec, m. Świętochłowice za rok 2023; https://bip.katowice.eu/dokument.aspx?idr=141551&idt=348 (dostęp 08.07.2024).