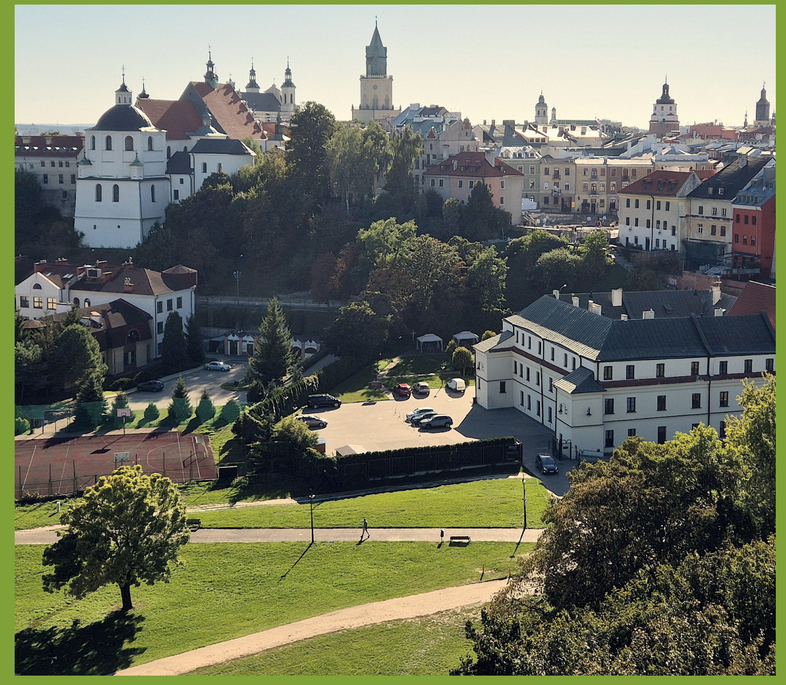
GEOCHEMICAL ATLAS OF LUBLIN AND ENVIRONS AT A SCALE 1:50,000

Editor: Irena Agnieszka Wysocka







Państwowy Instytut Geologiczny
Państwowy Instytut Badawczy

NARODOWY FUNDUSZ
OCHRONY ŚRODOWISKA
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Ministerstwo
Klimatu i Środowiska

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INTRODUCTION

Since the 1990s, the Polish Geological Institute – National Research Institute (PGI-NRI) has been conducting systematic geochemical research aimed at identifying the chemistry and degree of contamination of the Earth's surface (soils, aquatic sediments, and surface waters). The first publication in the geochemical cartography series was the *Geochemical Atlas of Warsaw and Environs 1:100,000* (Lis, 1992). Between 1992 and 2024 the following contributions were published as a result of the continuation of research in this field: *Geochemical Atlas of Poland at a scale of 1:250,000* (Lis, Pasieczna, 1995), 13 regional atlases for urban agglomerations, and 25 detailed atlases for the Silesia-Kraków region (https://mapgeochem.pgi.gov.pl/). To date, the series of regional atlases covers the largest cities in Poland and constitutes a significant contribution to the identification, documentation and cartographic presentation of the chemical condition of the natural environment in urban and industrial areas.

The project entitled *Geochemical Atlas of Lublin and Environs at a scale of 1:50,000*, implemented in 2023–2025, covers the areas of two cities – Lublin (city with *powiat* rights) and Świdnik, as well as their closest vicinity. The total area of this study is approximately 374 km². As part of the project, 909 soil samples, 169 aquatic sediment samples, and 182 surface water samples were subjected to chemical analysis. Soil sampling in urban areas was carried out in a regular grid of 500×500 m and in a grid of 1000×1000 m outside urban areas. More than 73% of all soil samples were taken from areas located within the administrative borders of Lublin and Świdnik.

In the study area, the human impact on the natural environment is manifested predominantly through progressive urbanization, industrial and transport development, the expansion of road and rail infrastructure, agriculture development, and the extraction of mineral deposits, e.g. natural gas, crude oil, clay raw materials, sand and gravel. Comprehensive studies of the chemical condition of individual components of the environment, supported by the knowledge of the geological setting of the region, and by comparing the current research results with applicable environmental standards or data from other geochemical studies, enable assessing the environmental quality, identifying contamination sources, as well as indicating trends in changes caused by anthropogenic pressure.

Due to the manner of conducting geochemical research by the PGI-NRI, including consistent application of a uniform methodology (reproducible procedures of sampling, preparation and chemical analysis, and data presentation), large number of samples taken at regular intervals, and simultaneous sampling of the three environmental components (soil, aquatic sediments, and surface waters), the obtained data can serve as a reference for future research conducted in this area. The collected information may be useful for developing strategic and sectoral documents, including environmental protection programmes, revitalization programmes (in the section presenting the geochemical condition of the environment) and environmental impact assessments. The achieved results of the studies of soils, aquatic sediments and surface waters can also be used to produce various reports and assessments on the state of the environment.

The study, commissioned by the Ministry of Climate and Environment, was financed by the National Fund for Environmental Protection and Water Management. The digital version of the *Atlas* is available at http://mapgeochem.pgi.gov.pl. The data collected during the preparation of the *Atlas* are made available in the form of spatial information on the Portal Geologia (https://geologia.pgi.gov.pl/mapy/?page=Geochemia) and the GeoLOG Portal (https://geolog.pgi.gov.pl/).

*Geochemical Atlas of Lublin and Environs at a scale of 1:50,*000 is the 14th cartographic project in a series of geochemical studies in urban-industrial areas carried out on a regional scale according to the concept of J. Lis and A. Pasieczna.

A number of specialists participated in this project:

- **I. A. Wysocka** – supervision and work coordination;
- **A. Biel, D. Kafara, P. Kaszycki, T. Kołecki, A. Krysa, R. Łusiak, W. Markowski, K. Pióro, K. Rudziński, J. Szyborska-Kaszycka, Ł. Wojcieszak, I. A. Wysocka** – sampling;
- **D. Kafara, I. A. Wysocka** – databases;
- **D. Kafara** – geological map construction;
- **K. Siwy-Będkowska** – description of geological setting;
- **D. Kafara, A. Szczypczyk** – geochemical map production;
- **A. Bliźniuk, I. A. Wysocka** – statistatical calculations;
- **A. Biel, P. Drzewicz, B. Kościuczyk, W. Markowski, A. Szczypczyk, I. A. Wysocka** – tabulation of data;
- **A. Bliźniuk, J. Fajfer, A. Gabryś-Godlewska, J. Hryciuk, D. Kafara, A. Konon, P. Kostrz-Sikora, A. Szczypczyk, Ł. Wojcieszak, I.A. Wysocka** – explanatory text to the Atlas;
- **K. Bala** – creation of table structures and spatial databases in ESRI technology;
- **M. Chada, A. Grabowska, P. Kucińska, A. Setla, P. Stefańska, J. Rau-Sierańska, K. Jakubczak, K. Szewczuk, A. Roguski** – grain size analyses;
- **A. Sztuczyńska** – leadership and coordination of analytical works;
- Ł. Andrzejewski, P. Andrzejewski – mechanical preparation of samples for analyses;
- – **R. Czerwiński, E. Kałwa** – chemical preparation of samples for analyses;
- **J. Gąsior, B. Kamińska, J. Retka** – determination of TOC in soils and aquatic sediment;
- **M. Bellok, M. Białecka, E. Kalwa, A. Maksymowicz** – determination of pH; EC; HCO_3^-, NH_4^+, TOC, COD, and total suspended solids in waters;
- **M. Bellok, R. Czerwiński, E. Kalwa, A. Maksymowicz** – determination of pH (KCl) in soils;
- **J. Duszyński, D. Karmasz, M. Szwejkowska** – determination of mercury;
- **W. Bureć-Drewniak, A. Krążała-Majewska, J. Kucharzyk, M. Szwejkowska** – determination of elements by ICP-OES method;
- **D. Karmasz, O. Lukianenko** – determination of elements by ICP-MS method;
- **M. Janasz, B. Kamińska, M. Stasiuk** – determination of anions in water;
- **J. Gąsior, B. Kamińska, M. Stasiuk** – determination of organochlorine pesticides, polychlorinated biphenyls and polycyclic aromatic hydrocarbons;
- **B. Kamińska, J. Retka, M. Stasiuk** – determination of sum of mineral oils.

CHARACTERISTICS OF THE STUDY AREA

Like many other cities, Lublin has developed based on natural constraints, such as the geological structure and geomorphological setting. These factors contributed to the growth in population and development of settlements in the early Middle Ages. Lublin was founded under Magdeburg Law in 1317, and its history spans over seven centuries of systematic expansion into the neighbouring areas of the left-bank loess plateau and the right-bank area composed mainly of sandy-silty deposits resting on Upper Cretaceous bedrock. The city was located at the crossroads of important trade routes (including the international routes of Kraków-Vilnius and Kraków-Kyiv). The course of the routes depended on various factors, including the river network, terrain relief and geological structure (Mroczek, 2014).

Before obtaining municipal rights in 1954, Świdnik was a village within the Lublin District. The first mention of a locality called Świdnik Wielki dates back to 1392. During the interwar period, this area was known as Adampol (now the oldest quarter of the city) and functioned as a health resort and summer retreat for Lublin residents. In 1939, the Marshal Śmigły-Rydz Civil Pilot School of the Air Defence and Anti-Gas League was opened. This event shaped Świdnik's future as an aviation hub. Both the airport and the pilot school were bombed by the Germans during the war. Construction of the "Wytwórnia Sprzętu Komunikacyjnego" equipment factory began in 1949, and the neighbouring barracks settlement for the factory builders gave rise to the development of the city (https://www.powiatswidnik.pl/gmina-swidnik).

ADMINISTRATIVE AND GEOGRAPHICAL LOCATION

The study area is located in the Lublin Voivodeship, covering approximately 1.5% of its area. It includes 13 administrative units in whole or in part (Figure 1), the largest of which is Lublin (147.5 km² in area), a city with *powiat* rights. With 328,310 inhabitants, it is the eighth largest city in Poland (as of 31 December 2024) (https://bdl.stat.gov.pl/bdl/dane/teryt/kategoria/138). Lublin is the capital of the Lublin Voivodeship and Lublin District (Lublin County; *pl. powiat lubelski*), and the central hub of the Lublin agglomeration and the Lublin Metropolitan Area. To the east, Lublin borders the urban municipality of Świdnik (20 km² in area). The rest of the study area belongs to the municipalities of the Świdnik District (Świdnik County; *pl. powiat świdnicki*): Piaski (urban-rural municipality) and Mełgiew (rural municipality), and to the municipalities of the Lublin District: Konopnica, Wólka, Jabłonna, Strzyżewice, Niedrzwica Duża, Niemce, Jastków and Głusk (rural municipalities). Lublin is divided into 27 auxiliary units with the status of city quarters (Figure 1).

According to the physico-geographical regionalization of Poland (Richling et al. (eds.), 2021), the study area is part of the Lublin Upland macroregion, which is divided into four mesoregions. The Świdnik Plateau covers the central and eastern parts of the study area and occupies its largest expanse. It is a gently undulating plain located in the interfluve of the Bystrzyca and Wieprz rivers. The Nałęczów Plateau is situated in the north-western part of the study area. It is distinguished by an almost continuous loess cover, which is up to 30 m thick and is featured by numerous depressions, periodically or episodically filled with water. Numerous ravines are also a characteristic feature of this mesoregion. The south-western part of the study area, which is part of the Bełżyce Plateau, has a thinner loess cover (up to 10 m) and less distinct relief. A small part of the study area, located in its south-eastern corner, is occupied by the Giełczew Hills (Richling et al., 2021).

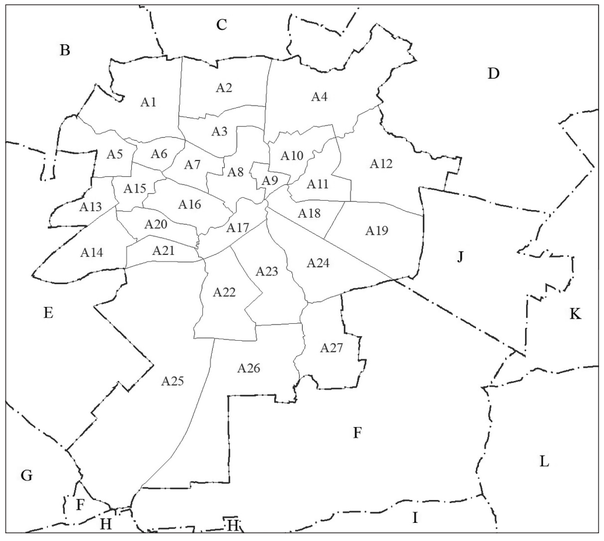

Figure 1. Administrative division of the study area: Lublin District: city of Lublin (A) and its quarters: A1 – Sławin, A2 – Czechów North, A3 – Czechów South, A4 – Ponikwoda, A5 – Szerokie, A6 – Sławinek, A7 – Wieniawa, A8 – Śródmieście (Downtown), A9 – Stare Miasto (Old Town), A10 – Kalinowszczyzna, A11 – Tatary, A12 – Hajdów – Zadębie, A13 – Węglin North, A14 – Węglin South, A15 – Konstantynów, A16 – Rury, A17 – Za Cukrownią, A18 – Bronowice, A19 – Felin, A20 – Czuby North, A21 – Czuby South, A22 – Wrotków, A23 – Dziesiąta, A24 – Kośminek, A25 – Zemborzyce, A26 – Abramowice, A27 – Głusk; municipalities in Lublin county: B – mun. Jastków, C – mun. Niemce, D – mun. Wólka, E – mun. Konopnica, F – mun. Głusk, G – mun. Niedrzwica Duża, H – mun. Strzyżewice, I – mun. Jabłonna; Świdnik District: J – city of Świdnik, K – mun. Mełgiew, L – mun. Piaski

SURFACE RELIEF, GEOMORPHOLOGY AND HYDROGRAPHY

Surface relief of the study area is varied. The elevation ranges from approximately 160 m to over 240 m a.s.l. The highest elevation – 243 m a.s.l. – is located west of Lublin in the village of Konopnica, while in Lublin itself, the highest point is located in the vicinity of Węglin Park (elevation 236.5 m a.s.l.). The lowest elevations in the area are found along the Bystrzyca and Czerniejówka river channels, ranging from 160 to 180 m a.s.l. The Lublin city area is characterized by significant hypsometric diversity, with a relief variation of up to 75 m (Smakulski et al., 2021). The Bystrzyca River divides the study area into two distinct landscapes. The western part is characterized by numerous ravines, valleys and hills, while the eastern part is mostly flat (Richling et al. (eds.), 2021).

Two areas at risk of mass movements have been documented within the boundaries of the study area in the village of Łysłów. They are located on steep slopes and include three small landslides, of which two are periodically active. The bedrock of the landslides consists of Quaternary loess, muds (silts) and sands of the North Polish Glaciation. Each of the landslides is less than 0.04 ha in area (Balicki, Walicka, 2022a; Balicki, Walicka, 2022b).

The study area is located in the Bystrzyca River catchment, which is a third-order river basin. The Bystrzyca is the main watercourse in the region. It receives most of the water that eventually flows further into the Wieprz River. Within the borders of Lublin, the Bystrzyca riverbed is embanked and straightened (except for the section near the former Lublin Equestrian Club). The pattern of a meandering river with a system of oxbow lakes is accentuated only upstream and downstream of the city (Mroczek, 2014). The right-hand tributaries of the Bystrzyca River are the Czerniejówka River (along with its tributary named Dopływ ze Skrzynic) and the Dopływ spod Świdnika Stream. Ciemięga, Czechówka (along with the Łazęga Stream and the tributary named Dopływ z Konopnicy) and Ciemięga (also known as Krężniczanka or Nędznica) are the left-hand tributaries of the Bystrzyca River. The Czechówka River channel in the area of Downtown and Old Town of Lublin is not only engineered, but also enclosed in an underground canal (over 700 metres long) under the surface of the main thoroughfare – Aleja Tysiąclecia Av. (Mroczek, 2014). The south-eastern part of the study area is crossed by the Stoki Stream that flows into the Sławka River outside the boundaries of the investigation area. The Sławka River belongs to the Wieprz River catchment. An important feature of the hydrographic network of the study area is the Zemborzycki Reservoir, which was created in 1974. Spanning 278 hectares, it serves as a retention and recreational facility (https://www.gov.pl/web/wody-polskie-lublin/historia-zalewu).

The study area encompasses eight surface water bodies (SWBs), seven of which are classified as streams or minor rivers on carbonate bedrock. One of them (SWB Bystrzyca from the Zemborzycki Reservoir to the river's mouth) is classified as a medium-sized river on carbonate bedrock. The largest expanses of the study area are occupied by the SWB Bystrzyca from the Zemborzycki Reservoir to the river's mouth (coded RW20000824699) and the SWB Czerniejówka (RW20000624669). The location of the individual surface water bodies within the boundaries of the study area is shown in Figure 2.

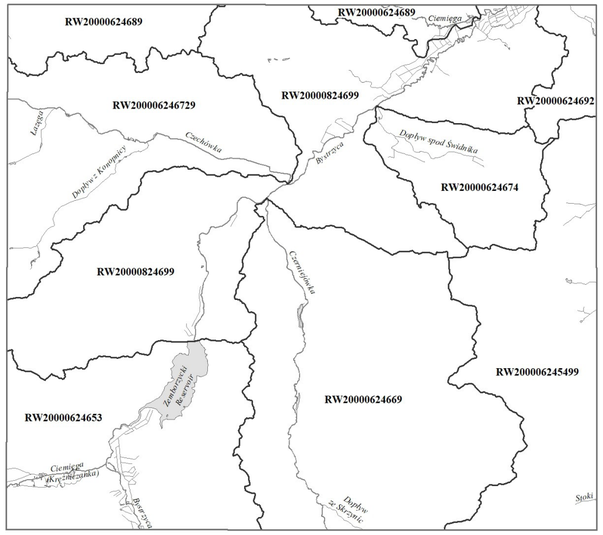

Figure 2. The extents of the surface water bodies (SWBs) and their coding: RW20000624689 – SWB Ciemięga, RW20000824699 – SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth, RW20000624692 – SWB Dopływ z Łuszczowa, RW20000624674 – SWB Dopływ spod Świdnika, RW200006245499 – SWB Stoki, RW20000624669 – SWB Czerniejówka, RW20000624653 – SWB Bystrzyca to the Zemborzycki Reservoir, RW200006246729 – SWB Czechówka

GEOLOGICAL SETTING AND MINERAL DEPOSITS

According to the regional geological division of Poland, the area of Lublin and its surroundings is located in the central part of the Devonian-Carboniferous Lublin Basin, within the Lublin Graben tectonic unit (Narkiewicz, Dadlez, 2008). The Devonian-Carboniferous series has been cut by numerous diagonal fault zones, resulting in the formation of a system of secondary tectonic depressions and elevations. In the north-eastern part of the study area is the Stoczek-Dorohucza fault-bounded depression, and another depression of Kazimierzówka is in the central part. The depressions are parallel to each other and separated by the Świdnik Fault. The south-eastern part of the area is occupied by the Zemborzyce-Wilczopole tectonic structure (Harasimiuk, Henkiel, 1982; Henkiel, Danel, 2015).

As regards the sub-Cenozoic structural level, the study area is located within the Puławy Basin, which is composed of Mesozoic (Jurassic-Cretaceous) formations overlain by a discontinuous Cenozoic cover (Narkiewicz, Dadlez 2008; Marszałek et al., 1991, 1996). A network of differently oriented faults has developed in the Mesozoic-Cenozoic complex. Some of the fault zones are clearly marked in the topography along valleys of the following rivers: Bystrzyca (SW-NE), Ciemięga (WSW-ENE), Czerniejówka (S-N), and upper Bystrzyca (S-N). Another tectonic zone, running WNW-ESE, has developed in the north-eastern part of the study area (in the Świdnik region). It separates a patch of Paleocene deposits (in the south) from an area showing a characteristic mosaic geological structure (in the north) with numerous outcrops of Cretaceous rocks (Harasimiuk, Henkiel, 1982; Marszałek et al., 1991, 1996).

Parts of four map sheets of the *Detailed Geological Map of Poland at a scale of 1:50,000* were used to present the geological structure of the study area: Lublin (Butrym et al., 1980), Bychawa (Marszałek et al., 1988), Niedrzwica (Marszałek et al., 1989) and Bełżyce (Henkiel, Danel, 2008).

Geological map of the Lublin area and its environs is presented in Plate 1. The map has been developed on the basis of four map sheets of the *Detailed Geological Map of Poland at a scale of 1:50,000*: Lublin (Butrym et al., 1980), Bychawa (Marszałek et al., 1988), Niedrzwica (Marszałek et al., 1989), and Bełżyce (Henkiel, Danel, 2008). The surface lithological units presented in the geological map are labelled with numbers (Plate 1) from youngest to oldest [1–38]. Information on the subsurface geological structure is derived from exploratory boreholes drilled in the Lublin region during the prospect for energy resources.

The oldest formations documented in the study area are Lower Devonian sandstones with mudstone interbeds, representing the Old Red facies. The Middle Devonian is composed of sandstones with claystones and mudstones, passing upwards into dolomites with anhydrites. These are overlain by Upper Devonian deposits: dolomites, organodetrital and pelitic limestones, marly limestones, and variegated mudstones with sandstone interbeds. The total drilled thickness of the Devonian section in the Kazimierzówka area (south-eastern part of the area) is more than 2,800 m (Harasimiuk, Henkiel, 1982).

Carboniferous deposits rest unconformably above an erosional surface of the Devonian rocks. The Lower Carboniferous is represented by mudstones with limestone and sandstone interbeds, locally (in the lower part of the section) with a series of diabases and their tuffs. The Upper Carboniferous consists of a series of mudstones, claystones and sandstones with limestone and marl interbeds, and thin hard coal seams (Harasimiuk, Henkiel, 1982; Henkiel, Danel, 2015). The total thickness of the Carboniferous succesion measured in boreholes ranges from approximately 400 m to over 1,100 m. The thickness of the Carboniferous section is reduced by erosion to approximately 40–55 m only in the south-eastern part of the study area, in the Wilczopol region (Harasimiuk, Henkiel, 1982).

Middle Jurassic rocks rest immediately on the denuded top surface of the Carboniferous deposits. Kaolin sandstones occur at the base, and heavily sandy limestones are found above. In the Late Jurassic, pelitic, organodetrital limestones with ooids were deposited, followed by marly and pelitic limestones, dolomites, and dolomitic marls. The total thickness of the Jurassic rocks may reach 300 m (Harasimiuk, Henkiel, 1982; Henkiel, Danel, 2015).

The Upper Jurassic rocks are unconformably overlain by Lower Cretaceous deposits represented by a thin (usually 0.1 m thick) bed of sands and glauconitic sandstones containing phosphorites. Above, there is a complex of Upper Cretaceous carbonates. The section starts with sandy limestones and marls, overlain by limestones and marly limestones with chert interbeds, followed up by a series of marly limestones with interbeds of marls and occasional white limestones. The uppermost Upper Cretaceous deposits are represented by marls, marly limestones and opokas, and sporadic glauconitic gaizes. To the south-east of the Bystrzyca River valley, Upper Cretaceous marls and opokas form extensive outcrops. They are also exposed along the valleys of the Bystrzyca and Czerniejówka rivers and in the north-eastern part of the study area. The total thickness of the Cretaceous succession is considerable, amounting to approximately 900 m (Henkiel, Danel, 2015; Harasimiuk, Henkiel, 1982).

Paleocene deposits are represented mainly by gaizes with interbeds, lenses and nodules of hard limestones, less frequently marls, and in places by marly gaizes (Harasimiuk, Henkiel, 1982; Marszałek et al. 1991, 1996; Henkiel, Danel, 2015). Locally, especially in the western part of the study area, glauconitic sandstones, mudstones, and carbonate-free clays, muds and sands with a high glauconite content are found in the section (Henkiel, Danel, 2015). Numerous extensive outcrops of gaizes and limestones occur to the south-east of the Bystrzyca River. There are also several small outcrops of gaizes in the south-western part of the area (Jakubówka region) and in the tributary valleys of the Czechówka River. Eocene (soils of weathered opokas and gaizes, clays, and muds) and Oligocene (quartz sands and muds with glauconite) deposits have been locally preserved upon the eroded surface of the Paleocene succession. They are very limited in distribution and occur in the form of small covers (Harasimiuk, Henkiel, 1982; Marszałek et al. 1991, 1996; Henkiel, Danel, 2015).

The Upper Cretaceous and Paleogene deposits are overlain by Quaternary sediments. However, they do not constitute a continuous cover in the study area. The thickness of the Quaternary series is up to 50 m in the Bystrzyca River valley and up to ca. 90 m in the fossil erosional trough at Łuszczów Pierwszy (Harasimiuk, Henkiel, 1982; Marszałek et al., 1991, 1996; Henkiel, Danel, 2015). The Quaternary section is represented by deposits of the Lower Pleistocene, Pleistocene glaciations (Sanian 1 and 2, Odranian and Vistulian) and the Holocene.

Lower Pleistocene sediments have been found in boreholes drilled in the fossil valley of the Bystrzyca River and in the north-western part of the study area. In the Bystrzyca valley, these are fluvial coarse gravels, lower and upper sands separated by a layer of lacustrine muds, and deluvial loams and clays of weathering mantles containing debris of Cretaceous and Paleocene rocks. In the north-western part of the study area, a series of eluvial-deluvial sandy loams and sands, found at the base of the Quaternary succession, have been included in the Lower Pleistocene (Harasimiuk, Henkiel, 1982; Marszałek et al., 1996).

The Sanian 1 and Sanian 2 glaciation complex is composed of a grey-green till bed, variously grained fluvial sands and glaciofluvial sands and gravels. Tills are found as a continuous layer in the north-western part of the study area. Thes tills have also been preserved in the erosional trough at Krępiec (at the eastern boundary of the area), and are overlain by fluvial sands. Glaciofluvial sands with gravel are found in the Bystrzyca River valley, in erosionally cut Lower Pleistocene deposits, and in erosionnal troughs at Krępiec and Łuszczów Pierwszy (near the north-eastern boundary of the area) (Harasimiuk, Henkiel, 1982).

The Mazovian Interglacial is represented by fluvial, lacustrine and wetland sediments. In the erosionnal troughs at Krępiec and Łuszczów Pierwszy, lacustrine muds and clays with some layers of fluvial sands were deposited. Towards the end of the interglacial period, alluvial peaty muds accumulated in this area. The Bystrzyca valley is dominated by a fluvial (sand-gravel) facies with interbeds of lacustrine muds (Harasimiuk, Henkiel, 1982). In the area of Bystrzejowice Pierwsze (south-eastern corner of the study area), only fluvial sediments (sandy-gravel) are found in the section (Marszałek et al., 1996). Small outcrops of lacustrine sediments were reported from the right bank of the Bystrzyca River in the north-eastern part of Lublin (near Bronowice).

The Odranian Glaciation is represented by lacustrine-fluvial (marshland), periglacial, glacial and glaciofluvial sediments. During the initial stage of glaciation, fluvial-periglacial sands were deposited. They form an over-flood terrace on the right bank of the Bystrzyca River, as well as dark peaty sands and muds in the top section of the Krępiec.erosional trough. Subsequently, glaciofluvial and glacial deposits were accumulated. The glaciofluvial sediments form a series of coarse-grained sands and gravels, up to 25 m thick. In the north-western part of the study area, the sands are more widespread and form an intermoraine series. In the remaining area, they occur as small separate patches (Harasimiuk, Henkiel, 1982; Marszałek et al., 1996). On the surface, these sediments are exposed in the north-eastern part of Lublin, on the right bank of the Bystrzyca

River (Bronowice), at the eastern boundary of the map near Łuszczów Pierwszy, Franciszków, Jacków and Bystrzejowice Pierwsze. In some places, glaciofluvial sands and gravels form a thin layer (less than 2 m thick) and overlie Upper Cretaceous marls and opokas and Paleocene gaizes.

The glacial level is represented by grey-brown, sandy, generally heavily weathered tills with a high content of gravels and boulders, approximately 1–4 m in thickness. A relatively continuous till layer is found only at the base of loess in the north-western part of the study area. Tills are also found in a few patches preserved within terrain depressions (Harasimiuk, Henkiel, 1982; Marszałek et al., 1996). More extensive outcrops of the tills occur in the south-east (near Bystrzejowice) and at the eastern boundary of the study area (Jacków). Glacial tills are also exposed in minor ravines and valleys of watercourses in the north-western and north-eastern parts of the map. Glacial deposits also include sands with gravels, cobbles and boulders, attaining several metres in thickness. North of the Ciemięga River, glacial sand-gravel sediments and tills form a vast moraine plateau (Harasimiuk, Henkiel, 1982). Outcrops of glacial sediments occur in the northern part of the study area on the left bank of the Ciemięga River, and in the eastern part near Krępiec. During the final stage of the Odranian Glaciation, fluvial-periglacial sands containing gravels of Cretaceous rocks were accumulated. These sediments were deposited in river valleys, terrain depressions, and hollows on slopes, and their thickness is only 1–3 m (Harasimiuk, Henkiel, 1982; Henkiel, Danel, 2015). On the surface, they are found in several places on the right banks of the Bystrzyca River (in the area of Zemborzyce, Tatar and Wólka) and the Czerniejówka River (at Dominów), as well as in the area where the Ciemięga River flows into the Bystrzyca. The latest research shows that the last ice sheet in the study area was that of the Sanian 2 Glaciation. The maximum limit of the Odranian ice sheet runs northwest of the study area's boundary, along the Puławy–Siedlce–Terespol line (Marks et al., 2022; Krawczyk, Kucharska, 2023; Kucharska, Krawczyk, 2023). Consequently, the Odranian glacial and glaciofluvial deposits shown in the map (Plate 1) are likely to be associated with the Sanian 2 Glaciation.

The Eemian Interglacial was a period of formation of reddish-brown pseudopodzolic soils with a characteristic "marbled" pattern of the soil profile. They have commonly preserved beneath the loess cover in the north-western part of the study area (Harasimiuk, Henkiel, 1982; Henkiel, Danel, 2015). Their exposures are found on the slopes of the Ciemięga River at its confluence with the Bystrzyca River, and in numerous ravines cut into the loess base, e.g. at Węglin (in the west of Lublin). Fluvial sands containing sparse gravels of Cretaceous rocks and intercalations of muds and clays also deposited during this period. These occur in the northern part of the study area beneath the cover of either Vistulian Glaciation or Holocene sediments (Harasimiuk, Henkiel, 1982; Marszałek et al., 1996).

The vast majority of the map sheet's surface is covered by Vistulian Glaciation deposits. The oldest period of this glaciation is represented by paleosols found at the bottom of loess in the Bystrzyca River fossil valley in the north-eastern part of Lublin near Trześniów (Harasimiuk, Henkiel, 1982). Subsequently, fluvial and fluvial-periglacial sediments were accumulated. The fluvial-periglacial silty sands, which are exposed only in the ravine at Węglin (western part of Lublin) (Henkiel, Danel, 2015), interfinger with the bottom part of the loess cover. Fluvial and fluvial-periglacial sands and muds (silts) form the floodplain terraces of the Bystrzyca, Czerniejówka and Ciemięga (Krężniczanka) rivers (Harasimiuk, Henkiel, 1982; Marszałek et al., 1991, 1996; Henkiel, Danel, 2015). Major outcrops of these sediments are found mainly in the southern part of the study area, while in the north-east they occur only as small patches.

During the final stage of the last glaciation, the dominant process was deposition of loess. It covers approximately 25% of the study area, occurring across the entire north-western region. The thickness of the loess cover in boreholes ranges from 11 to 25 m. Loess is distinguished by a characteristic granulometric composition, wherein the silt fraction predominates over the clay and sand fractions. The carbonate content varies widely from 0 to 15.6%. The upper part of the loess is decalcified, and the thickness of the decalcification zone ranges from 1.8 to 4 m. In the lower part, very poorly developed paleosols were observed (Harasimiuk, Henkiel, 1982; Henkiel, Danel, 2015). Locally, at the bottom of the loess cover, there is multicoloured laminated loess (lower) with an admixture of tills. This most likely formed in the initial phase of loess accumulation (Henkiel, Danel, 2015).

In the plateaus extending in the south-western part of the study area (Jakubówka) and in the area where the Ciemięga River flows into the Bystrzyca River (north-eastern corner), sandy loess occurs. It contains distinct thin interbeds of sandy silts or fine-grained sands (Henkiel, Danel, 2015). The sandy loess deposits may reach a thickness of 10 m, but in some areas it is no more than 2 m. At the north-eastern boundary of the study area, the sandy loess overlies Upper Cretaceous marls, opokas and gaizes and Paleocene gaizes (Harasimiuk, Henkiel, 1982; Henkiel, Danel, 2015).

The sedimentation of the Upper Stadial of the Vistulian Glaciation is terminated by sandy muds (silts) and loess-like silty sands. In terms of lithology, these are muds, sandy tills, and silty sands, at the base often with gravels and boulders of northern rocks and debris of Cretaceous and Paleocene rocks. Large areas where the aeolian loess accumulation did not occur are covered by sandy muds (silts), sandy loams and loess-like silty sands. In terms of lithology, these are rusty-brown muds, sandy loams and silty sands, often with northern gravels at the base. They also contain debris of Cretaceous and Paleocene rocks. Their thickness usually does not exceed 2 m, occasionally reaching 4–5 m. These deposits represent mainly extensive eluvial-deluvial covers resting upon older, Upper Cretaceous to Quaternary deposits (Harasimiuk, Henkiel, 1982; Marszałek et al., 1991, 1996; Henkiel, Danel, 2015). The loess-like sediments attain greater thicknesses in the Zemborzyce and Majdan Wrotkowski regions (south-western part of the study area), on the right bank of the Bystrzyca River downstream of Lublin, in Łuszczów Pierwszy (in the northeast), and in the eastern part of Świdnik.

At the end of the Vistulian Glaciation or the beginning of the Holocene, periglacial weathering resulted in the formation of weathering mantles (brown muds, sands, and weathering loams) on elevated areas and slopes in the western part of the study area. In places where their thickness is below 2 m, the sediments occur on Paleocene gaizes, sandstones, clays, muds and sands, or on Upper Cretaceous marls, opokas, limestones, and glauconite-containing gaizes (Henkiel, Danel, 2015). There are several irregular dunes on the eastern shore of the Zemborzycki Reservoir, which are composed of white fine-grained aeolian sands (Harasimiuk, Henkiel, 1982). In the southern and south-eastern parts of the study area, some dry valleys are filled with sands and silty sands of fluvial and fluvial-deluvial origin. The thickness of these deposits is below 2 m (Marszałek et al., 1996). Deluvial sandy-silty sediments occur in the bottoms of dry valleys, in the lower sections of ravines, and at the foot of valley slopes. Narrow valleys and ravines cutting through the loess cover are dominated by the silt fraction admixed with humic material. The sediments reach 6 m in thickness. In the remaining area, in denudation valleys with wider bottoms and gentler slopes, there are deluvial deposits dominated by the sand fraction, up to 3 m thick. They contain numerous pebbles and clasts of Cretaceous rocks and gravels of crystalline rocks (Harasimiuk, Henkiel, 1982; Henkiel, Danel 2015).

Holocene sediments in the study area fill the river valleys and closed basins of different origins. These are fluvial, alluvial, and organic sediments. Fluvial sands fill the bottoms of narrow and shallowly incised river valleys (Henkiel, Danel, 2015). Fluvial sediments also form parts of the upper floodplain (1–3 m above the river level) of the Bystrzyca River in the Zemborzyce region (in the south-west) and at the confluence of the Ciemięga River with the Bystrzyca River (in the northeast). These are white fine- and medium-grained sands, locally with gravel, 2–4 m in thickness. During flood events, alluvial muds (dark-colour sands and loams, as well as clays and clayey muds) accumulated in the river valleys. They can be seen in the valleys of the Bystrzyca, Czerniejówka, Czechówka and Ciemięga rivers. Alluvial muds fill the closed depressions of different origins, which occur in the eastern and north-eastern parts of the study area (in the Kalinówka, Jacków, Świdnik Mały, Turka and Krępiec regions), and partly the valleys of some rivers. In the valleys of the Bystrzyca, Ciemięga (Krężniczanka) and Czerniejówka rivers and in the karst depressions near Świdnik Mały, there are transitional peatlands and valley fens, with peats attaining a thickness of 3–4 m (Harasimiuk, Henkiel, 1982; et al., 1991, 1996; Henkiel, Danel, 2015).

Mineral deposits. Mineral deposits. Resources of natural gas, crude oil, clay raw materials, and sands have been found in the Lublin area and its surroundings.

According to the MIDAS database (as of January 2025), 33 mineral deposits have been so far documented in the study area (https://geoportal.pgi.gov.pl/midas-web). Currently, only two natural gas fields are developed, while 10 deposits have already been abandoned. Nine gas deposits that are preliminarily or thoroughly explored remain formally undeveloped. In addition, 12 deposits have been removed from the register of Mineral Resources of Poland (Szuflicki et al. (eds.), 2023).

Two natural gas accumulations have been discovered in Upper Devonian carbonates: "Ciecierzyn", and "Mełgiew A and Mełgiew B." They occupy significant areas in the northern and north-eastern parts of the study area. The reservoir layer of the "Ciecierzyn" deposit is represented by fractured calcareous dolomites found at a depth of 3,736.0–3,792.0 m. In the "Mełgiew A and Mełgiew B" deposit, two gas-bearing levels have been identified – the lower level Mełgiew A (at a depth of 3,900.0–4,018.5 m) and the upper level Mełgiew B (at 3,413.5–3,445.0 m). The reservoir layer is composed of dolomites (Mełgiew A) and limestones (Mełgiew B). The mineral product in both deposits is natural gasoline gas. The helium content in the Ciecierzyn deposit averages 0.10% vol., and in the Mełgiew A and Mełgiew B deposits it averages 0.017–0.068% vol. The Ciecierzyn, Mełgiew A and Mełgiew B deposits are developed. The gas-bearing levels of the deposits are exploited through deep wells, and the obtained gas is desulfurized before being fed into the national gas network (Heliasz et al., 2011).

The "Świdnik" crude oil deposit was documented in Upper Carboniferous fine-grained sandstones. It was located in the northern part of the map sheet, within the administrative boundaries of Lublin. Heavy, highly viscous asphalt oil accompanied by natural gas was produced from the deposit. At most five wells were used to exploit it. In 2003, after more than 20 years, the production was terminated, three wells were decommissioned, and further two were designated for the injection of liquid waste. Subsequently, at the end of 2004, the "Świdnik" deposit was removed from the register of mineral deposits.

Within the Quaternary loesses of the northern and north-western parts of the study area, six mineral deposits of clay raw materials have been documented: four deposits of clay raw materials for building ceramics ("Rudnik I," "Zakątek," "Dębówka," and "Lublin-Przejrzysta") and two deposits of clay raw materials for the production of lightweight aggregate ("Dębówka" and "Żulin"). Currently, none of the above-mentioned deposits are being in production. In the past, the mineral product was extracted only from three minor (0.8–1.14 ha) deposits of clay raw materials for construction ceramics: "Rudnik I", "Zakątek" and "Lublin-Przejrzysta". The deposit layer consists of beige-yellow loess with an average thickness of 8.8–9.1 m, occurring right on the surface or under a thin soil layer. The raw material was processed at small local brickyards and used to produce building ceramics, mainly solid bricks (Heliasz et al., 2011; Dusza-Dobek et al., 2011). Declining demand for local ceramic building products led to the gradual expiry of concessions and the closure of mining operations. Finally, licensed loess mining was terminated in 2012. The "Rudnik I" and "Zakątek" deposits remain abandoned, and their excavations have been reclaimed (Bąk, Milianowicz, 2021a). The "Lublin-Przejrzysta" deposit, which has not been exploited since 2002, is already removed from the register of Mineral Resources of Poland in 2021.

The most numerous group of mineral deposits is represented by those occurring in Quaternary sand layers. According to the MIDAS database, 24 sand fields have been so far documented in the study area. These mineral deposits are generally concentrated in two areas – in the north-eastern part of the analysed area, where 11 deposits have been documented ("Turka", "Turka I", "Turka II", "Turka III", "Turka IV", "Turka V", "Turka VI", "Turka VII", "Łuszczów VII," "Łuszczów IX," and "Łuszczów X") and at its south-eastern edge, where 10 deposits have been identified ("Dominów I," "Wilczopole I," "Mętów I," "Skrzynice II," "Skrzynice III," "Skrzynice IV," Skrzynice V, Skrzynice VI, Skrzynice VII, and Jadwisin I). In addition, three mineral deposits have been found in the south-western part of the study area: Zemborzyce, Zemborzyce-Prawiedniki and Cienista. The vast majority of the sand deposits in the Lublin area and its surroundings cover an area of less than 2 ha. The mineral product is mainly fine- and medium-grained sand, often with interbeds of silty and clayey sands, silts, and local coarse-grained sands.

Mining operations were conducted within the boundaries of 22 deposits (Heliasz et al., 2011; Król et al., 2011). The raw material was used for local needs, for road and construction works, and for some earthworks. Currently, the sand mineral deposits are abandoned – the extraction of aggregate from the last deposit developed in the area ("Jadwisin I") was completed in 2016. Following the termination of extraction, the "Turka", "Turka V", "Turka VI", "Turka VII", "Dominów I", "Skrzynice II", "Skrzynice IV", "Skrzynice VI" and "Jadwisin I" were removed from the register of Mineral Resources of Poland, and the "Turka II", "Turka III", "Turka IV", "Łuszczów IX", "Wilczopole I", "Mętów I", "Skrzynice III" and "Skrzynice V" deposits are classified as abandoned. Aggregate extraction was also carried out within the boundaries of five formally undeveloped deposits: "Zemborzyce", "Zemborz.-Prawiedniki", "Turka I", "Łuszczów VII" and "Luszczów X" (Heliasz et al., 2011; Król et al., 2011). Most of the excavations left after sand extraction have been reclaimed (Heliasz et al., 2011; Król et al., 2011; Bąk, Milianowicz, 2021a, 2021b).

In the past, unlicensed mining of minerals to meet the needs of local populations was taken place at several locations within the study area. Sands, loess, marls, opokas and gaizes were periodically extracted here on a small scale.

LAND DEVELOPMENT AND LAND USE

According to Corine Land Cover 2018 (CLC), an inventory of European land cover, a significant part of the study area (over 50%) is occupied by agricultural land, including arable land and mixed cropland (https://land.copernicus.eu/en). These are located mainly in the Świdnik Plateau and the Bełżyce Plateau (Richling et al. (eds.), 2021). Most of the Nałęczów Plateau is occupied by residential, service and recreational facilities. The areas of loose and dense development practically coincide with the cities of Lublin and Świdnik. Industrial areas of Lublin are concentrated in the Tatary quarter (righ-bank side of the city), while the industrial area in Świdnik is almost entirely represented by the Wytwórnia Sprzętu Komunikacyjnego plant (PZL-Świdnik Transport Equipment Plant). The river valleys feature green areas used for recreational purposes. In the south, this function is performed by the Zemborzycki Reservoir and the adjacent Dąbrowa Forest. The forest complexes consist of mixed forests (with oak and pine predominant in the tree stand), which are found mainly in the Bełżyce Plateau and Świdnik plateaus (Studium cz. I, 2019).

Due to its natural and landscape values, part of the study area is under legal protection. In its eastern side, there is the Wierzchowiska Reserve (24.52 ha in area), which was established to preserve oak-hornbeam forest, locally dominated by lime trees, as well as numerous rare and protected herbaceous plant species. The Stasin Reserve (24.4 ha), situated in the west of the study area, protects part of deciduous forest with a high proportion of black birch. The southern part of the study area is located within the Czerniejów Protected Landscape Area, while its northern edges lie within the boundaries of the Ciemięga Valley Protected Landscape Area. The study area also includes two Natura 2000 sites, designated as special areas of habitat conservation. One of them, Bystrzyca Jakubowicka (PLH060096), stretches along the Bystrzyca River valley in the north-eastern part of the study area and continues beyond its northern boundary. The other area, Świdnik (PLH060021), is located in the eastern part. Its range largely overlaps with that of the ecological site Siedlisko Susła Perełkowanego (https://geoserwis.gdos.gov.pl/mapy/); (https://parki.lubelskie.pl/obszary-chronionego-krajobrazu).

ECONOMY

For many years, economic activity in the study area was linked to the food, automotive, metallurgical, pharmaceutical, energy and aviation industries, and to a lesser extent to mining. It was concentrated mainly in the cities of Lublin (city quarters: Kośminek, Za Cukrownią, Kalinowszczyzna, Wrotków, Tatary, Bronowice, Dziesiąta, Felin and Sławinek) and Świdnik (Studium cz. I, 2019). The remaining area was dominated by agriculture (Smakulski et al., 2021; Program..., 2024). The oldest branch of the food industry was milling. Its most intensive period of development was in the 1880s (Czuchryta, 2003), being facilitated by the natural topography and numerous river valleys, which were used to build dams and create flow-through ponds, close to which mills were located (Kociuba, 2019). At present, the food industry continues to play an important role in the economy of the region. There are many Polish companies with a long tradition, well-known both in Poland and abroad, including Lubella SA in Lublin – a producer of pasta and breakfast cereals (part of the Maspex Group since 2003); Perła-Browary Lubelskie SA brewery, Stock Polska sp. z o.o. – a producer and distributor of alcoholic beverages, part of Stock Spirits Group Ltd.; Herbapol Lublin SA – a producer of, i.a., herbal teas; Spółdzielnia Pszczelarska APIS in Lublin – a producer of honey and mead. The plants are located mainly in the industrial areas of the Wrotków and Tatar quarters (Szczepanik, 1973; Kociuba, 2010; https://lublin.eu/gfx/lublin/userfiles/_public/pliki_do_pobrania/broszury_informacyjne/przemysl_spozywczy_w_lublinie_pl.pdf).

Unlike the food industry, the automotive and metallurgical industries were important to the region's economy in the post-war period until economic changes began in 1989. The history of the automotive industry dates back to the inter-war period, when the construction of a car factory under licence from General Motors began in 1938. In the post-war period, the construction was resumed. Finally, it was launched in 1951 under the name Fabryka Samochodów Ciężarowych (FSC) in Lublin (FSC Lublin Automotive Factory). Since 1995, the plant has had several owners, including Daewoo Motor Polska, DZT Tymińscy, and Ursus SA. It ceased operations in 2021. During its activity, the plant manufactured agricultural tractors, trolleybuses, trucks, delivery vans, and passenger cars (https://www.domzalski.pl/historia/lubelski-ursus/). At present, the former FSC site in Lublin is home to a number of warehouses and smaller industrial plants representing various economy sectors. In the Lublin region, the automotive industry is represented by small and medium-sized enterprises that produce various components for automotive companies (https://gospodarczy.lublin.eu/branze/specjalizacje-gospodarcze-lublina/przemysl-motor-i-maszynowy/). One of the best-known manufacturers of agricultural and gardening machinery in Poland and abroad is the Sipma SA company that operates in the Wrotków quater. Since 1996, it has been part of the Sipma Group (https://www.sipma.pl/o-firmie/grupa-sipma/). The metallurgical industry played a minor role in the study area. Between 1972 and 2000, an iron foundry – Odlewnia Ursus – operated in the Lublin area. It was one of the largest plants of its kind in Poland. It produced large-size components and advanced thin-walled castings, water access chambers, anchors, and radiator ribs (https://www.farmer.pl/technika-rolnicza/maszyny-rolnicze/co-zostalo-z-wielkiej-odlewni-ursusa-w-lublinie,140960).

When discussing the development of economic activity in Lublin during the post-war period, it is also important to mention the establishment and operation of two pharmaceutical companies under several different names: the Synthaverse SA (a serum and vaccine manufacturer) and the Polfa Lublin SA (a manufacturer of infusion fluids and small medical devices) (https://synthaverse.com/pl/o-firmie/; https://polfa.pl/pl/o-nas/).

The energy industry has its origins in 1928, when the first power plant was built in the Kośminek quarter. Initially, it produced energy only for the needs of small industrial plants, with a small surplus sold to a few customers, and provided electricity for street lamps and households (https://teatrnn.pl/leksykon/artykuly/elektrownia-w-lublinie/). At present, the energy sector is represented by the PGE Energia Ciepła SA Branch in Lublin (in the map: Lublin-Wrotków Heat and Power Plant), Elektrociepłownia Megatem EC-Lublin Sp. z o.o. (heat and power plant), and Veolia Wschód Sp. z o.o. Zakład Świdnik. These were built after the end of World War II (Studium cz. I, 2019; https://veoliaterm.pl/strefa-klienta/veolia-wschod/).

Świdnik became the centre of the aviation industry in the post-war period, where the Wytwórnia Sprzętu Komunikacyjnego (WSK) PZL-Świdnik SA (on the map and hereinafter: WSK PZL-Świdnik) was established in the 1950s. However, the Lubelskie Zakłady Samolotów (Lublin Aircraft Factory), located in the Bronowice quarter before World War II, did not resume its activities. In 2012, the Lublin International Airport SA (https://www.pzlswidnik.pl/pl/o-nas/nasza-firma/historia) was launched in the area of the existing WSK PZL-Świdnik airport.

The study area hosts numerous brickyards, and he first ones were established as early as the 12th century. In 1928, there were 11 factories producing building ceramics in Lublin. Several more brickyards were located at Konopnica and Zemborzyce. The last brickyard in Lublin was closed in 2010 (https://teatrnn.pl/leksykon/artykuly/lubelskie-cegielnie/#upanstwowienie-cegielni).

In the eastern part of Lublin, in the Felin quarter near the under-construction ring road, the S17 expressway junction and the Lublin Airport SA, the EURO-PARK Mielec Special Economic Zone Lublin Subzone (on the map SSE EURO-PARK Mielec Podstrefa Lublin) has been operating since 2007. It covers an area of 128 hectares and is home to 82 businesses. Around 6,500 people are employed in the Subzone (https://sse.lublin.eu/). Most of the companies represent industries that align with the city's specialisms, i.e. metal and machinery, biotechnology, and food (Czuprym et al., 2021).

HUMAN IMPACT

Atmospheric air. The main source of air contamination in the study area is emissions from the municipal and residential sectors (surface emissions). Transport (linear) emissions and industrial (point source) emissions have a smaller impact on air quality (Lesicka et al., 2020). The magnitude of surface emissions is affected mostly by a large number of low emitters, discharging combustion products from domestic furnaces and local coal-fired boiler rooms, at low altitudes and with low outlet velocities (Pietrusiak, 2020). The released contaminants tend to accumulate around their sources, which are most often found in densely populated residential areas. This results in the accumulation of harmful substances, mainly particulate matter and benzo(a)pyrene, in small areas with high population densities (Lesicka et al., 2019). It is estimated that the municipal and residential sectors of the Lublin agglomeration were responsible for nearly 88.6% of PM10 emissions, over 92.9% of PM2.5 emissions, and nearly 90.6% of benzo(a)pyrene emissions in 2020 (Pietrusiak, 2020). Linear emissions occur in areas that are directly adjacent to heavy traffic roads (expressways S12, S17 and S19, as well as national road No. 82). Traffic contamination in the form of dust is caused by the abrasion of vehicle tyres and brakes, and by the erosion of road surfaces. Contaminants are also lifted from road surfaces (Smakulski et al., 2021). The emissions from combustion engines cause an increase in the concentration of nitrogen oxides and benzene (Lesicka et al., 2019). Industrial emissions originate from facilities involved in the production of commercial energy. The largest amount of contamination is released into the atmosphere by combined heat and power plants: the Megatem EC-Lublin in Lublin, PGE Energia Ciepła SA Branch in Lublin, and Veolia Wschód Sp. z o.o. Zakład Świdnik. Because the emitter sources are tall, contaminants from these plants are transported largely beyond the borders of the Lublin Voivodeship (Lesicka et al., 2023).

The study area is located within two zones: the Lublin agglomeration (which coincides with the Lublin city area) and the Lublin zone (which covers the municipalities described in the study). For these zones, annual assessments of air pollutant levels are carried out as part of the *State Environmental Monitoring* (SEM) (Lesicka et al., 2025). Based on measurements taken at monitoring stations and analyses performed using an air quality modelling-based estimation method, exceedances of benzo(a)pyrene in PM10 dust in the Lublin zone and ozone in both zones were found. Exceedance of the benzo(a)pyrene level in PM10 dust was due to emissions from the municipal and residential sectors, i.e. "low" emissions from the individual heating of buildings. Excessive levels were observed during the heating seasons, January–March, October–December (Lesicka et al., 2025). Ozone exceedances were related mainly to the weather conditions prevailing in 2024 (Lesicka et al., 2025), as well as to the release of nitrogen oxides into the air (Makles, Galwas-Zakrzewska, 2004).

In recent years, low levels of air contamination (below the permissible/target levels) have been found in the study area for sulfur dioxide, nitrogen dioxide, benzene and carbon monoxide, as well as for metals measured in PM10 particulate matter: lead, arsenic, cadmium and nickel (Lesicka et al., 2025). In addition, there has been a gradual improvement in air quality in terms of PM10 and PM2.5 contamination over the last decade. This is due to a large number of individual furnaces being connected to district heating networks and the gradual transition from solid fuels to so-called "clean" fuels (Lesicka et al., 2023; TRANSEKO sp.j., 2018).

Soils. The soils in the study area are characterized by spatial variability resulting from the region's geological structure, terrain relief, water relations, vegetation cover, and human activity such as urbanization, industrialization and agriculture processes (Chodorowski et al., 2024). Lessive (**luvisols/alfisol)** and brown (cambisol) soils (which formed on loess) are found in the Nałęczów Plateau. The Bełżyce and Świdnik plateaus are covered by soils that formed from sandy silts and loess-like silty sands. Brown soils, which developed on loess, and rendzinas occur in a small area in the Giełczew Hills. Organic soils and alluvial soils are present in river valleys (Bystrzyca, Czerniejówka and Czechówka rivers) and around the area of the Zemborzycki Reservoir (Plak, 2007; Chodorowski et al., 2024; Tołoczko, 2020). Anthropogenic soils are found in urbanized and industrial areas, as well as along transport routes (Chodorowski et al., 2024). The study area is dominated by class II soils, with only a small proportion of class I and IIIa soils. Its western part is dominated by soils classified as complex II – good wheat complex. The eastern part is characterised by poorer quality soils, with a predominance of defective wheat and very good rye complexes included in class III. There is also some proportion of class IV soils, and in some places, even class V (Smakulski et al., 2021).

Based on the assessment of soil chemical condition carried out as part of the *State Environmental Monitoring* (SEM) for arable soils in Poland, no contamination has been found at the measurement and control point No. 283 at the village of Świdniczek (https://www.gios.gov.pl/chemizm_gleb/index.php?mod=pomiary&p=283). However, a few studies have documented the presence of point contamination sites within the investigated area (Kłosowski, 2013; Suska-Jakubczak, 2010; Maciołek et al. 2013; Smakulski et al. 2020). The topsoil layer along Lublin's main transport routes shows slightly higher contents of lead and zinc (7–54 mg/kg Pb and 11–99 mg/kg Zn) than the soils located further away from expressways (Strupieniuk, Farjan, 2001). Analysis of the natural and anthropogenic factors that cause urban soils to become enriched with As, Cd, Cr, Cu, Hg, Ni, Pb, S and Zn shows that the topsoil (0.0–0.2 m depth) in Lublin is among the least contaminated in Poland (Pasieczna, 2003).

The study area also includes sites listed in the *Register of Direct Threats of Environmental Damage and Environmental Damage* and in the *Register of Historical Land Contamination* (https://geoserwis.gdos.gov.pl/mapy/). Historical contamination of the land surface involves several substances, including metals (e.g. Ba, Cd, Co, Cr, Cu, Hg, Mo, Ni, Pb, Sn and Zn) and organic compounds (e.g. anthracene, toluene, benzo(b)fluoranthene, benzo(a)anthracene, benzo(a)pyrene, chrysene, indeno(1,2,3-c,d)pyrene, xylenes, total C12–C35 hydrocarbons in oil fraction, total C6–C12 hydrocarbons in petrol fraction). Among the contaminants causing damage to the environment (for the component *land surface*) are metals (e.g. Ba, Cd, Cr, Cu, Ni, Pb and Zn) and organic compounds (e.g. sum of C12-C35 hydrocarbons in oil fraction and total C6–C12 hydrocarbons in petrol fraction). Preventive or remedial measures have already been completed at most of the registered locations. However, the status of remediation work in these areas varies (completed/in progress/not undertaken).

Aquatic sediments. Previous studies of aquatic sediments in the study focused mainly on the Bystrzyca River and the Zemborzycki Reservoir. The results showed elevated levels of Cd, Co, Ni and Zn in sediment samples collected from the lower section of the Bystrzyca River, from Lublin to its confluence with the Wieprz River (Bojakowska, Sokołowska, 1996). Analyses

performed in 2022 as part of the regular inland surface water quality monitoring programme within the SEM, which has been carried out since 1995, also show that the Environmental Quality Standards (EQS) were exceeded in aquatic sediments collected at two locations on the Bystrzyca River (one of which was located about 1 km south of the study area). Sediments from these locations were classified as contaminated (Stefaniak et al., 2022). At the site located within the study area, only excessive Zn content was recorded – 477 mg/kg (EQS value: 120 mg/kg). At the other site, however, exceedances were found for seven parameters: Cd – 77.60 mg/kg; Cr – 88.40 mg/kg; Cu – 104 mg/kg; Ni – 92.14 mg/kg; Pb – 79.60 mg/kg; Zn – 447 mg/kg, and the total content of polycyclic aromatic hydrocarbons (PAHs) – 2541 µg/kg. Studies of Bystrzyca River sediments, carried out as part of an inventory of contaminated areas in the periods 1980–1983 and 1992–1993 (sampled during spring and autumn), showed a clear negative impact of anthropogenic factors (due to urbanization) on the condition of the aquatic sediments. An increase in sediment acidification was observed from the head to the mouth of the Bystrzyca River (Turski et al., 1985). High levels of Cd, Cu, Pb and Zn were recorded in sediments from the middle and lower sections of the river. The chemical composition of the sediments was affected by sewage from the meat processing plant – *Lubelskie Zakłady Mięsne* (Cu, Mn, Pb and Zn emissions) and the dyeing plant – *Zakłady Farbiarskie* (Cd and Zn emissions). The Wrotków housing estate also contaminated the sediments with all these metals. The results of the studies clearly indicated an increase in the content of the elements in the sediments along the river course (Misztal et al., 1996). Based on archival data obtained as part of the *Geochemical Atlas of Poland*, it can also be concluded that elevated levels of metals (Cd and Cr) in the Bystrzyca River sediments and water occurred in its final section within the borders of Lublin (Lis, Pasieczna, 1995).

Surface waters. An assessment of the status of surface water bodies, based on monitoring data from 2019 to 2024, in accordance with the Regulation of the Minister of Infrastructure of 25 June 2021 on the classification of ecological status, ecological potential and chemical status, and the method of classifying the status of surface water bodies, as well as environmental quality standards for priority substances (Rozporządzenie..., 2021), indicates poor surface water quality in the study area. The waters were characterized by bad to poor ecological status and poor ecological potential, with the exception of the SWB Dopływ z Łuszczowa and the SWB Czerniejówka, where moderate potential was found (Ocena..., 2021–2024). This situation is influenced mainly by surface runoff from agricultural areas and rainwater from urban areas: roads, squares, car parks and roof surfaces. The water quality is also affected by industrial activity and contamination from municipal and domestic sources, as well as transport and tourism (SWB Ciemięga and SWB Bystrzyca from the Zemborzycki Reservoir to the river's mouth). The catchment areas of all of the river surface-water bodies are sensitive to eutrophication caused by emissions from municipal sources. Each of the SWBs have been identified as being at risk of failing to meet the environmental targets set out in the Water Management Plan for the Vistula River Basin (Rozporządzenie..., 2023).

Other studies have also confirmed the problem of water eutrophication at the Zemborzycki Reservoir, which is the largest water body in the study area. The excessive concentration of biogenic compounds (phosphorus and nitrogen) in the water has a significant negative impact on the ecological status of this reservoir. This is primarily due to the continuous supply of biogenic compounds in dissolved or suspended form, flowing from the surrounding agricultural areas into the Bystrzyca River. As the reservoir is shallow, the concentration of phosphorus and nitrogen in its waters increases rapidly, and these elements continuously accumulate within the bottom sediments (Dobrowolski et al., 2016). The bottom of the reservoir is covered with a thick mud layer. This is due, in part, to the inadequate preparation of the site during the reservoir's construction (prior to 1974, the reservoir area consisted of wet meadows with a several-metre-thick peat layer) (https://teatrnn.pl/leksykon/artykuly/zalew-zemborzycki/).

Research conducted at the Polish Geological Institute in the 1990s as part of the *Geochemical Atlas of Poland* revealed elevated concentrations of several metals (Cu, Fe and Mn) in the waters of the Bystrzyca River, particularly in the lower river section within the borders of Lublin city (Lis, Pasieczna, 1995).

Groundwater. The study area is located in the Lublin-Radom hydrological region (VII) (Paczyński, Sadurski (eds.), 2007). According to the division into groundwater bodies (GWB), it is located within the boundaries of GWB No. 89 (covering over 80% of the study area) and GWB No. 90 (in the east and south-east; https://www.pgi.gov.pl/psh/zadania-psh/8913-zadania-psh-jcwpd.html). The usable groundwater levels are generally found in fissured rocks and are recharged either directly or through the infiltration of rainwater via loess deposits occurring on the ground surface. They are also recharged through thin layers of glacial tills or deluvial loamy deposits resting on weathered Cretaceous rocks. The geological structure poses a threat to the groundwater because contaminants can easily migrate. In areas without aquitards, the time of water to infiltrate into the groundwater table is determined solely by its depth. Despite the unfavourable geological conditions, the quality of the groundwater is assessed as good (https://bazadata.pgi.gov.pl/data/hydro/jcwpd/jcwpd90.pdf; https://bazadata.pgi.gov.pl/data/hydro/jcwpd/jcwpd89.pdf).

The study area is located within the range of the major groundwater reservoir MGR No. 406 Lublin Basin (Lublin). This reservoir is composed of Upper Cretaceous carbonates and contains groundwater within a pore-fracture medium. In most cases, the water has been categorized as classes I and II (locally class III in the valleys of major rivers and in small areas in the central, northern and north-western parts of the reservoir). Its chemical condition has been assessed as good. The main sources of potential threats to the quality of the reservoir's waters are areas without sewage systems, sewage treatment plants, liquid fuel storage facilities, the road and railway network, and agricultural production areas. The reservoir does not yet have any designated protection zones. However, due to the presence of susceptible and highly susceptible areas to contamination within its boundaries, the reservoir documentation proposes a protected zone divided into four sub-areas. The study area covers parts of the following three sub-areas: A – highly susceptible to contamination, B – susceptible to contamination, and C – urban areas, including Lublin and Świdnik (Mikołajków, Sadurski (eds.), 2017).

Sewage treatment plant. Municipal (domestic and industrial) sewage is sent to the Hajdów Sewage Treatment Plant, which is located on the eastern outskirts of Lublin. It is a mechanical-biological sewage treatment plant with increased removal of biogenic compounds (nitrogen and phosphorus). It receives wastewater from the municipalities of Lublin, Świdnik, Głusk, Jastków, Konopnica, Niemce and Wólka. The treatment plant has an average daily capacity of 120,000 m^3/d. The Bystrzyca River is the recipient of the treated wastewater (Uchwała..., 2021). The average reduction rate of basic contamination indicators is 97.4%, enabling the plant to comply with the terms of the water permit (https://www.mpwik.lublin.pl/o-spolce/infrastruktura/obiekty/). The Lublin city sewage system is a distribution-type system. Rainwater is discharged into the Bystrzyca, Czerniejówka and Czechówka rivers via a separate storm-water drainage system (https://www.mpwik.lublin.pl/wp-content/uploads/2023/02/Deklaracja-Srodowiskowa-2021.pdf). Treated industrial sewage from the WSK PZL-Świdnik plant is discharged into a minor watercourse called Graniczny Rów (a tributary of the Sławka River) via a collector.

RESEARCH SCOPE AND METHODS

The research carried out between 2023 and 2025 during the development of the *Geochemical Atlas of Lublin and Environs at a scale of 1:50,000* included the following stages: study of published and archival materials, delineation of the soil sampling grid, sampling, recording of geographic coordinates of sampling sites, field measurements of pH and specific electrical conductivity (EC) of surface waters, chemical analyses at the PGI-NRI laboratory, development of databases for storing measurement results, field observations and results of laboratory analyses of samples, calculations and statistical analyses for the research results, development of a topographic base, a geological map, and geochemical maps, and interpretation of the research results. The workflow sequence is illustrated in the diagram below (Figure 3).

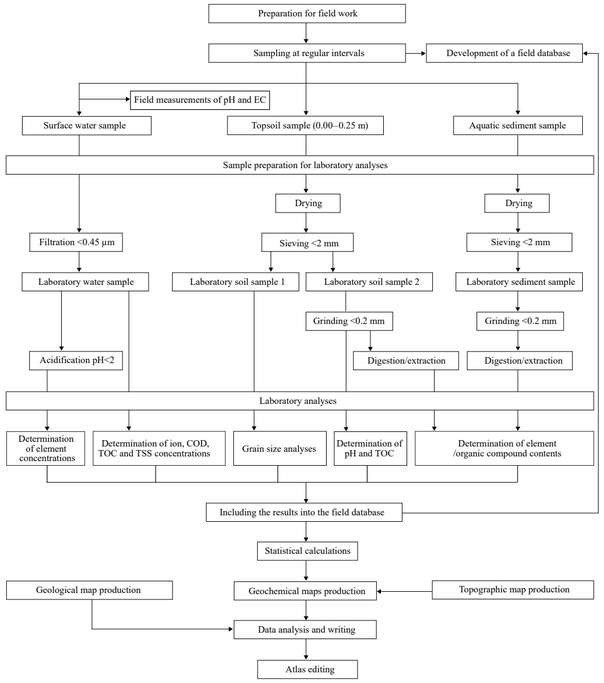

Figure 3. Workflow scheme

FIELD WORK

Designation of sampling sites. The sampling sites were located using GPS devices (measurement accuracy from 2 m to 5 m), and additionally marked in the field on topographic maps at a scale of 1:10,000. The applied devices enabled both the measurement of geographic coordinates and the recording of additional information, such as sample number and sample types, data on land development and land use. Before heading out into the field, spatial data (in the form of a shapefile) were entered into the GPS device's memory. The data show the locations of the sampling sites in accordance with the adopted grid. To provide additional security, all field information was also recorded on specially prepared field sheets (Figure 4).

Soil sampling. Soil samples in the study area were collected in a regular grid of 500×500 m (4 samples/km^2) in the cities of Lublin and Świdnik, and in a grid of 1000×1000 m (1 sample/km^2) outside city areas. The location of soil sampling sites is documented on maps showing both land development and land use (Plates 2 and 3). Soil samples were collected at 909 locations (points) from the topsoil layer (depth 0.00–0.25 m) to determine the granulometric composition, pH, and inorganic content. The samples were taken using a 60 mm diameter hand auger (Eijkelkamp). Each sample (weighing approximately 500 g) was placed in a linen bag labelled with an appropriate identification number and then pre-dried on wooden pallets in a field storage facility. An additional soil sample was collected at every fourth grid point (237 locations in total) to determine the content of organic compounds. Samples for organic compound analysis were placed in 250 ml dark glass jars and transported in a coolbox (at a temperature of approximately 4–8°C).

Sampling of aquatic sediments and surface waters. Samples of surface waters and aquatic sediments (182 and 169 samples, respectively) were collected from rivers, streams, ditches, canals, lakes, settling ponds, and natural ponds. The same locations were used for the collection of pairs of water and sediment samples. The difference in the number of water and sediment samples is because it is sometimes impossible to collect a sediment sample due to a lack of material, such as in areas where the river channel has been concreted. The distance between sampling points in watercourses and reservoirs was approximately 500 m within city borders, and around 1000 m outside cities. In addition, sediment samples for the content of organic compounds were collected at every fourth location (49 locations in total). The location of sampling sites is shown on the plates illustrating the content of individual chemicals in these environmental compartments. Aquatic sediment samples of the finest possible fraction were collected using an aluminium sampling bucket and then placed in 500 ml plastic vessels labelled with the appropriate numbers. The sediment samples collected for the determination of organic compound content were placed in 250 ml dark glass jars. All activities were performed using disposable powder-free nitrile gloves.

Surface water samples were taken directly from watercourses and reservoirs using a plastic syringe. In a few cases, where it was impossible to reach the water surface by hand, samples were collected using an aluminium sampling bucket. Specific electrical conductivity (EC) and pH of the water were measured in the field using a dual-function meter – a conductometer combined with a pH meter (Elmetron CPC-105) with automatic temperature compensation, taking 25°C as the reference temperature. After collection, the water samples were filtered in the field using Millipore syringe filters with a pore diameter of 0.45 µm, poured directly into 30 ml plastic (PE) bottles containing 1.5 ml of HNO_3 (v/v 1:4), and labelled with the symbol K. The acidified samples had a pH level of less than 2. Water for total organic carbon (TOC) analysis was poured into plastic bottles (PE, 15 ml), labelled with the symbol TOC. Water intended for anion concentration determination was poured into bottles (PE, 250 ml) marked with the symbol A. The samples used to determine anions and TOC were not filtered in the field. All sample bottles were labelled with identification numbers, packed in separate plastic bags, and placed in a coolbox (temperature approximately 4–8°C). All surface water samples and sediment samples intended for the determination of organic compound content were transported in a coolbox to the PGI-NRI Chemical Laboratory (ChL) in Warsaw, and delivered to the ChL within a maximum of 5 days after collection. In order to limit sample contamination, brand new vessels, filters and syringes were always used.

POLISH GEOLOGICAL INSTITUTE - NATIONAL RESEARCH INSTITUTE
Geochemical Atlas of Lublin and Environs at a scale of 1:50,000 **A)**

Date: .....
Person: .....

Organic compounds ☐

Sample ID | **Coordinates, PL-1992**

1 ☐☐☐☐☐ Depth x 0,00–0,25 | X ☐☐☐☐☐☐
Y ☐☐☐☐☐☐

No. of photo ☐☐☐

District: ..... Community: ..... Place: .....

Land development	Land use	Soil type
1 ☐ non-built areas	1 ☐ cultivated field	1 ☐ sand
2 ☐ village dev.	2 ☐ forest	2 ☐ sand-clay
3 ☐ low-rise dev.	3 ☐ meadow	3 ☐ clay-sand
4 ☐ high-rise dev.	4 ☐ fallow field	4 ☐ clay
5 ☐ industrial ares	5 ☐ lawn	5 ☐ till
	6 ☐ park	6 ☐ sandy silt
	7 ☐ allotment	7 ☐ peat
		8 ☐ anthropogenic
		9 ☐ loess, silty loess-like sand

Notes:.....

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Geochemical Atlas of Lublin and Environs at a scale of 1:50,000 **B)**

Sediment	Org. comp.	☐
Water	K ☐ C ☐ F ☐ T ☐ A ☐	

Date: .....
Person: .....

Sample ID | **Coordinates, PL-1992**

Sediment: 3 ☐☐☐☐☐ pH ☐☐☐☐ | X: ☐☐☐☐☐☐
Water: 4 ☐☐☐☐☐ EC ☐☐☐☐ | Y: ☐☐☐☐☐☐

No. of photo ☐☐☐

District:..... Community: ..... Place: ..... Water body: .....

Land development	Land use	Water body	Sediment
1 ☐ non-built areas	1 ☐ cultivated field	1 ☐ river	1 ☐ sand
2 ☐ village dev.	2 ☐ forest	2 ☐ stream	2 ☐ organic mud
3 ☐ low-rise dev.	3 ☐ meadow	3 ☐ lake	3 ☐ silt
4 ☐ high-rise dev.	4 ☐ fallow field	4 ☐ reservoir	4 ☐ clay
5 ☐ industrial ares	5 ☐ lawn	5 ☐ canal	
	6 ☐ park	6 ☐ ditch	
	7 ☐ allotment	7 ☐ pond	
		8 ☐ fish pond	
		9 ☐ setting pond	

Notes:.....

Figure 4. Field sampling sheets for samples of soils (A) and sediments and surface waters (B)

LABORATORY WORK

Mechanical preparation of samples. Physicochemical analyses, including sample preparation, were performed at the PGI-NRI Chemical Laboratory in Warsaw. Soil and aquatic sediment samples were dried at room temperature and sieved through 2 mm mesh nylon sieves. Each soil sample from a depth of 0.00–0.25 m (topsoil), after sieving, was divided into two sub-samples – one for chemical analysis and the other for granulometric analysis. The sediment and soil samples intended for chemical analysis were grinded to a fraction of <0.2 mm in agate ball mills (Figure 3).

Chemical preparation of samples – acid digestion. Dried, sieved and grinded samples of soils and sediments were subjected to acid extraction using aqua regia (HCl and HNO_3, volume ratio of 3:1). The samples were weighed into reaction vessels and then acids were added; 8 ml of aqua regia was used per 1g sample. Prepared in this way, the samples were left at room temperature for at least 16 hours. After this time, they were placed in a thermostatic heating block. The temperature of the reaction mixture was gradually raised to ca. 95°C, and the dissolution process was continued under these conditions for 1 hour. After cooling, the dissolved samples were filtered through a filter paper. The extract was supplemented with distilled water to a final weight of 50 g.

Chemical preparation of samples – solvent extraction technique. Dried, sieved and grinded samples of soils and sediments were subjected to extraction procedures to isolate the compounds to be determined. Dichloromethane extraction, using an accelerated solvent extractor at elevated temperature and pressure (100°C, 1500 psi), was used to isolate compounds from the group of polycyclic aromatic hydrocarbons (PAHs). Extraction using a mixture of hexane and acetone (volume ratio 1:1) was performed with the use of an accelerated solvent extractor at elevated temperature and pressure (100°C, 1500 psi) to extract compounds from the group of polychlorinated biphenyls (PCBs) and organochlorine pesticides (OCPs). Shaking extraction with tetrachloroethene was used to extract mineral oils.

Chemical analyses. The following measurement methods were employed in the analysis of soil, aquatic sediment and surface water samples:

- Inductively coupled plasma optical emission spectrometry (ICP-OES) to determine the contents of Al, As, Ba, Ca, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, P, S, Sr, Ti, V and Zn in soils and sediments;
- Inductively coupled plasma mass spectrometry (ICP-MS) to determine the contents of Ag, Be, Cd, Co, Li, Mo, Pb, Sb, Se, Sn, Tl and U in soils and sediments;
- Cold Hg vapour atomic absorption spectrometry (CV-AAS) in a flow-injection system to determine the Hg content in soils and sediments;
- Potentiometric titration in a 1 mol/l of KCl solution (pH-KCl), using a weight-to-volume ratio of 1:5 (soil:KCl), to determine the pH of soils;
- High-temperature combustion method with infrared (IR) detection to measure the total organic carbon (TOC) content in soils and sediments;
- Inductively coupled plasma optical emission spectrometry (ICP-OES) to measure the concentrations of B, Ba, Ca, Cr, Fe, K, Mg, Mn, Na, P, Si, Sr, Ti and Zn in water;
- Inductively coupled plasma mass spectrometry (ICP-MS) to determine the concentrations of Ag, Al, As, Be, Cd, Co, Cu, Li, Mo, Ni, Pb, Sb, Se, Sn, Tl, U and V in water;
- Ion chromatography (IC) method to determine the concentrations of Br^-, Cl^-, F^-, NO_2^-, NO_3^- and SO_4^{2-} anions in water;
- Spectrophotometric method to determine the concentrations of NH_4^+, HCO_3^-, total suspended solids, and COD in water;
- Gas chromatography coupled with mass spectrometry (GC-MS) to determine the contents of polycyclic aromatic hydrocarbons (PAHs) in soils and sediments;
- Gas chromatography with electron capture detection (GC-ECD) to determine the contents of polychlorinated biphenyls (PCBs) and organochlorine pesticides (OCPs) in soils and sediments;
- Fourier transform infrared spectroscopy (FTIR) to determine the total amount of mineral oils in soils and sediments.

Quality control of the determinations was performed both at the sampling stage and during physicochemical analyses. Approximately 2–3% of the total number of samples taken in the field were duplicates. Quality control of the determinations included analysis of duplicate samples (5% of all samples), analysis of reference materials with certified content of the tested chemicals (2% of all samples), and analysis of internal control samples (5% of all samples). The purity of reagents and vessels was checked using "reagent blanks" containing solutions of appropriate chemical reagents, if they were added to the analysed samples at any stage of laboratory testing. The potential impact of contamination during sample preparation for analysis was verified using "procedural blanks".

A summary of the determined physicochemical parameters, along with the analytical methods, limits of determination, and result uncertainties, is presented in Tables 1 and 2. The expanded uncertainty of the results is given for a 95% confidence level and a coverage factor of k = 2.

Granulometric (grain size) analyses. Determination of the grain size distribution in topsoil samples (0.00–0.25 m depth) was performed at the Soil and Rock Laboratory Testing Centre, Department of Engineering Geology, PGI-NRI, Warsaw. The grain size composition was determined using sieve (granulometric) analysis according to an in-house procedure developed on the basis of the PN-EN ISO 17892-4:2017-01 Standard. The procedure involved weighing a soil sample of ca. 35–40 g, and adding an appropriate amount (10–100 ml) of 30% hydrogen peroxide solution, depending on the soil type, to oxidize organic matter. The sample was then dried, weighed after cooling, flooded with water, and washed through a 0.02 mm mesh sieve. The residue on the sieve was dry-sifted through a column of sieves with mesh sizes of 2 mm, 0.063 mm and 0.02 mm, and the resulting fractions of 2–0.063 mm, 0.063–0.02 mm, and <0.02 mm were weighed. The results of the grain size analyses (after conversion to percentage fractions) are presented in grain class maps for fractions $0.063 < d \leq 2.0$ mm, $0.02 < d \leq 0.063$ mm, and $d \leq 0.02$ (Plates 4–6).

DATABASES AND GEOCHEMICAL MAP CONSTRUCTION

Databases. Three separate datasets (Excel spreadsheets) were created for topsoil (from a depth of 0.00–0.25 m), aquatic sediments, and surface waters. The following information was included: sample identification numbers, geographic coordinates of sampling sites, field observations (including the type of land development and land use in all environments tested, the type of soil in soil samples, the type of water body/watercourse in aquatic sediment and surface water samples, and the type of aquatic sediment), administrative location of sampling sites (including district, municipality and locality), the date of sampling, the name of the sample collector, and the results of chemical analyses. The data were entered into three separate tables (for soils, aquatic sediments, and surface waters) and then input into the database of the Central Geological Database (CBDG), which operates in the Oracle environment. This database stores descriptive (metadata), numerical (results of chemical analyses of samples), and geometric information. Based on this data, a cartographic version of the study was prepared.

Descriptive statistics. Statistical parameters were calculated using *Statistica* software (*version 13*). If the content of a chemical substance was lower than the determination limit of the analytical method, half of this limit value was taken for statistical calculations. The arithmetic mean, geometric mean, and median were calculated, and the minimum and maximum values were presented. In the case of chemicals for which the percentage of results below the limit of determination exceeded 50%, the arithmetic and geometric means were not calculated; only the minimum, maximum and median values were presented. No statistical analysis was performed on sets or subsets containing fewer than five samples. Descriptive statistics for individual physicochemical parameters for the entire sets of soils, sediments and waters are presented in the geochemical maps (Plates 7–105) and in Tables 2–5. The data gathered in the databases were also used to perform statistical calculations on subsets separated according to the adopted criteria, such as lithology, land development and soil use, and according to their location within the range of individual surface water bodies (SWBs) in the case of aquatic sediments and surface waters (Figure 2).

Geochemical studies assume that the typical content of a given sample set is better characterized by the median content of a given element than by the arithmetic mean. The median, being the middle value in an ascending dataset, is less affected by extreme values (Salminen, Gregorauskiene, 2000). In some studies, the median defined in this way was used to represent the geochemical background level (base reference content) of an element occurring in a given area (Lis, Pasieczna, 1995; Lis, Pasieczna, 2001).

Topographic map. VMap L2 data (vector record) at a scale of 1:50,000 in the PL-1992 rectangular coordinate system and other auxiliary materials were used to develop the topographic base of the 1:50,000 geochemical maps. The topographic map includes the following vector information layers: terrain relief, hydrography (including rivers, streams, ditches, and stagnant

Analytical methods, determination limits and result uncertainties of elements and other physicochemical parameters **Table 1**

Parameter	Analytical method	Determination limit	Unit	Expanded uncertainty	Analytical method	Determination limit	Unit	Expanded uncertainty
	Soils and aquatic sediments				Surface water			
pH	potentiometry	—	—	0.4 unit	potentiometry	—	—	0.2 unit
EC	n.o.	—	—	—	conductometry	—	[mS/cm]	8%
Ag	ICP-MS	0.05	[mg/kg]	25%	ICP-MS	0.05	[µg/dm^3]	25%
Al	ICP-OES	0.01	[%]	25%	ICP-MS	0.5	[µg/dm^3]	25%
As	ICP-OES	3	[mg/kg]	25%	ICP-MS	2	[µg/dm^3]	25%
B	n.o.	—	—	—	ICP-OES	0.01	[mg/dm^3]	15%–30%
Ba	ICP-OES	1	[mg/kg]	25%	ICP-OES	0.001	[mg/dm^3]	20%–25%
Be	ICP-MS	0.05	[mg/kg]	25%	ICP-MS	0.05	[µg/dm^3]	25%
Br^-	n.o.	—	—	—	IC	0.10	[mg/dm^3]	14%
Ca	ICP-OES	0.01	[%]	25%	ICP-OES	0.1	[mg/dm^3]	10%–15%
Cd	ICP-MS	0.05	[mg/kg]	25%	ICP-MS	0.05	[µg/dm^3]	25%
COD	n.o.	—	—	—	spectrophotometry	2.0	[mg/dm^3]	25%
Cl^-	n.o.	—	—	—	IC	0.50	[mg/dm^3]	12%
Co	ICP-MS	0.05	[mg/kg]	25%	ICP-MS	0.05	[µg/dm^3]	25%
Cr	ICP-OES	1	[mg/kg]	25%	ICP-OES	0.003	[mg/dm^3]	15%–25%
Cu	ICP-OES	1	[mg/kg]	25%	ICP-MS	0.05	[µg/dm^3]	25%
F^-	n.o.	—	—	—	IC	0.10	[mg/dm^3]	15%
Fe	ICP-OES	0.01	[%]	25%	ICP-OES	0.01	[mg/dm^3]	15%–25%
HCO_3	n.o.	—	—	—	spectrophotometry	24	[mg/dm^3]	20%
Hg	CV-AAS	0.02	[mg/kg]	30%	n.o.	—	—	
K	ICP-OES	0.01	[%]	25%	ICP-OES	0.5	[mg/dm^3]	10%–15%
Li	ICP-MS	0.3	[mg/kg]	25%	ICP-MS	0.3	[µg/dm^3]	25%
Mg	ICP-OES	0.01	[%]	25%	ICP-OES	0.1	[mg/dm^3]	10%–25%
Mn	ICP-OES	2	[mg/kg]	25%	ICP-OES	0.001	[mg/dm^3]	15%–25%
Mo	ICP-MS	0.05	[mg/kg]	25%	ICP-MS	0.05	[µg/dm^3]	25%
Na	ICP-OES	0.003	[%]	25%	ICP-OES	0.5	[mg/dm^3]	10%–15%
NH_4^+	n.o.	—	—	—	spectrophotometry	0.05	[mg/dm^3]	20%
Ni	ICP-OES	1	[mg/kg]	25%	ICP-MS	0.5	[µg/dm^3]	25%
NO_2	n.o.	—	—	—	IC	0.01	[mg/dm^3]	14%
NO_3	n.o.	—	—	—	IC	0.01	[mg/dm^3]	14%
TOC	IR	0.02	[%]	30%	spectrophotometry	1.0	[mg/dm^3]	20%
P	ICP-OES	0.002	[%]	25%	ICP-OES	0.05	[mg/dm^3]	15%
Pb	ICP-MS	0.05	[mg/kg]	25%	ICP-MS	0.05	[µg/dm^3]	25%
S	ICP-OES	0.003	[%]	25%	n.o.	—	—	—
Sb	ICP-MS	0.05	[mg/kg]	25%	ICP-MS	0.05	[µg/dm^3]	25%
Se	ICP-MS	2	[mg/kg]	25%	ICP-MS	2	[µg/dm^3]	25%
Si*	n.o.	—	—	—	ICP-OES	0.1	[mg/dm^3]	15%
Sn	ICP-MS	0.5	[mg/kg]	25%	ICP-MS	0.5	[µg/dm^3]	25%
SO_4^{2-}	n.o.	—	—	—	IC	0.50	[mg/dm^3]	12%
Sr	ICP-OES	1	[mg/kg]	25%	ICP-OES	0.002	[mg/dm^3]	15%–25%
Ti	ICP-OES	5	[mg/kg]	25%	ICP-OES	0.002	[mg/dm^3]	15%–25%
Tl	ICP-MS	0.05	[mg/kg]	25%	ICP-MS	0.05	[µg/dm^3]	25%
U	ICP-MS	0.05	[mg/kg]	25%	ICP-MS	0.05	[µg/dm^3]	25%
V	ICP-OES	1	[mg/kg]	25%	ICP-MS	1	[µg/dm^3]	25%
Zawiesina ogólna	n.o.	—	—	—	spectrophotometry	5	[mg/dm^3]	30%
Zn	ICP-OES	1	[mg/kg]	25%	ICP-OES	0.003	[mg/dm^3]	15%–25%

ICP-OES – inductively coupled plasma optical emission spectrometry
ICP-MS – inductively coupled plasma mass spectrometry
CV-AAS – cold vapour atomic absorption spectrometry
IR – high-temperature combustion with IR detection
n.o. – not determined
IC – ion chromatography
* – determination limit expressed as SiO_2

water bodies), road network (divided by class), railway network, land development, forests, and industrial areas.

Geological map. Parts of four map sheets of the *Detailed Geological Map of Poland at a scale of 1:50,000* were used to present the geological structure of the study area: Lublin (Butrym et al., 1980), Bychawa (Marszałek et al., 1988), Niedrzwica (Marszałek et al., 1989) and Bełżyce (Henkiel, Danel, 2008), as well as the *Geological map of Poland at a scale 1:500,000* (Marks et al., 2022). Vector images of the study area were created through digitization, and then combined with the topographic base in the form of a geological map at a scale of 1:50,000 (Plate 1).

Geochemical map production. The maps were constructed using ArcGIS 10.8.2 software package from ESRI, designed for working with maps and spatial data. The software allows creating new or modifying existing maps, analysing and visualizing spatial data, and managing the data in geodatabases. For the purpose of developing the *Geochemical Atlas of Lublin and Environs at a scale of 1:50,000*, the following maps have been constructed (Plates 2–105):

- land development;
- land use;
- contents of the following grain size fractions: 0.063 < d ≤ 2.0 mm, 0.02 < d ≤ 0.063 mm and d ≤ 0.02 in topsoil (0.00–0.25 m depth);
- pH in topsoil (0.00–0.25 m depth);
- contents of elements: Ag, Al, As, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Li, Mg, Mn, Mo, Na, Ni, P, Pb, S, Sb, Se, Sn, Sr, Ti, Tl, U, V, Zn, and TOC in topsoil (0.00–0.25 m depth) and aquatic sediments;
- contents of organic compounds: dieldrin, hexachlorobenzene, total HCH (α-HCH, β-HCH, γ-HCH and δ-HCH), total DDT (p,p'-DDT, p,p'-DDD and p,p'-DDE), total mineral oils, total PCB (congeners: PCB28, PCB52, PCB101, PCB118, PCB138, PCB153 and PCB180), 17 individual polycyclic aromatic hydrocarbons (acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(e)pyrene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, phenanthrene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, perylene, and pyrene) in topsoil (0.00–0.25 m depth) and aquatic sediments;
- pH and EC in surface waters;
- contents of elements: Ag, Al, As, B, Ba, Be, Br^-, Ca, Cd, Cl^-, Co, Cr, Cu, F^-, Fe, HCO_3, K, Li, Mg, Mn, Mo, Na, Ni, NH_4^+, NO_2, NO_3, P, Pb, Sb, SiO_2, Sn, SO_4^{2-}, Sr, Ti, Tl, U, V, Zn, as well as COD, TOC, and total suspended solids in surface waters.

To show the distribution grain size classes in soils, their pH, and the content of chemical substances, an isoline (areal) method of mapping was chosen 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 cell by averaging the values from the nearest points. Additionally, points located closer to a given grid cell have a greater influence on the interpolated value. This influence is mathematically expressed as the inverse of the distance between two points, raised to a power determined by a map maker. The advantage of the method is the ability to determine the distance between the points used in the interpolation process. The following percentiles were used to determine the spatial distribution classes of physicochemical parameters measured in soils: 10th, 25th, 50th, 75th, 90th, 95th and 98th; however, the 98th percentile has been omitted from the maps of organic compounds. A maximum of eight or seven classes are presented on the maps. The number of classes may be smaller. In special cases, only one class is shown when the results are within a very narrow range (i.e. below or slightly above the limit of determination). If the designated class is not represented by any result in the dataset, or would occupy a very small area on the map (practically a point), it has not been presented either. Soil pH variability is presented according to the scale that is adopted from soil science (Bednarek et al., 2004), for the following soil categories: very acidic (pH < 4.5), acidic (pH 4.5–5.5), slightly acidic (pH 5.5–6.5), neutral (pH 6.5–7.2), and alkaline (pH > 7.2). The resulting maps of individual physicochemical parameters are presented on the topographic base map.

Analytical methods, determination limits and result uncertainties of organic compounds in soils and aquatic sediments **Table 2**

Parameter	Class of organic compounds	Analytical method	Unit	Determination limit	Expanded uncertainty
Acenaphthene	PAHs	GC-MS	[µg/kg]	1	61%
Acenaphthylene	PAHs	GC-MS	[µg/kg]	1	61%
Anthracene	PAHs	GC-MS	[µg/kg]	1	54%
Benzo(a)anthracene	PAHs	GC-MS	[µg/kg]	2	38%
Benzo(a)pyrene	PAHs	GC-MS	[µg/kg]	3	38%
Benzo(b)fluoranthene	PAHs	GC-MS	[µg/kg]	3	42%
Benzo(e)pyrene	PAHs	GC-MS	[µg/kg]	3	39%
Benzo(g,h,i)perylene	PAHs	GC-MS	[µg/kg]	5	46%
Benzo(k)fluoranthene	PAHs	GC-MS	[µg/kg]	3	39%
Chrysene	PAHs	GC-MS	[µg/kg]	2	41%
Dibenz(a,h)anthracene	PAHs	GC-MS	[µg/kg]	5	52%
Phenantrene	PAHs	GC-MS	[µg/kg]	1	48%
Fluoranthene	PAHs	GC-MS	[µg/kg]	1	37%
Fluorene	PAHs	GC-MS	[µg/kg]	1	57%
Indeno(1,2,3-cd) pyrene	PAHs	GC-MS	[µg/kg]	5	50%
Perylene	PAHs	GC-MS	[µg/kg]	3	39%
Pyrene	PAHs	GC-MS	[µg/kg]	1	37%
PCB28	PCBs	GC-ECD	[µg/kg]	0.1	38%
PCB52	PCBs	GC-ECD	[µg/kg]	0.1	34%
PCB101	PCBs	GC-ECD	[µg/kg]	0.1	33%
PCB118	PCBs	GC-ECD	[µg/kg]	0.1	32%
PCB138	PCBs	GC-ECD	[µg/kg]	0.1	33%
PCB153	PCBs	GC-ECD	[µg/kg]	0.1	32%
PCB180	PCBs	GC-ECD	[µg/kg]	0.1	37%
α-HCH	OCPs	GC-ECD	[µg/kg]	0.5	40%
β-HCH	OCPs	GC-ECD	[µg/kg]	0.5	37%
γ-HCH	OCPs	GC-ECD	[µg/kg]	0.5	40%
δ-HCH	OCPs	GC-ECD	[µg/kg]	0.5	42%
Endrin aldehyde	OCPs	GC-ECD	[µg/kg]	0.1	41%
Aldrin	OCPs	GC-ECD	[µg/kg]	0.1	39%
α-chlordane	OCPs	GC-ECD	[µg/kg]	0.1	41%
γ-chlordane	OCPs	GC-ECD	[µg/kg]	0.1	39%
Dieldrin	OCPs	GC-ECD	[µg/kg]	0.1	41%
Endosulfan I	OCPs	GC-ECD	[µg/kg]	0.5	47%
Endosulfan II	OCPs	GC-ECD	[µg/kg]	0.3	48%
Endrin	OCPs	GC-ECD	[µg/kg]	0.3	48%
Heptachlor epoxide	OCPs	GC-ECD	[µg/kg]	0.1	39%
Hexachlorobenzene	OCPs	GC-ECD	[µg/kg]	0.1	37%
Heptachlor	OCPs	GC-ECD	[µg/kg]	0.8	49%
Endrin ketone	OCPs	GC-ECD	[µg/kg]	0.1	42%
p,p'-DDD	OCPs	GC-ECD	[µg/kg]	0.1	42%
p,p'-DDE	OCPs	GC-ECD	[µg/kg]	0.1	41%
p,p'-DDT	OCPs	GC-ECD	[µg/kg]	0.5	50%
p,p'-methoxychlor	OCPs	GC-ECD	[µg/kg]	5.0	48%
Endosulfan sulfate	OCPs	GC-ECD	[µg/kg]	0.5	45%
Sum of mineral oils	Mineral oils	FTIR	[mg/kg]	10.0	26%

FTIR – Fourier transform infrared spectroscopy
GC-MS – gas chromatography – mass spectrometry
GC-ECD – gas chromatography with electron capture detector
OCPs – organochlorine pesticides
PCBs – polychlorinated biphenyls
PAHs – polycyclic aromatic hydrocarbons

The land development and land use of the area, as well as the distribution of chemical substances in aquatic sediments and surface waters, are presented in the form of point maps. The geochemical maps for aquatic sediments and surface waters are constructed using circular cartodiagrams with diameters corresponding to individual content classes, which are expressed as percentiles (10th, 25th, 50th, 75th, 90th, 95th, and 98th); however, the 98th percentile has been omitted from the maps of organic compounds in sediments. The number of classes may be smaller. In special cases, only one class is displayed when the results are within a very narrow range (i.e. below or slightly above the limit of determination).

For the purpose of publication, the same plate shows a map of the content of a given chemical substance in topsoil (0.00–0.025 m depth), alongside a geochemical map of the same substance in aquatic sediments.

For some chemical compounds, geochemical maps have not been constructed because they were present in the tested samples at levels equal to or below the determination limits of the analytical methods used. Furthermore, the spatial distributions of the contents of these compounds were characterized by a lack of variation in soils and aquatic sediments. Geochemical maps have not been produced for the following substances: p,p'-DDD, p,p'-DDE, p,p'-DDT, α-HCH, β-HCH, γ-HCH, δ-HCH, endrin aldehyde, aldrin, α-chlordane, γ-chlordane, endosulfan I, endosulfan II, endrin, heptachlor epoxide, heptachlor, endrin ketone, p,p'-methoxychlor, endosulfan sulphate, PCB28, PCB52, PCB101, PCB118, PCB153 and PCB180 congeners. However, these chemical compounds are included in the tables presenting descriptive statistics.

RESULTS

The results obtained during the project *Geochemical Atlas of Lublin and Environs at a scale of 1:50,000* were interpreted by referring, among other things, to applicable national regulations, data from monitoring programmes of the *State Environmental Monitoring* (SEM), and data presented in previous cartographic studies covering Poland and Europe (both national and international projects were taken into account). Additionally, during the discussion of the current results for aquatic sediments, reference was made to the ecotoxicological risk indices TEC (*Threshold Effect Concentration*) and PEC (*Probable Effect Concentration*). These indices define the levels of chemical substances at which no negative impact or an expected negative impact on benthic organisms is anticipated, respectively (MacDonald et al., 2000).

ELEMENTS AND OTHER PHYSICO-CHEMICAL PARAMETERS IN SOILS, AQUATIC SEDIMENTS AND SURFACE WATERS

GRAIN SIZE COMPOSITION

Soils: Plates 4–6, Table 3

The grain size composition of soil, i.e. the percentage content of individual granulometric fractions in its solid phase, has a significant impact on its physical and biological properties, as well as on its chemical element content. Soils that contain a high proportion of fine-grained fractions (clay and silt) are usually characterized by a higher content of elements that are less mobile under hypergenic conditions. The standards and recommendations that specify permissible concentrations of metals in soils usually consider the grain size composition, but the limit values for soils with a high proportion of clay fractions are increased. On the other hand, lower elemental concentrations are acceptable for soils containing a high proportion of sand fraction (Kabata-Pendias et al., 1995).

Soils in urban areas are characterized by high grain size variability, depending on the type of parent rock and anthropopression level (reflecting the types of functional zones within the urban area). The presence of foreign materials in soil, mainly construction and municipal waste, as well as the vertical and horizontal movement of soil layers and levels, removal of surface layers, soil compaction, and the soil's cover by screening materials, affects the diversity of soil's grain size composition. In soils of industrial zones, they cause an increase in the skeleton (coarse) fraction content (>2 mm) (Greinert, 2011; Plak, 2018).

The results of granulometric analyses of soil samples collected in the study area are presented for the following grain size groups: 0.063< d ≤2.0 mm, 0.02< d ≤0.063 mm, and ≤0.02 mm (Plates 4–6). The grain size variation is clearly related to the lithology of the parent rocks, although the original composition is partially obscured by earthworks, construction works, and gardening (especially in the industrial and urban areas of Lublin). Soils rich in the sand fraction (0.063< d ≤2.0 mm) occur mainly in the valleys of the Bystrzyca and Czerniejówka rivers and in the eastern quarters of Lublin (Plate 4). These soils have formed on fluvial and fluvial-periglacial sands and sandy-silty deluvial sediments. In 24% of soils, the sand fraction content is recorded as being higher than 50%. They occur in areas covered largely with forests. In contrast, soils that develop on loess and loess-like sediments generally contain below 30% of the sand fraction. Soils that form on loess sediments, which dominate in the north-western part of the research area, are characterized by a high proportion of fine-grained fractions. These grain size fractions also make up a significant proportion of soils that develop on sandy silts and loess-like silty sands, which occur in the central, south-eastern and south-western parts of the survey area. In over 75% of the analysed soils, the proportion of the 0.02< d ≤0.063 mm fraction was found to be greater than 25%. In about 23% of all samples, the content of this fraction was above 50%. The proportion of the 0.02< d ≤0.063 mm fraction was found to be less than 10% in only 4% of soil samples (Plate 5). The vast majority of the soils tested (67%) are characterized by a percentage of ≤0.02 mm fraction in the range of 25–50% (Plate 6). Only seven samples contained more than 50% of this fraction. The spatial distribution of the grain size fractions in the study area soils (Plates 4–6) indicates a higher proportion of the 0.063< d ≤2.0 mm sand fraction and a lower proportion of the ≤0.02 mm grain size group in soils of the central part of Lublin, particularly in the Old Town, Bronowice, Kośminek and Tatary quarters. These areas have been subject to both intense anthropopression and varied land use for decades.

pH

Soils: Plate 7, Table 3

Soil pH is constrained by processes occurring in the soil (chemical and biochemical reactions, mineralization of organic matter, presence of organic acids), anthropogenic processes, as well as by the geological structure of the bedrock on which the soil has formed. Soil acidity can change under the influence of various natural factors (climate – temperature and precipitation, groundwater level position, organic matter content) and as a result of human activity (agriculture, fertilization, agrotechnical treatments, construction, industry). These factors can cause both an increase and a decrease in the natural pH of soils. Emissions of nitrogen oxide, sulfur dioxide and carbon dioxide contribute to soil acidification. Soil alkalization, which is caused mainly by dust emissions from power plants and industrial facilities, is also observed in large cities in Poland and around the world. A significant proportion of building materials with high calcium carbonate content, in the form of admixtures of bricks (including hollow bricks), cement, concrete, gypsum, lime and rubble, is also found (Walenczak, 2011).

The study area soils show a wide range of pH values, ranging from acidic soils of forests to alkaline soils characteristic of anthropogenically transformed areas. The pH of the topsoil layer ranges from 3.27 to 8.51. The median soil pH in the Lublin area (7.11) is slightly lower than in Warsaw – median 7.4 (Tomassi-Morawiec, 2016) and slightly higher than in Poznań – median 6.7 (Lis, Pasieczna, 2005). Acidic soils occur in the southern, north-eastern and north-western parts of the survey area. These are silty, sandy, loamy and peaty soils, found mainly in areas of forests and arable fields. The forest soils have a pH ranging from 3.27 to 7.87. The median pH measured in the soil samples from forest areas is 4.18. The lowest ones were recorded in forests growing on peaty soils (3.27–4.15), to the southeast of the Zemborzycki Reservoir. The pH of arable soils ranges from 4.04 to 7.83 (median 6.08). These are acidic, slightly acidic, neutral and alkaline soils

Descriptive statistics for elements and other physicochemical parameters in soils **Table 3**

Soils	Statistical measures	Ag [mg/kg]	Al [%]	As [mg/kg]	Ba [mg/kg]	Be [mg/kg]	Ca [%]	Cd [mg/kg]	Co [mg/kg]	Cr [mg/kg]	Cu [mg/kg]	Fe [%]	Hg [mg/kg]	K [%]	Li [mg/kg]	Mg [%]	Mn [mg/kg]	Mo [mg/kg]	Na [%]	Ni [mg/kg]	TOC [%]	P [%]	Pb [mg/kg]	S [%]	Sb [mg/kg]	Se [mg/kg]	Sn [mg/kg]	Sr [mg/kg]	Ti [mg/kg]	Tl [mg/kg]	U [mg/kg]	V [mg/kg]	Zn [mg/kg]	Fraction			pH [–]
																																	0.063 < d ≤ 2.0 mm [%]	0.02 < d ≤ 0.063 mm [%]	d ≤ 0.02 mm [%]	
Total soils n = 909	a	<0.05	0.08	<3	8	<0.05	<0.01	<0.05	0.32	2	1	0.13	<0.02	0.02	0.6	0.01	8	0.12	0.004	1	0.13	0.005	3.35	<0.003	0.06	<2	<0.5	1	19	<0.05	0.13	2	4	2.00	1.09	2.29	3.27
	b	1.48	1.66	18	1,327	4.71	12.89	15.57	20.54	348	224	5.37	1.94	0.34	17.9	0.93	1,142	18.41	0.172	649	34.66	1.290	340.79	0.726	10.70	10	17.7	545	530	0.34	8.73	36	1,435	96.48	67.98	71.75	8.51
	c	n.o.	0.67	<3	58	0.46	0.97	0.38	3.91	13	13	0.89	0.05	0.13	5.6	0.17	317	0.38	0.011	11	1.94	0.052	19.91	0.023	0.43	n.o.	1.0	37	113	0.10	0.69	14	66	32.42	37.55	30.03	6.49
	d	n.o.	0.63	<3	49	0.39	0.39	0.20	3.62	11	10	0.82	0.03	0.12	5.3	0.14	292	0.29	0.009	9	1.49	0.043	15.11	0.018	0.30	n.o.	0.7	19	102	0.09	0.64	13	41	22.65	33.13	27.38	6.35
	e	<0.05	0.68	3	49	0.43	0.35	0.19	4.04	12	10	0.90	0.03	0.13	5.7	0.15	305	0.26	0.008	10	1.36	0.044	12.97	0.016	0.25	<2	0.6	18	111	0.10	0.66	14	35	27.04	40.58	30.71	7.11
Anthropogenic soils n = 234	a	<0.05	0.18	<3	12	0.08	0.09	0.06	0.54	2	4	0.14	<0.02	0.02	1.3	0.02	45	0.12	0.004	2	0.20	0.011	3.58	0.004	0.13	<2	<0.5	4	24	<0.05	0.24	2	17	2.36	2.32	2.29	5.24
	b	1.48	1.38	10	1,327	4.71	8.96	15.57	20.54	348	224	5.37	1.94	0.34	14.9	0.93	701	6.22	0.126	649	26.29	1.290	340.79	0.237	10.70	2	17.7	399	530	0.34	7.54	33	1,435	95.39	67.31	49.46	8.51
	c	0.10	0.69	3	83	0.58	2.06	0.61	4.30	19	22	1.07	0.08	0.15	6.1	0.22	281	0.57	0.017	16	2.57	0.071	33.38	0.031	0.80	n.o.	1.8	76	137	0.11	0.76	16	130	45.73	29.97	24.30	7.51
	d	0.06	0.67	<3	64	0.51	1.54	0.34	4.07	15	17	1.00	0.05	0.14	5.9	0.20	265	0.42	0.014	12	1.97	0.056	22.09	0.026	0.49	n.o.	1.2	55	128	0.10	0.69	15	85	39.27	25.95	21.82	7.50
	e	0.06	0.70	3	55	0.49	1.67	0.30	4.10	13	14	0.99	0.04	0.14	6.1	0.20	266	0.34	0.013	11	2.04	0.052	19.07	0.024	0.41	<2	1.0	55	130	0.10	0.66	15	76	45.63	30.39	24.38	7.53
Clay soils n = 110	a	<0.05	0.28	<3	23	0.15	0.05	<0.05	1.96	5	4	0.35	<0.02	0.05	2.6	0.05	132	0.14	0.004	3	0.20	0.016	6.04	0.004	0.14	<2	<0.5	4	37	<0.05	0.42	6	14	2.00	13.82	14.42	4.32
	b	0.53	1.66	5	104	1.09	12.89	6.47	8.17	25	60	1.58	0.19	0.29	15.1	0.51	797	1.57	0.042	20	11.17	0.125	180.57	0.141	1.15	3	6.7	545	237	0.21	0.99	28	219	64.17	62.60	56.02	7.93
	c	n.o.	0.76	<3	51	0.47	0.94	0.31	4.27	13	12	0.97	0.04	0.14	6.4	0.19	320	0.30	0.009	10	1.75	0.050	15.08	0.021	0.28	n.o.	0.9	34	126	0.10	0.67	15	46	20.98	44.57	34.45	6.73
	d	n.o.	0.73	<3	49	0.45	0.46	0.20	4.14	12	10	0.94	0.03	0.14	6.2	0.17	307	0.28	0.008	10	1.38	0.047	12.86	0.017	0.26	n.o.	0.7	20	117	0.10	0.66	15	39	14.22	42.69	33.10	6.66
	e	<0.05	0.79	3	49	0.47	0.43	0.18	4.36	13	11	0.98	0.03	0.15	6.5	0.17	293	0.26	0.008	11	1.28	0.050	11.85	0.017	0.23	<2	0.6	18	133	0.10	0.67	16	36	15.13	47.86	35.61	7.19
Sandy soils n = 102	a	<0.05	0.08	<3	8	<0.05	<0.01	<0.05	0.32	2	1	0.13	<0.02	0.02	0.6	0.01	8	0.12	0.004	1	0.16	0.005	3.35	0.004	0.06	<2	<0.5	1	19	<0.05	0.13	2	4	8.08	1.09	2.36	3.51
	b	0.47	1.34	18	955	4.05	4.45	5.91	9.90	25	77	2.29	0.24	0.24	17.9	0.55	516	1.75	0.172	29	10.17	0.626	90.08	0.118	3.15	<2	7.2	265	285	0.32	1.99	36	1,049	96.48	60.76	41.66	8.12
	c	n.o.	0.47	n.o.	56	0.38	0.81	0.43	2.61	9	11	0.65	0.05	0.09	4.2	0.13	232	0.32	0.012	7	2.17	0.049	18.48	0.024	0.39	n.o.	0.9	33	83	0.09	0.49	10	73	58.87	22.51	18.61	6.21
	d	n.o.	0.42	n.o.	37	0.24	0.24	0.16	2.09	7	8	0.53	0.03	0.08	3.6	0.09	194	0.26	0.008	5	1.69	0.035	14.26	0.018	0.28	n.o.	0.6	14	69	0.08	0.44	8	33	52.63	17.60	16.31	6.02
	e	<0.05	0.44	<3	39	0.26	0.24	0.16	2.43	8	8	0.57	0.04	0.09	3.8	0.08	227	0.23	0.008	6	1.64	0.037	13.02	0.017	0.23	<2	0.6	15	63	0.08	0.46	9	32	65.38	19.32	16.76	6.83
Silty soils n = 457	a	<0.05	0.21	<3	15	0.08	0.01	<0.05	0.71	3	1	0.22	<0.02	0.03	1.8	0.03	48	0.14	0.004	2	0.13	0.008	5.55	<0.003	0.12	<2	<0.5	2	23	<0.05	0.21	3	7	2.44	7.35	8.49	3.55
	b	1.26	1.53	9	260	2.43	4.35	13.01	9.90	32	64	2.12	0.90	0.25	16.0	0.71	1142	2.62	0.058	28	15.45	0.270	211.30	0.155	3.44	3	12.7	170	280	0.27	1.47	29	368	82.42	67.98	51.34	8.05
	c	n.o.	0.68	n.o.	48	0.41	0.44	0.26	3.92	11	9	0.84	0.04	0.12	5.5	0.15	356	0.26	0.008	9	1.41	0.043	14.45	0.016	0.28	n.o.	0.6	18	105	0.10	0.67	14	37	22.36	43.38	34.26	5.99
	d	n.o.	0.65	n.o.	45	0.37	0.21	0.17	3.73	10	8	0.80	0.03	0.11	5.2	0.13	338	0.25	0.007	8	1.23	0.039	13.06	0.015	0.25	n.o.	<0.5	12	96	0.09	0.65	13	30	15.76	41.19	32.87	5.85
	e	<0.05	0.68	<3	48	0.40	0.18	0.17	4.08	11	8	0.84	0.03	0.12	5.4	0.12	352	0.23	0.006	9	1.18	0.041	12.34	0.014	0.22	<2	0.6	11	101	0.10	0.68	14	29	16.76	46.16	36.07	6.05
Peaty soils n = 6	a	<0.05	0.32	<3	19	0.18	0.78	0.24	0.75	4	4	0.19	0.03	0.03	1.5	0.02	18	0.27	0.007	4	4.92	0.042	6.20	0.062	0.25	<2	<0.5	63	34	0.06	0.57	6	9	15.23	3.75	11.32	3.27
	b	0.38	1.42	13	95	0.90	3.30	5.00	6.91	23	29	1.73	0.19	0.14	13.8	0.24	383	18.41	0.017	24	34.66	0.093	38.87	0.726	0.67	10	2.5	145	79	0.16	8.73	27	156	75.71	27.00	71.75	7.19
	c	n.o.	0.63	n.o.	51	0.42	1.68	1.19	3.69	14	13	0.78	0.08	0.10	5.3	0.13	158	3.77	0.012	15	17.44	0.068	22.25	0.263	0.46	3	1.0	105	51	0.09	3.17	14	52	39.90	16.30	43.80	5.57
	d	n.o.	0.53	n.o.	43	0.37	1.49	0.61	2.81	11	10	0.61	0.07	0.09	4.0	0.09	89	1.24	0.012	12	13.25	0.065	18.59	0.181	0.44	2	0.8	101	49	0.09	1.86	12	34	33.60	13.19	35.75	5.37
	e	<0.05	0.41	<3	47	0.35	1.55	0.47	4.20	16	12	0.73	0.07	0.11	3.4	0.14	148	1.01	0.013	16	14.07	0.068	22.15	0.159	0.48	3	0.7	103	50	0.08	1.45	11	41	32.84	17.14	44.29	5.91
Forests n = 128	a	<0.05	0.08	<3	8	<0.05	<0.01	<0.05	0.32	2	1	0.13	<0.02	0.02	0.6	0.01	8	0.12	0.004	1	0.22	0.005	3.35	<0.003	0.06	<2	<0.5	1	19	<0.05	0.13	2	4	2.44	1.09	2.36	3.27
	b	0.13	1.66	5	85	0.88	9.90	0.48	5.81	25	16	1.50	0.28	0.20	15.1	0.50	797	1.57	0.028	20	31.68	0.100	31.99	0.394	0.51	3	3.6	388	190	0.16	8.73	28	87	96.48	61.95	70.63	7.87
	c	n.o.	0.46	n.o.	30	0.22	0.22	0.10	2.47	7	5	0.54	0.03	0.07	3.8	0.08	295	0.23	0.006	5	2.02	0.025	13.15	0.018	0.22	n.o.	n.o.	12	67	0.08	0.53	9	18	39.79	31.53	28.68	4.52
	d	n.o.	0.41	n.o.	27	0.18	0.06	0.07	2.02	6	4	0.47	0.03	0.06	3.4	0.07	234	0.21	0.006	4	1.53	0.022	12.66	0.013	0.21	n.o.	n.o.	5	60	0.08	0.44	8	16	26.66	25.10	24.88	4.43
	e	<0.05	0.40	<3	26	0.18	0.04	0.07	2.22	6	4	0.44	0.03	0.06	3.4	0.06	281	0.19	0.005	4	1.40	0.021	12.65	0.011	0.20	<2	<0.5	4	59	0.08	0.45	8	16	39.25	30.99	28.48	4.18
Meadows n = 16	a	<0.05	0.45	<3	36	0.39	0.11	0.11	2.95	11	7	0.68	<0.02	0.06	4.5	0.11	141	0.19	0.006	8	0.39	0.030	6.53	0.007	0.14	<2	<0.5	8	46	0.07	0.52	11	22	5.43	18.37	16.77	5.00
	b	0.73	1.53	9	99	0.85	3.30	6.80	6.81	22	25	2.12	0.35	0.16	12.8	0.59	450	0.67	0.014	19	15.45	0.098	32.57	0.155	0.93	2	2.7	145	206	0.16	1.11	28	115	58.17	57.43	47.89	7.77
	c	0.10	0.79	3	55	0.48	0.99	0.68	4.41	14	12	1.01	0.06	0.12	6.5	0.20	304	0.32	0.009	12	2.85	0.051	17.57	0.034	0.35	n.o.	1.0	44	103	0.10	0.68	16	49	29.45	37.80	32.76	6.70
	d	0.05	0.76	<3	53	0.47	0.59	0.30	4.33	14	12	0.98	0.04	0.11	6.3	0.18	288	0.30	0.008	11	1.92	0.048	16.01	0.024	0.31	n.o.	0.8	29	93	0.10	0.67	15	43	23.73	35.96	31.22	6.64
	e	0.05	0.78	3	52	0.45	0.47	0.27	4.21	14	11	0.95	0.04	0.13	6.4	0.16	306	0.27	0.008	11	1.54	0.047	15.45	0.020	0.27	<2	0.7	24	95	0.10	0.66	16	38	27.18	39.31	31.05	6.99
Wasteland, fallows n = 173	a	<0.05	0.18	<3	12	0.08	0.04	<0.05	0.54	2	3	0.14	<0.02	0.02	1.3	0.02	45	0.12	0.004	2	0.20	0.016	3.58	0.004	0.12	<2	<0.5	4	24	<0.05	0.24	2	15	2.36	2.32	2.29	4.48
	b	1.26	1.42	18	955	4.71	8.96	13.01	20.54	281	224	5.37	0.44	0.34	16.0	0.93	701	18.41	0.126	56	34.66	1.290	340.79	0.726	8.96	10	17.7	399	530	0.32	7.54	33	1,141	95.39	67.98	71.75	8.51
	c	0.09	0.72	3	78	0.55	1.60	0.63	4.40	17	20	1.05	0.06	0.14	6.1	0.22	302	0.61	0.014	13	2.71	0.072	28.60	0.034	0.67	n.o.	1.5	60	127	0.11	0.80	16	109	36.93	34.73	28.34	6.92
	d	0.05	0.68	<3	59	0.48	0.85	0.30	4.12	14	14	0.97	0.04	0.13	5.8	0.19	283	0.37	0.011	11	1.84	0.054	17.92	0.023	0.38	n.o.	0.9	35	114	0.10	0.69	15	62	24.26	28.95	24.88	6.84
	e	0.05	0.74	3	54	0.48	1.02	0.24	4.23	14	12	1.00	0.04	0.14	6.1	0.19	289	0.30	0.009	11	1.80	0.050	14.71	0.020	0.31	<2	0.7	34	122	0.10	0.67	16	49	36.69	35.61	29.90	7.29
Allotments n = 48	a	<0.05	0.23	<3	38	0.19	0.12	0.11	1.02	5	7	0.27	0.02	0.05	2.1	0.04	147	0.20	0.005	3	0.63	0.029	8.33	0.010	0.17	<2	0.5	9	35	<0.05	0.29	4	30	2.84	8.06	10.40	4.41
	b	1.48	1.34	7	439	4.05	12.89	5.91	9.90	21	116	2.29	1.94	0.24	17.9	0.68	516	2.44	0.172	29	17.09	0.275	156.84	0.117	3.15	<2	7.9	545	285	0.27	1.99	36	1,435	81.26	53.99	48.65	7.96
	c	0.13	0.71	<3	89	0.74	1.54	0.65	4.21	13	20	1.00	0.12	0.14	6.5	0.21	286	0.48	0.020	11	2.87	0.069	30.47	0.029	0.63	n.o.	1.8	61	136	0.11	0.71	16	163	38.30	32.88	28.82	7.16
	d	0.08	0.67	<3	70	0.58	0.87	0.40	3.90	12	16	0.94	0.06	0.13	6.1	0.18	273	0.39	0.014	11	2.14	0.062	22.49	0.024	0.45	n.o.	1.4	36	124	0.10	0.67	15	94	26.67	28.63	26.42	7.11
	e	0.08	0.71	3	56	0.51	0.86	0.30	4.09	13	12	0.96	0.06	0.14	6.4	0.18	273	0.34	0.011	11	1.82	0.060	19.07	0.020	0.37	<2	1.2	29	137	0.10	0.67	15	78	41.66	32.22	26.03	7.43
Parks n = 16	a	<0.05	0.48	<3	25	0.26	0.21	<0.05	2.42	8	7	0.59	<0.02	0.09	4.2	0.10	162	0.13	0.005	7	0.16	0.028	4.68	0.004	0.10	<2	<0.5	12	56	0.06	0.43	10	17	4.85	17.02	5.13	5.09
	b	0.19	1.06	5	103	0.84	5.42	0.64	5.46	20	25	1.32	0.16	0.23	8.7	0.55	777	1.05	0.024	16	11.98	0.080	76.44	0.237	1.36	2	5.1	216	229	0.14	0.85	20	102	76.23	60.76	56.02	8.12
	c	n.o.	0.70	3	54	0.49	2.07	0.22	4.04	13	13	1.00	0.05	0.14	6.1	0.27	306	0.37	0.011	11	2.59	0.053	21.03	0.038	0.41	n.o.	1.1	68	127	0.11	0.63	15	50	28.82	40.19	30.99	7.27
	d	n.o.	0.68	<3	51	0.46	1.35	0.18	3.96	12	12	0.98	0.04	0.14	6.0	0.24	283	0.31	0.010	11	1.67	0.050	16.38	0.022	0.33	n.o.	0.8	43	121	0.10	0.62	15	44	21.09	37.69	27.69	7.23
	e	<0.05	0.69	3	49	0.45	1.70	0.18	3.92	13	12	0.96	0.04	0.15	6.2	0.25	265	0.27	0.010	11	1.83	0.051	15.57	0.021	0.31	<2	0.8	30	123	0.11	0.60	15	43	21.83	41.62	32.36	7.46
Cultivated fields n = 279	a	<0.05	0.24	<3	12	0.11	0.01	<0.05	0.98	3	2	0.25	<0.02	0.04	2.2	0.04	68	0.13	0.004	2	0.13	0.016	5.13	<0.003	0.09	<2	<0.5	2	30	<0.05	0.30	4	10	2.00	11.35	11.04	4.04
	b	0.32	1.25	5	106	0.77	2.01	3.68	6.02	21	64	1.51	0.10	0.25	9.0	0.45	653	0.65	0.031	16	3.04	0.091	159.03	0.094	3.44	2	12.7	65	232	0.23	1.47	23	137	77.61	63.54	50.42	7.83
	c	n.o.	0.68	n.o.	48	0.40	0.23	0.23	3.95	11	9	0.83	0.03	0.12	5.3	0.12	372	0.25	0.007	9	1.11	0.044	12.80	0.015	0.25	n.o.	0.5	13	100	0.10	0.71	14	30	20.69	44.29	35.02	6.12
	d	n.o.	0.66	n.o.	47	0.38	0.17	0.18	3.82	10	8	0.79	0.02	0.12	5.1	0.12	358	0.24	0.006	8	1.04	0.042	12.04	0.014	0.23	n.o.	<0.5	11	93	0.09	0.69	13	29	14.47	42.54	33.71	6.04
	e	<0.05	0.68	<3	49	0.40	0.16	0.18	4.11	11	8	0.83	0.03	0.12	5.3	0.12	368	0.23	0.006	9	1.04	0.043	11.84	0.014	0.22	<2	0.5	10	100	0.10	0.71	14	28	14.32	46.51	36.78	6.08
Lawns n = 249	a	<0.05	0.29	<3	19	0.18	0.08	0.06	1.44	5	5	0.35	<0.02	0.06	2.6	0.06	64	0.14	0.004	4	0.20	0.011	4.45	0.004	0.12	<2	<0.5	5	50	<0.05	0.26	6	15	2.53	2.96	2.61	4.25
	b	0.67	1.38	9	1,327	2.98	8.34	15.57	10.98	348	124	3.31	1.75	0.24	15.0	0.55	1,142	4.06	0.107	649	11.17	0.626	313.63	0.106	10.70	2	14.1	363	353	0.34	2.09	32	580	93.31	67.31	46.38	8.36
	c	0.07	0.71	3	65	0.52	1.56	0.46	4.19	16	16	1.01	0.07	0.14	6.2	0.22	285	0.42	0.014	14	2.02	0.057	23.34	0.025	0.54	n.o.	1.3	54	135	0.10	0.67	15	86	37.95	35.77	26.29	7.44
	d	<0.05	0.70	<3	56	0.49	1.19	0.27	4.05	13	14	0.98	0.04	0.14	6.0	0.20	271	0.35	0.012	11	1.70	0.051	17.39	0.022	0.38	n.o.	1.0	41	130	0.10	0.65	15	65	31.85	32.19	24.29	7.42
	e	0.05	0.71	3	52	0.48	1.27	0.23	4.16	13	12	0.99	0.04	0.14	6.3	0.20	271	0.31	0.010	11	1.74	0.049	14.77	0.021	0.32	<2	0.8	37	137	0.10	0.64	16	56	35.57	36.77	27.08	7.50
Non-built-up areas n = 390	a	<0.05	0.08	<3	8	<0.05	<0.01	<0.05	0.32	2	1	0.13	<0.02	0.02	0.6	0.01	8	0.12	0.004	1	0.13	0.005	3.35	<0.003	0.06	<2	<0.5	1	19	<0.05	0.13	2	4	2.44	1.09	2.29	3.27
	b	1.26	1.66	13	791	4.71	12.89	13.01	9.90	32	71	2.12	1.94	0.22	16.0	0.71	797	18.41	0.126	35	34.66	0.126	158.69	0.726	5.02	10	6.7	545	485	0.23	8.73	29	1,081	96.48	67.98	71.75	8.51
	c	n.o.	0.61	n.o.	46	0.37	0.59	0.28	3.48	10	9	0.76	0.04	0.10	5.0	0.14	320	0.31	0.008	8	1.87	0.039	14.41	0.022	0.28	n.o.	0.6	24	94	0.09	0.64	12	35	29.97	38.33	31.70	5.75
	d	n.o.	0.56	n.o.	39	0.31	0.18	0.14	3.09	9	7	0.68	0.03	0.09	4.6	0.11	284	0.24	0.007	7	1.35	0.034	12.82	0.015	0.24	n.o.	<0.5	11	82	0.09	0.58	11	26	18.96	33.08	28.78	5.59
	e	<0.05	0.61	<3	43	0.36	0.15	0.14	3.74	10	8	0.76	0.03	0.10	5.1	0.11	318	0.22	0.006	8	1.21	0.038	12.05	0.014	0.21	<2	0.5	9	90	0.09	0.62	13	26	21.84	43.12	32.95	5.64

Table 3 cont.

Soils	Statistical measures	Ag [mg/kg]	Al [%]	As [mg/kg]	Ba [mg/kg]	Be [mg/kg]	Ca [%]	Cd [mg/kg]	Co [mg/kg]	Cr [mg/kg]	Cu [mg/kg]	Fe [%]	Hg [mg/kg]	K [%]	Li [mg/kg]	Mg [%]	Mn [mg/kg]	Mo [mg/kg]	Na [%]	Ni [mg/kg]	TOC [%]	P [%]	Pb [mg/kg]	S [%]	Sb [mg/kg]	Se [mg/kg]	Sn [mg/kg]	Sr [mg/kg]	Ti [mg/kg]	Tl [mg/kg]	U [mg/kg]	V [mg/kg]	Zn [mg/kg]	Fraction			pH [–]
																																	0.063 < d ≤ 2.0 mm [%]	0.02 < d ≤ 0.063 mm [%]	d ≤ 0.02 mm [%]	
Vilage areas n = 109	a	<0.05	0.31	<3	21	0.12	0.02	0.09	0.99	3	3	0.31	<0.02	0.03	2.5	0.03	93	0.15	0.004	2	0.56	0.019	8.12	0.008	0.14	<2	<0.5	3	27	<0.05	0.37	5	11	2.84	6.48	9.93	4.04
	b	0.54	1.20	9	189	1.23	3.92	3.82	6.73	24	85	2.02	0.19	0.29	9.0	0.35	593	1.17	0.037	22	6.95	0.626	211.30	0.059	4.66	<2	12.7	181	185	0.21	1.19	25	450	82.29	61.52	48.65	7.79
	c	n.o.	0.71	<3	57	0.45	0.51	0.34	4.16	12	11	0.92	0.04	0.14	5.6	0.14	369	0.30	0.008	10	1.54	0.061	19.27	0.019	0.38	n.o.	0.9	26	106	0.10	0.69	15	52	25.02	41.32	33.65	6.44
	d	n.o.	0.69	<3	54	0.43	0.29	0.24	4.03	11	10	0.88	0.03	0.13	5.4	0.13	356	0.28	0.008	9	1.35	0.052	14.72	0.017	0.28	n.o.	0.6	17	99	0.10	0.68	14	41	17.56	38.73	31.99	6.36
	e	<0.05	0.71	3	51	0.43	0.24	0.21	4.22	12	9	0.89	0.03	0.14	5.5	0.13	358	0.26	0.007	9	1.27	0.048	12.95	0.016	0.26	<2	0.6	14	107	0.10	0.70	15	35	19.37	44.02	35.69	6.80
Low-block urban areas n = 212	a	<0.05	0.28	<3	19	0.11	0.03	<0.05	0.98	3	2	0.25	<0.02	0.04	2.3	0.04	48	0.14	0.004	2	0.20	0.013	4.34	0.004	0.12	<2	<0.5	3	25	<0.05	0.26	4	13	2.00	8.06	6.77	3.97
	b	1.48	1.38	7	955	4.05	5.27	5.91	9.90	24	116	2.29	0.99	0.24	17.9	0.68	1142	2.62	0.172	29	17.09	0.441	156.84	0.118	3.15	2	8.7	265	285	0.30	1.99	36	1,435	82.17	62.60	49.46	7.97
	c	n.o.	0.72	<3	68	0.56	1.08	0.35	4.16	13	15	0.96	0.05	0.14	6.2	0.19	316	0.37	0.014	11	1.96	0.058	19.52	0.023	0.42	n.o.	1.1	43	129	0.11	0.71	15	89	33.34	37.19	29.47	7.05
	d	n.o.	0.70	<3	56	0.49	0.63	0.25	3.99	12	12	0.92	0.04	0.13	6.0	0.17	300	0.32	0.010	10	1.54	0.052	15.56	0.019	0.33	n.o.	0.8	27	120	0.10	0.68	15	56	24.84	33.97	27.31	7.00
	e	<0.05	0.72	3	53	0.48	0.73	0.21	4.20	13	11	0.97	0.04	0.14	6.1	0.17	299	0.28	0.009	11	1.39	0.049	13.52	0.018	0.28	<2	0.7	25	127	0.10	0.68	16	47	28.75	39.17	30.10	7.37
Tower-block urban areas n = 108	a	<0.05	0.29	<3	25	0.18	0.07	0.06	1.44	8	6	0.35	<0.02	0.08	2.7	0.09	64	0.17	0.005	4	0.20	0.021	5.07	0.007	0.12	<2	<0.5	7	71	<0.05	0.30	6	22	3.57	4.08	2.61	4.26
	b	0.33	1.19	8	339	1.76	8.34	4.10	9.53	281	130	3.76	1.75	0.21	15.0	0.93	651	6.22	0.090	33	9.48	0.196	340.79	0.094	4.24	<2	14.1	363	530	0.34	2.09	23	1,120	93.31	67.31	50.42	8.22
	c	0.08	0.69	<3	61	0.51	1.66	0.30	4.04	16	17	1.00	0.09	0.15	6.3	0.27	265	0.42	0.014	11	1.98	0.059	26.66	0.025	0.48	n.o.	1.5	48	147	0.10	0.65	15	94	35.25	38.86	25.89	7.43
	d	0.06	0.67	<3	55	0.48	1.32	0.22	3.94	13	14	0.97	0.05	0.15	6.2	0.25	255	0.33	0.012	11	1.67	0.055	17.85	0.022	0.37	n.o.	1.1	37	141	0.10	0.63	15	65	28.77	35.01	23.70	7.40
	e	0.06	0.71	3	52	0.47	1.37	0.21	4.06	13	12	0.98	0.05	0.15	6.4	0.26	256	0.29	0.010	11	1.79	0.051	14.84	0.022	0.32	<2	0.9	34	143	0.10	0.60	15	55	31.19	40.60	26.98	7.50
Industrial areas n = 90	a	<0.05	0.40	<3	19	0.20	0.12	0.09	1.50	7	6	0.41	<0.02	0.08	3.3	0.10	63	0.12	0.005	5	0.36	0.011	5.04	0.007	0.13	<2	<0.5	10	50	<0.05	0.35	8	21	9.06	2.96	4.96	4.79
	b	0.77	1.06	18	1,327	3.94	8.96	15.57	20.54	348	224	5.37	1.21	0.34	8.9	0.50	701	4.06	0.054	649	26.29	1.290	313.63	0.202	10.70	2	17.7	399	297	0.32	7.54	33	1,141	92.08	66.42	42.99	8.36
	c	0.10	0.71	4	88	0.54	2.07	1.04	4.77	24	26	1.14	0.07	0.14	5.9	0.20	308	0.69	0.015	23	2.64	0.074	37.31	0.032	1.08	n.o.	2.0	78	123	0.11	0.87	16	132	46.47	28.89	24.65	7.32
	d	0.06	0.69	3	66	0.49	1.25	0.51	4.48	17	17	1.06	0.05	0.14	5.7	0.19	290	0.47	0.013	14	2.02	0.049	24.22	0.025	0.57	n.o.	1.2	53	117	0.10	0.74	16	81	40.30	24.37	21.85	7.29
	e	0.06	0.71	4	58	0.49	1.56	0.45	4.35	15	14	1.04	0.05	0.14	5.8	0.18	291	0.38	0.012	12	1.94	0.045	19.02	0.023	0.49	<2	1.1	55	119	0.10	0.71	16	71	44.53	29.46	24.87	7.50
Geochemical background for soils																																						
Soils of Europe[1), 2)]	e	0.27** n = 840	(5.82) n = 845	6.00* n = 837	65.0* n = 837	<2.0** n = 843	(0.659) n = 845	0.145** n = 840	7.00* n = 837	22,00* n = 837	12* n = 837	1.96* n = 837	0.037*** n = 833	(1.59) n = 845	b.d.	0.46* n = 845	382* n = 837	0,62** n = 840	(0,59) n = 845	14,0* n = 837	1.73“ n = 819	(0.056) n = 845	15.0* n = 837	0.023* n = 837	0.60^ n = 840	b.d.	3.00** n = 845	(89.0) n = 845	(3,426) n = 845	0.66** n = 840	2.00* n = 843	33.0* n = 837	48.0* n = 837	b.d.	b.d.	b.d.	5.51 n = 818
Soils of Poland[3)] n = 10 840	e	<1	0,272)	<5	32	b.d.	0.18	<0.5	2	4	5	0.51	<0.05	b.d.	b.d.	0.06	217	<1	b.d.	4	b.d.	0.034	13	0.012	b.d.	b.d.	b.d.	8	26	b.d.	b.d.	7	35	b.d.	b.d.	b.d.	6.1
Permissible contents of risk-causing substances by land groups[4)]																																						
Group I		n.d.	n.d.	25	400	n.d.	n.d.	2	50	200	200	n.d.	5	n.d.	n.d.	n.d.	n.d.	50	n.d.	150	n.d.	n.d.	200	n.d.	n.d.	n.d.	20	n.d.	n.d.	n.d.	n.d.	n.d.	500	n.d.	n.d.	n.d.	n.d.
Group II		n.d.	n.d.	10–50	200–600	n.d.	n.d.	2–5	20–50	150–500	100–300	n.d.	2–5	n.d.	n.d.	n.d.	n.d.	10–50	n.d.	100–300	n.d.	n.d.	100–500	n.d.	n.d.	n.d.	10–40	n.d.	n.d.	n.d.	n.d.	n.d.	300–1,000	n.d.	n.d.	n.d.	n.d.
Group III		n.d.	n.d.	50	1,000	n.d.	n.d.	10	100	500	300	n.d.	10	n.d.	n.d.	n.d.	n.d.	100	n.d.	300	n.d.	n.d.	500	n.d.	n.d.	n.d.	100	n.d.	n.d.	n.d.	n.d.	n.d.	1,000	n.d.	n.d.	n.d.	n.d.
Group IV		n.d.	n.d.	100	1,500	n.d.	n.d.	15	200	1000	600	n.d.	30	n.d.	n.d.	n.d.	n.d.	250	n.d.	500	n.d.	n.d.	600	n.d.	n.d.	n.d.	350	n.d.	n.d.	n.d.	n.d.	n.d.	2,000	n.d.	n.d.	n.d.	n.d.

a – minimum
b – maximum
c – aritmethic mean
d – geometric mean
e – median
n – number of samples
b.d. – no data
n.d. – not applicable
n.o. – not calculated in the case when the percentage of the results below determination limit exceeded 50%
( ) XRF method
*ICP-OES method after aqua regia digestion
**ICP-MS method after digestion with HF
***AMA method
“carbon analyser
[1)]Salminen, 2005
[2)]De Vos, Tarvainen, 2006
[3)]Lis, Pasieczna, 1995
[4)]Rozporządzenie..., 2024

Descriptive statistics for organic compounds in soils **Table 4**

Soils	Statistical measures	Acenaphthene [µg/kg]	Acenaphthylene [µg/kg]	Anthracene [µg/kg]	Benzo(a)anthracene [µg/kg]	Benzo(a)pyrene [µg/kg]	Benzo(b) fluoranthene [µg/kg]	Benzo(e)pyrene [µg/kg]	Benzo(g,h,i) perylene [µg/kg]	Benzo(k) fluoranthene [µg/kg]	Chrysene [µg/kg]	Dibenz(a,h) anthracene [µg/kg]	Phenanthrene [µg/kg]	Fluoranthene [µg/kg]	Fluorene [µg/kg]	Indeno(1,2,3-cd) pyrene [µg/kg]	Perylene [µg/kg]	Pyrene [µg/kg]	PAH (sum) [µg/kg]	PCB28 [µg/kg]	PCB52 [µg/kg]	PCB101 [µg/kg]	PCB118 [µg/kg]	PCB138 [µg/kg]	PCB153 [µg/kg]	PCB180 [µg/kg]	PCB (sum) [µg/kg]	α-HCH [µg/kg]	β-HCH [µg/kg]	γ-HCH [µg/kg]	δ-HCH [µg/kg]	HCH (sum) [µg/kg]	Endrin aldehyde [µg/kg]	Aldrin [µg/kg]	α-chlordane [µg/kg]	γ-chlordane [µg/kg]	Dieldrin [µg/kg]	Endosulfan I [µg/kg]	Endosulfan II [µg/kg]	Endrin [µg/kg]	Heptachlor epoxide [µg/kg]	Hexachlorobenzene [µg/kg]	Heptachlor [µg/kg]	Endrin ketone [µg/kg]	p,p'-DDD [µg/kg]	p,p'-DDE [µg/kg]	p,p'-DDT [µg/kg]	DDT, DDE i DDD (sum) [µg/kg]	p,p'-methoxychlor [µg/kg]	Endosulfan sulfate [µg/kg]	Sum of mineral oils [mg/kg]
Total soils n = 237	a	<1	<1	<1	2	<3	<3	<3	<5	<3	2	<5	3	5	<1	<5	<3	4	23	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	<0.1	<0.8	<0.1	<0.1	0.1	<0.5	0.1	<5.0	<0.5	<10.0
	b	216	103	976	5,400	6,900	5,900	4,000	3,700	2,800	4,700	1,014	4,200	10,000	310	4,000	1,532	9,100	64,823	28	9.7	2.3	3.3	2.9	2.0	1.3	46	2.5	3.3	4.8	<0.5	5.8	<0.1	0.1	0.1	<0.1	8.4	102.0	24.0	1.1	<0.1	10.8	<0.8	10.9	81	130	200	391	15.7	20.8	950.0
	c	9	4	33	169	223	180	138	134	83	151	33	148	307	13	139	48	283	2092	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	1.0	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	2.8	8.2	7.6	19	n.o.	n.o.	38.7
	d	2	1	5	35	47	50	38	35	20	38	9	44	72	4	36	8	63	510	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	0.2	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	0.9	3.0	1.9	6.1	n.o.	n.o.	15.8
	e	1	1	3	28	37	36	30	26	15	28	6	31	54	3	28	6	45	383	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	<0.1	<0.8	<0.1	0.8	2.7	1.8	5.3	<5.0	<0.5	12.6
Anthropogenic soils n = 67	a	<1	<1	<1	2	<3	<3	<3	<5	<3	2	<5	4	5	<1	<5	<3	4	23	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	<0.1	<0.8	<0.1	0.1	0.4	<0.5	1.0	<5.0	<0.5	<10.0
	b	186	103	550	3,000	3,800	2,800	2,100	1,950	1,315	2,500	498	2,100	5,400	215	2,100	864	5,200	34,498	28	9.7	2.3	3.3	2.9	2.0	1.3	46	2.5	3.3	4.8	<0.5	5.8	<0.1	<0.1	0.1	<0.1	8.4	102.0	24.0	<0.3	<0.1	10.8	<0.8	10.9	81	110	200	391	15.7	20.8	950.0
	c	18	9	73	330	442	341	267	264	157	289	63	290	597	24	271	99	553	4,086	1.0	n.o.	n.o.	n.o.	0.3	0.3	n.o.	2.2	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	0.5	n.o.	n.o.	4.2	8.3	9.8	22	n.o.	n.o.	81.1
	d	5	4	20	119	160	139	112	109	61	110	26	108	211	8	110	34	193	1,537	0.2	n.o.	n.o.	n.o.	0.1	0.1	n.o.	0.6	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	0.2	n.o.	n.o.	1.4	3.8	2.9	8.9	n.o.	n.o.	37.4
	e	6	4	18	112	145	117	98	98	51	98	22	97	185	8	96	33	172	1,310	0.2	<0.1	<0.1	<0.1	0.1	0.1	<0.1	0.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	0.2	<0.8	<0.1	1.0	3.5	2.7	7.5	<5.0	<0.5	34.7
Clay soils n = 31	a	<1	<1	<1	2	<3	4	3	<5	<3	3	<5	8	6	<1	<5	<3	5	40	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	<0.1	<0.8	<0.1	<0.1	0.4	<0.5	0.7	<5.0	<0.5	<10.0
	b	216	75	976	5,400	6,900	5,900	4,000	3,700	2,800	4,700	1,014	4,200	10,000	310	4,000	1,532	9,100	64,823	2.0	0.4	0.3	0.4	0.3	0.3	0.4	3.1	<0.5	<0.5	0.6	<0.5	0.6	<0.1	<0.1	<0.1	<0.1	0.1	<0.5	<0.3	<0.3	<0.1	0.6	<0.8	<0.1	72	99	177	315	<5.0	<0.5	104.0
	c	11	n.o.	47	250	314	265	188	175	125	216	n.o.	201	458	16	187	n.o.	418	2,987	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	3.8	11	9.5	25	n.o.	n.o.	n.o.
	d	2	n.o.	3	23	30	33	27	24	14	25	n.o.	36	49	3	25	n.o.	42	345	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	0.7	2.7	1.6	5.3	n.o.	n.o.	n.o.
	e	1	<1	2	17	25	24	20	19	10	18	<5	27	33	2	20	<3	29	252	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	<0.1	<0.8	<0.1	0.6	2.0	1.4	4.1	<5.0	<0.5	<10.0
Silty soils n = 25	a	<1	<1	<1	2	<3	7	4	<5	<3	5	<5	5	9	<1	<5	<3	6	42	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	<0.1	<0.8	<0.1	<0.1	0.2	<0.5	0.2	<5.0	<0.5	<10.0
	b	71	46	351	1,701	2,200	1,588	1,274	1,249	774	1,550	319	1,739	3,100	96	1,315	465	2900	20,738	8.6	1.2	1.0	0.6	0.6	0.7	0.6	12	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	0.3	2.3	<0.3	<0.3	<0.1	0.5	<0.8	<0.1	32	130	120	282	<5.0	<0.5	103.0
	c	7	n.o.	24	121	160	132	105	98	60	115	24	123	220	9	102	33	203	1536	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	2.7	9.3	8.5	21	n.o.	n.o.	21.3
	d	2	n.o.	4	28	39	43	33	29	17	32	8	36	59	3	30	7	51	421	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	0.7	2.3	1.4	4.4	n.o.	n.o.	13.4
	e	1	<1	3	22	30	42	30	26	15	25	6	24	46	3	28	5	41	369	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	<0.1	<0.8	<0.1	0.6	2.5	1.3	4.7	<5.0	<0.5	13.3
Silty soils n = 113	a	<1	<1	<1	3	<3	6	4	<5	<3	4	<5	3	7	<1	<5	<3	6	37	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	<0.1	<0.8	<0.1	<0.1	0.1	<0.5	0.1	<5.0	<0.5	<10.0
	b	62	27	103	818	1,113	895	732	708	438	832	157	814	1,781	55	712	231	1,582	11,031	3.7	0.8	0.6	0.4	0.5	0.9	0.9	5.3	<0.5	<0.5	0.8	<0.5	0.8	<0.1	0.1	<0.1	<0.1	1.1	<0.5	0.4	1.1	<0.1	2.3	<0.8	0.5	22	69	150	192	<5.0	<0.5	383.0
	c	3	n.o.	9	62	84	73	57	55	33	60	n.o.	56	115	5	56	n.o.	106	801	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	0.3	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	1.8	7.0	5.6	14	n.o.	n.o.	n.o.
	d	1	n.o.	2	20	27	31	23	21	12	24	n.o.	29	44	3	22	n.o.	38	309	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	0.1	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	0.8	2.8	1.6	5.5	n.o.	n.o.	n.o.
	e	1	<1	2	14	18	20	16	15	8	16	<5	22	31	3	15	<3	26	214	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	<0.1	<0.8	<0.1	0.8	2.6	1.5	5.2	<5.0	<0.5	<10.0
Forests n = 29	a	<1	<1	<1	2	<3	6	4	<5	<3	5	<5	5	9	<1	<5	<3	6	42	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	<0.1	<0.8	<0.1	<0.1	0.4	<0.5	0.7	<5.0	<0.5	<10.0
	b	6	4	6	60	73	64	49	45	28	55	11	78	105	22	46	14	84	688	2.5	0.9	0.5	0.4	0.4	0.3	0.1	4.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	0.1	<0.1	<0.1	0.5	<0.5	0.4	1.1	<0.1	0.4	<0.8	0.5	3.8	40	15	59	<5.0	<0.5	162.0
	c	n.o.	n.o.	n.o.	10	15	21	14	13	8	16	n.o.	24	28	4	14	n.o.	21	191	n.o.	n.o.	n.o.	n.o.	n.o.	0.1	n.o.	0.5	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	0.5	3.0	n.o.	4.9	n.o.	n.o.	27.1
	d	n.o.	n.o.	n.o.	8	10	17	12	10	6	13	n.o.	19	23	2	11	n.o.	17	154	n.o.	n.o.	n.o.	n.o.	n.o.	<0.1	n.o.	0.2	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	0.3	1.2	n.o.	2.1	n.o.	n.o.	17.2
	e	<1	<1	<1	6	10	16	10	9	5	11	<5	20	20	2	10	<3	14	137	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	0.3	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	<0.1	<0.8	<0.1	0.3	1.0	<0.5	1.5	<5.0	<0.5	18.1
Wasteland, fallows n = 48	a	<1	<1	<1	2	<3	<3	<3	<5	<3	2	<5	4	5	<1	<5	<3	4	23	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	<0.1	<0.8	<0.1	<0.1	0.1	<0.5	0.1	<5.0	<0.5	<10.0
	b	216	75	976	5,400	6,900	5,900	4,000	3,700	2,800	4,700	1,014	4,200	10,000	310	4,000	1,532	9,100	64,823	6.7	1.4	2.3	2.0	2.0	2.0	0.9	17	<0.5	0.6	0.6	<0.5	0.6	<0.1	<0.1	0.1	<0.1	1.1	2.3	<0.3	<0.3	<0.1	2.8	<0.8	<0.1	81	130	200	391	<5.0	<0.5	383.0
	c	16	8	72	366	462	369	276	262	173	316	66	292	670	23	277	101	619	4367	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	1.0	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	5.8	12	16	34	n.o.	n.o.	42.7
	d	3	2	9	56	75	72	58	54	31	57	13	64	111	6	56	14	98	785	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	0.2	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	0.9	2.8	2.1	5.9	n.o.	n.o.	18.0
	e	2	2	6	46	70	63	56	55	27	49	11	47	88	5	54	12	80	691	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	0.1	<0.8	<0.1	0.8	2.3	1.5	4.8	<5.0	<0.5	12.9
Allotments n = 10	a	<1	<1	2	12	17	16	13	13	7	12	<5	18	23	<1	12	5	20	174	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	<0.1	<0.8	<0.1	0.6	2.5	2.2	5.3	<5.0	<0.5	<10.0
	b	24	14	128	987	1,285	963	714	687	446	774	167	426	1,476	27	729	299	1,527	10,669	28.3	9.7	2.2	3.3	0.5	0.9	1.1	46	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	8.4	<0.5	<0.3	<0.3	<0.1	0.7	<0.8	<0.1	12	99	23	123	<5.0	<0.5	266.0
	c	8	7	42	282	375	320	245	235	142	251	55	191	454	11	243	83	431	3374	3.1	n.o.	n.o.	0.4	0.2	0.2	0.3	5.4	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	0.3	n.o.	n.o.	4.0	22	9.9	36	n.o.	n.o.	61.6
	d	5	5	23	155	209	188	146	139	82	147	30	128	264	7	142	45	242	1964	0.3	n.o.	n.o.	n.o.	0.1	0.1	0.2	0.7	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	0.2	n.o.	n.o.	2.8	12	7.6	24	n.o.	n.o.	33.1
	e	8	9	33	212	273	259	201	183	117	202	44	177	349	10	195	57	332	2617	0.3	<0.1	<0.1	0.1	0.2	0.1	0.2	1.3	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	0.4	<0.8	<0.1	2.8	11	7.8	22	<5.0	<0.5	34.8
Cultivated fields n = 77	a	<1	<1	<1	2	<3	4	3	<5	<3	3	<5	3	6	<1	<5	<3	5	37	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	<0.1	<0.8	<0.1	<0.1	0.4	<0.5	0.7	<5.0	<0.5	<10.0
	b	48	14	103	818	1113	895	732	708	438	832	157	814	1,781	53	712	231	1,582	11,031	0.3	0.3	0.2	0.2	0.5	0.9	0.9	2.9	<0.5	<0.5	0.8	<0.5	0.8	<0.1	<0.1	<0.1	<0.1	0.4	<0.5	<0.3	<0.3	<0.1	2.2	<0.8	<0.1	22	69	192	<5.0	<0.5	64.5
	c	n.o.	n.o.	5	42	57	53	41	39	23	41	n.o.	39	78	3	40	n.o.	71	551	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	1.8	7.7	6.3	16	n.o.	n.o.	n.o.
	d	n.o.	n.o.	2	16	22	25	19	17	10	18	n.o.	22	34	2	18	n.o.	30	241	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	0.9	3.4	2.1	6.9	n.o.	n.o.	n.o.
	e	<1	<1	2	12	16	18	13	12	7	14	<5	20	27	2	13	<3	23	178	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	<0.1	<0.8	<0.1	1.0	3.2	2.0	6.5	<5.0	<0.5	<10.0
Lawns n = 68	a	<1	<1	1	7	11	11	9	8	5	8	<5	6	16	<1	8	<3	13	125	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	<0.1	<0.8	<0.1	0.1	0.4	<0.5	1.0	<5.0	<0.5	<10.0
	b	186	103	550	1,790	2,500	1,919	1,555	1,451	880	1,653	362	1,840	3,400	215	1,470	533	3,200	21,893	8.6	1.2	1.6	1.1	2.9	1.8	1.3	12	2.5	3.3	4.8	<0.5	5.8	<0.1	<0.1	<0.1	<0.1	0.7	102.0	24.0	<0.3	<0.1	10.8	<0.8	10.9	25	92	110	147	15.7	20.8	950.0
	c	15	7	51	222	306	235	187	186	109	199	44	215	403	19	189	68	373	2825	0.6	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	1.4	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	0.4	n.o.	n.o.	2.8	6.5	6.1	15	n.o.	n.o.	63.9
	d	4	3	14	86	115	101	81	77	44	81	18	84	156	7	78	22	142	1133	0.2	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	0.6	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	0.2	n.o.	n.o.	1.1	3.3	2.3	7.4	n.o.	n.o.	30.4
	e	4	3	13	82	112	88	72	65	40	75	16	87	152	8	69	22	138	998	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	0.1	<0.8	<0.1	0.9	3.1	2.1	6.4	<5.0	<0.5	28.0
Non-built-up areas n = 106	a	<1	<1	<1	2	<3	<3	<3	<5	<3	2	<5	3	5	<1	<5	<3	4	23	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	<0.1	<0.8	<0.1	<0.1	0.1	<0.5	0.1	<5.0	<0.5	<10.0
	b	85	27	479	1,249	1,286	977	717	694	470	933	181	1089	2900	113	731	296	2500	14,716	2.5	0.9	0.6	0.4	0.5	0.6	0.7	5.3	<0.5	<0.5	0.6	<0.5	0.6	<0.1	0.1	0.1	<0.1	1.1	<0.5	0.4	1.1	<0.1	2.3	<0.8	0.5	22	99	150	192	<5.0	<0.5	383.0
	c	4	n.o.	12	55	72	66	50	48	28	52	n.o.	59	109	6	50	n.o.	96	731	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	0.4	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	1.6	5.9	5.0	13	n.o.	n.o.	n.o.
	d	1	n.o.	2	15	20	25	19	17	10	19	n.o.	26	35	2	17	n.o.	29	243	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	0.2	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	0.6	2.0	1.2	4.0	n.o.	n.o.	n.o.
	e	1	<1	1	10	14	17	13	11	7	13	<5	21	23	2	12	<3	19	161	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	<0.1	<0.8	<0.1	0.6	1.5	1.1	3.3	<5.0	<0.5	<10.0
Vilage areas n = 32	a	<1	<1	<1	4	6	8	6	6	3	5	<5	5	11	<1	6	<3	9	81	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	<0.1	<0.8	<0.1	0.2	0.6	<0.5	1.1	<5.0	<0.5	<10.0
	b	216	75	976	5,400	6,900	5,900	4,000	3,700	2,800	4,700	1,014	4,200	10,000	310	4,000	1,532	9,100	64,823	2.2	0.5	0.3	0.3	0.4	0.5	0.4	4.2	<0.5	<0.5	0.6	<0.5	0.6	<0.1	<0.1	<0.1	<0.1

Descriptive statistics for elements and other physicochemical parameters in aquatic sedimentsl **Table 5**

Aquatic sediments	Statistical measures	Ag [mg/kg]	Al [%]	As [mg/kg]	Ba [mg/kg]	Be [mg/kg]	Ca [%]	Cd [mg/kg]	Co [mg/kg]	Cr [mg/kg]	Cu [mg/kg]	Fe [%]	Hg [mg/kg]	K [%]	Li [mg/kg]	Mg [%]	Mn [mg/kg]	Mo [mg/kg]	Na [%]	Ni [mg/kg]	TOC [%]	P [%]	Pb [mg/kg]	S [%]	Sb [mg/kg]	Se [mg/kg]	Sn [mg/kg]	Sr [mg/kg]	Ti [mg/kg]	Tl [mg/kg]	U [mg/kg]	V [mg/kg]	Zn [mg/kg]
Total aquatic sediments n = 169	a	<0.05	0.04	<3	6	<0.05	0.03	<0.05	0.09	<1	<1	0.02	<0.02	0.01	0.5	<0.01	3	<0.05	0.003	<1	0.11	<0.002	1.09	0.006	<0.05	<2	<0.5	2	12	<0.05	0.12	<1	1
	b	5.22	1.65	47	309	1.03	9.74	85.79	40.81	79	123	4.21	2.46	0.23	16.5	0.93	3530	5.40	0.077	154	25.32	0.688	127.53	1.135	5.63	8	10.9	445	426	0.24	3.95	28	510
	c	0.16	0.50	n.o.	47	0.36	3.07	1.43	3.81	14	18	0.89	0.10	0.08	5.0	0.22	286	0.69	0.015	13	3.86	0.074	16.65	0.160	0.63	n.o.	1.8	109	97	0.07	0.71	11	95
	d	0.07	0.42	n.o.	38	0.30	2.19	0.34	2.97	11	12	0.73	0.03	0.07	4.3	0.17	184	0.42	0.012	9	2.51	0.056	12.38	0.092	0.34	n.o.	1.0	77	82	0.06	0.57	9	58
	e	0.06	0.49	<3	40	0.36	2.65	0.32	3.38	13	13	0.84	0.03	0.08	5.0	0.18	215	0.41	0.011	11	3.05	0.059	13.31	0.100	0.34	<2	0.9	89	87	0.07	0.56	11	67
SWB Bystrzyca from the Zemborzycki Reservoir to the river's mouth (RW20000824699) n = 46	a	<0.05	0.12	<3	12	0.07	0.16	0.06	0.79	3	2	0.17	<0.02	0.02	1.4	0.03	28	0.14	0.006	2	0.33	0.015	2.73	o.021	<0.05	<2	<0.5	6	21	<0.05	0.28	3	7
	b	5.22	0.95	13	252	0.78	7.58	85.79	40.81	79	123	4.21	2.46	0.19	9.0	0.44	3215	5.40	0.044	154	12.36	0.688	127.53	0.822	3.15	6	10.9	252	174	0.24	3.95	22	510
	c	0.39	0.49	3	53	0.37	3.55	4.41	5.06	19	32	0.92	0.26	0.08	4.8	0.23	236	1.22	0.018	19	4.19	0.084	25.75	0.223	1.07	n.o.	2.9	129	100	0.08	0.87	12	154
	d	0.13	0.45	<3	44	0.33	2.56	0.88	3.79	16	22	0.80	0.06	0.07	4.5	0.19	149	0.82	0.016	13	3.27	0.061	18.87	0.154	0.69	n.o.	2.0	97	91	0.07	0.70	11	104
	e	0.11	0.47	3	41	0.35	3.65	0.49	3.41	16	23	0.83	0.06	0.08	5.1	0.23	161	0.91	0.015	13	3.79	0.061	18.57	0.181	0.75	<2	2.7	131	112	0.08	0.62	12	139
SWB Bystrzyca to the Zemborzycki Reservoir (RW20000624653) n = 38	a	<0.05	0.04	<3	6	<0.05	0.03	<0.05	0.09	<1	<1	0.02	<0.02	0.01	0.5	<0.01	3	<0.05	0.003	<1	0.11	<0.002	1.09	0.006	<0.05	<2	<0.5	2	12	<0.05	0.12	<1	1
	b	0.84	0.89	7	131	0.67	5.18	0.84	6.14	22	24	1.97	0.12	0.14	8.8	0.31	3530	2.05	0.023	20	25.32	0.356	18.86	1.046	0.65	8	2.0	190	125	0.08	3.84	20	183
	c	n.o.	0.40	n.o.	32	0.28	1.63	0.24	2.45	9	8	0.64	0.04	0.06	4.2	0.11	257	0.45	0.008	8	4.73	0.059	8.63	0.160	0.21	n.o.	n.o.	70	55	n.o.	0.66	8	47
	d	n.o.	0.29	n.o.	24	0.18	1.01	0.15	1.57	6	5	0.41	0.03	0.05	3.1	0.07	95	0.27	0.007	5	2.17	0.034	6.49	0.079	0.14	n.o.	n.o.	44	47	n.o.	0.46	6	25
	e	<0.05	0.41	<3	28	0.29	1.45	0.17	2.59	9	8	0.67	0.04	0.06	4.5	0.12	133	0.30	0.007	8	2.74	0.046	9.50	0.080	0.18	<2	<0.5	62	56	<0.05	0.44	8	35
SWB Ciemięga (RW20000624689) n = 5	a	<0.05	0.38	<3	25	0.25	1.52	0.13	2.28	7	5	0.69	<0.02	0.07	3.8	0.22	83	0.08	0.006	6	0.77	0.033	5.44	0.023	0.11	<2	<0.5	40	90	0.06	0.41	7	25
	b	<0.05	0.56	3	32	0.34	3.27	0.19	3.05	11	6	0.85	<0.02	0.10	5.4	0.33	413	0.13	0.008	8	1.32	0.064	8.83	0.039	0.14	<2	<0.5	99	117	0.09	0.66	11	28
	c	n.o.	0.43	n.o.	28	0.29	1.97	0.15	2.55	8	5	0.78	n.o.	0.08	4.3	0.26	306	0.11	0.007	6	1.07	0.052	6.60	0.031	0.12	n.o.	n.o.	56	97	0.07	0.49	8	27
	d	n.o.	0.43	n.o.	28	0.29	1.88	0.15	2.54	8	5	0.78	n.o.	0.08	4.2	0.25	267	0.11	0.007	6	1.05	0.050	6.50	0.031	0.12	n.o.	n.o.	53	97	0.07	0.48	8	27
	e	<0.05	0.42	<3	28	0.28	1.61	0.14	2.44	8	5	0.78	<0.02	0.07	4.0	0.23	347	0.12	0.006	6	1.05	0.059	6.31	0.030	0.12	<2	<0.5	48	93	0.06	0.47	8	27
SWB Czechówka (RW200006246729) n = 38	a	<0.05	0.15	<3	25	0.14	0.76	0.12	1.46	7	5	0.35	<0.02	0.04	1.5	0.14	98	0.08	0.005	4	0.28	0.025	5.94	0.016	0.10	<2	<0.5	23	86	<0.05	0.27	5	25
	b	0.27	1.65	9	309	1.03	9.33	0.68	8.36	30	68	1.92	0.19	0.23	16.5	0.93	759	2.32	0.077	24	10.07	0.154	36.04	1.135	5.63	2	10.1	206	426	0.21	2.63	28	410
	c	0.07	0.61	n.o.	60	0.41	3.02	0.30	3.94	14	18	1.03	0.03	0.10	5.9	0.36	308	0.46	0.021	11	2.49	0.072	15.76	0.115	0.71	n.o.	2.0	67	150	0.09	0.61	13	101
	d	0.06	0.54	n.o.	52	0.38	2.54	0.27	3.69	13	15	0.97	0.02	0.10	5.2	0.32	277	0.32	0.017	10	1.79	0.067	14.02	0.063	0.45	n.o.	1.2	56	139	0.07	0.55	12	77
	e	0.06	0.57	<3	49	0.38	2.55	0.26	3.80	13	15	1.00	0.02	0.10	5.2	0.33	248	0.30	0.017	10	1.89	0.070	13.43	0.051	0.41	<2	1.2	53	131	0.08	0.54	13	74
SWB Czerniejówka (RW20000624669) n = 28	a	<0.05	0.09	<3	11	0.05	0.45	0.07	0.94	2	1	0.11	<0.02	0.02	0.9	0.02	109	0.10	0.005	1	0.21	0.012	2.52	0.009	<0.05	<2	<0.5	19	23	<0.05	0.14	2	8
	b	0.12	0.83	5	157	0.63	7.72	0.67	5.88	42	57	1.35	0.08	0.11	9.6	0.78	946	1.80	0.045	25	6.74	0.139	43.57	0.309	2.28	4	6.2	305	267	0.15	2.71	17	272
	c	0.06	0.51	n.o.	42	0.40	3.66	0.40	3.56	16	16	0.82	0.04	0.08	5.4	0.21	352	0.57	0.015	11	3.55	0.065	15.72	0.111	0.52	n.o.	1.7	143	94	0.07	0.58	10	82
	d	0.05	0.47	n.o.	37	0.36	3.06	0.35	3.29	13	12	0.75	0.03	0.07	4.9	0.17	301	0.44	0.012	9	2.68	0.057	13.13	0.080	0.32	n.o.	1.1	124	85	0.06	0.51	9	60
	e	0.07	0.49	<3	38	0.43	3.75	0.43	3.75	15	12	0.82	0.04	0.08	5.0	0.16	323	0.44	0.009	11	3.44	0.055	13.42	0.104	0.26	<2	0.9	143	79	0.07	0.52	11	61
SWB Dopływ spod Świdnika (RW20000624674) n = 9	a	<0.05	0.16	<3	15	0.12	1.12	0.12	1.37	3	2	0.38	<0.02	0.04	1.4	0.03	113	0.11	0.006	3	0.71	0.030	3.25	0.015	0.06	<2	<0.5	51	25	<0.05	0.22	4	10
	b	0.13	0.63	47	72	0.49	9.24	0.89	7.44	17	25	2.53	0.10	0.15	5.6	0.32	925	3.76	0.020	29	10.55	0.197	23.76	0.628	1.48	7	2.5	445	81	0.09	3.69	20	130
	c	0.08	0.45	13	49	0.38	5.21	0.52	4.49	11	13	1.35	0.06	0.09	4.3	0.16	430	0.84	0.014	15	5.77	0.122	14.82	0.270	0.55	3	1.1	229	55	0.05	1.10	12	65
	d	0.06	0.42	8	45	0.35	4.55	0.42	3.98	10	10	1.20	0.04	0.09	4.0	0.13	344	0.50	0.013	13	4.34	0.110	12.84	0.160	0.37	3	0.8	200	51	<0.05	0.80	11	50
	e	0.09	0.49	7	49	0.38	4.89	0.56	5.01	12	14	1.42	0.07	0.09	4.7	0.15	421	0.54	0.013	15	6.93	0.119	16.08	0.301	0.40	4	1.0	203	59	0.06	0.79	13	68
Geochemical background for aquatic sediments																																	
Stream sediments of Europe[1), 2)]	e	n.d.	(5.50) n = 802	6.00* n = 794	87.5* n = 794	1.42** n = 797	(1.74) n = 802	0.290** n = 797	8.00* n = 794	22.0* n = 794	15.0* n = 794	1.97* n = 794	0.038*** n = 797	(1.67) n = 802	20.8** n = 797	(0.72) n = 802	453* n = 794	0.600** n = 797	(0.667) n = 802	17.0* n = 794	1.63** n = 796	(0.0567) n = 802	14.0* n = 794	0.0500* n = 794	0.640** n = 797	n.d.	(2.10) n = 802	(124) n = 802	(3798) n = 802	0.370** n = 797	(2.00) n = 802	29.0* n = 794	59.5* n = 794
Aquatic sediments of Poland[3)] n = 12 788	e	<1	n.d.	<5	54	n.d.	0.84	<0.5	3	5	7	0.8	0.05	n.d.	n.d.	0.11	274	n.d.	bd	6	n.d.	0.059	13	0.040	n.d.	n.d.	n.d.	20	30	n.d.	n.d.	7	62
Numerical sediment quality guidelines[4), 5)]																																	
TEC		≤1.6	n.d.	≤9.8	n.d.	n.d.	n.d.	≤0.99	n.d.	≤43	≤32	≤2	≤0.18	n.d.	n.d.	n.d.	≤460	n.d.	n.d.	≤23	n.d.	n.d.	≤36	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	≤120
PEC		>2.2	n.d.	>33	n.d.	n.d.	n.d.	>5	n.d.	>110	>150	>4	>1.1	n.d.	n.d.	n.d.	>1100	n.d.	n.d.	>49	n.d.	n.d.	>130	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	>460

a – minimum
b – maximum
c – arithmetic mean
d – geometric mean
e – median
n – number of samples
n.d. – not applicable
n.o. – not calculated in the case when the percentage of the results below determination limit exceeded 50%
SWB – surface water body
TEC (Threshold Effect Concentration) – threshold value defining content of substance below which adverse effects to benthic organisms are not expected to occur
PEC (Probable Effect Concentration) – threshold value defining content of substance above which adverse effects to benthic organisms are expected to occur more often than not
( ) XRF method
*ICP-OES method after aqua regia digestion
**ICP-MS method after digestion with HF
***AMA method
"carbon analyser
[1)]Salminen, 2005
[2)]De Vos, Tarvainen, 2006
[3)]Lis, Pasieczna, 1995
[4)]MacDonald i in., 2000
[5)]Contaminated Sediment Standing Team, 2003

Descriptive statistics for organic compounds in aquatic sediments **Table 6**

Aquatic sediments	Statistical measures	Acenaphthene [µg/kg]	Acenaphthylene [µg/kg]	Anthracene [µg/kg]	Benzo(a)anthracene [µg/kg]	Benzo(a)pyrene [µg/kg]	Benzo(b)fluoranthene [µg/kg]	Benzo(e)pyrene [µg/kg]	Benzo(g,h,i)perylene [µg/kg]	Benzo(k)fluoranthene [µg/kg]	Chrysene [µg/kg]	Dibenz(a,h)anthracene [µg/kg]	Phenanthrene [µg/kg]	Fluoranthene [µg/kg]	Fluorene [µg/kg]	Indeno(1,2,3-cd)pyrene [µg/kg]	Perylene [µg/kg]	Pyrene [µg/kg]	PAH (sum) [µg/kg]	PCB28 [µg/kg]	PCB52 [µg/kg]	PCB101 [µg/kg]	PCB118 [µg/kg]	PCB138 [µg/kg]	PCB153 [µg/kg]	PCB180 [µg/kg]	PCB (sum) [µg/kg]	α-HCH [µg/kg]	β-HCH [µg/kg]	γ-HCH [µg/kg]	δ-HCH [µg/kg]	HCH (sum) [µg/kg]	Endrin aldehyde [µg/kg]	Aldrin [µg/kg]	α-chlordane [µg/kg]	γ-chlordane [µg/kg]	Dieldrin [µg/kg]	Endosulfan I [µg/kg]	Endosulfan II [µg/kg]	Endrin [µg/kg]	Heptachlor epoxide [µg/kg]	Hexachlorobenzene [µg/kg]	Heptachlor [µg/kg]	Endrin ketone [µg/kg]	p,p'-DDD [µg/kg]	p,p'-DDE [µg/kg]	p,p'-DDT [µg/kg]	DDT, DDE i DDD (sum) [µg/kg]	p,p'-methoxychlor [µg/kg]	Endosulfan sulfate [µg/kg]	Sum of mineral oils [mg/kg]
Total aquatic sediments n = 49	a	<1	<1	<1	<2	<3	<3	<3	<5	<3	<2	<5	2	1	<1	<5	<3	<1	3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	<0.1	<0.8	<0.1	<0.1	0.1	<5.0	0.1	<5.0	<0.5	<10.0
	b	100	33	157	614	856	966	823	929	486	731	190	609	1321	72	898	290	1199	10,223	14.6	6.9	6.4	4.8	5.4	8.0	3.4	49.5	0.5	0.50	1.90	0.5	1.90	0.1	0.1	0.1	<0.1	1.40	0.5	0.3	0.3	0.1	5.5	<0.8	0.1	16	22	3.8	40	<5.0	0.5	2,000
	c	10	7	28	130	168	183	157	172	92	145	34	133	275	17	163	57	243	2,010	1.0	0.6	0.6	0.4	0.4	0.6	0.3	3.8	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	0.4	n.o.	n.o.	2.0	3.8	n.o.	6.5	n.o.	n.o.	318
	d	4	3	10	50	62	69	60	64	34	55	16	65	107	8	60	24	87	721	0.2	0.3	0.3	0.2	0.2	0.3	0.1	1.1	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	0.1	n.o.	n.o.	0.8	2.0	n.o.	3.2	n.o.	n.o.	93.0
	e	4	3	13	78	99	106	86	89	49	82	19	86	158	12	86	41	136	1,118	0.2	0.3	0.4	0.2	0.2	0.4	0.1	2.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	0.1	<0.8	<0.1	1.1	3.1	<0.5	5.1	<5.0	<0.5	149
SWB Bystrzyca from the Zemborzycki Reservoir to the river's mouth (RW20000824699) n = 13	a	1	<1	5	5	<3	7	5	7	<3	11	<5	49	31	5	<5	<3	14	193	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	<0.1	<0.8	<0.1	0.4	0.9	<0.5	1.3	<5.0	<0.5	25.5
	b	100	33	157	614	856	966	823	929	486	731	190	609	1,321	72	898	290	1,199	10,223	14.6	6.9	6.4	4.8	5.4	8.0	3.4	49.5	<0.5	0.50	1.90	<0.5	1.90	<0.1	<0.1	<0.1	<0.1	1.40	<0.5	<0.3	<0.3	<0.1	5.5	<0.8	<0.1	10	9.4	3.8	21	<5.0	<0.5	1,700
	c	21	12	52	227	300	320	279	303	164	255	59	236	481	28	292	96	426	3,548	2.0	1.2	1.2	0.9	0.9	1.2	0.6	8.0	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	0.8	n.o.	n.o.	3.5	3.8	1.5	8.6	n.o.	n.o.	530
	d	11	7	31	146	170	205	172	193	94	167	39	173	325	21	169	57	276	2,397	0.5	0.6	0.5	0.4	0.5	0.6	0.3	3.0	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	0.3	n.o.	n.o.	1.8	3.0	0.9	6.2	n.o.	n.o.	306
	e	8	7	34	141	208	240	215	248	118	148	43	197	295	21	232	67	266	2,209	0.5	0.7	0.8	0.6	0.6	0.7	0.3	4.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	0.3	<0.8	<0.1	1.5	3.4	1.3	6.2	<5.0	<0.5	284
SWB Bystrzyca to the Zemborzycki Reservoir (RW20000624653) n = 13	a	<1	<1	<1	<2	<3	<3	<3	<5	<3	<2	<5	2	1	<1	<5	<3	<1	3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	<0.1	<0.8	<0.1	<0.1	0.1	<0.5	0.1	<5.0	<0.5	<10.0
	b	13	5	28	157	185	191	150	151	81	144	32	185	282	43	149	49	246	2,089	1.5	1.3	1.8	0.8	0.7	1.0	0.3	7.4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	0.3	<0.8	<0.1	3.5	15	1.4	19	<5.0	<0.5	347
	c	n.o.	n.o.	n.o.	36	46	47	39	n.o.	n.o.	35	n.o.	42	65	8	n.o.	n.o.	57	501	n.o.	0.2	0.4	n.o.	n.o.	0.2	n.o.	1.3	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	0.8	2.7	n.o.	3.7	n.o.	n.o.	n.o.
	d	n.o.	n.o.	n.o.	7	10	10	9	n.o.	n.o.	7	n.o.	16	15	2	n.o.	n.o.	11	84	n.o.	0.1	0.2	n.o.	n.o.	0.1	n.o.	0.4	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	0.2	0.7	n.o.	0.9	n.o.	n.o.	n.o.
	e	<1	<1	<1	3	4	4	4	<5	<3	4	<5	11	8	2	<5	<3	6	38	<0.1	0.1	0.2	<0.1	<0.1	0.1	<0.1	0.4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	<0.1	<0.8	<0.1	0.1	0.3	<0.5	0.3	<5.0	<0.5	<10.0
SWB Czechówka (RW200006246729) n = 10	a	1	3	10	56	61	57	62	52	43	66	8	59	126	3	45	19	108	848	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	<0.1	<0.8	<0.1	0.4	0.3	<0.5	0.7	<5.0	<0.5	17.2
	b	30	29	96	390	493	643	534	677	338	528	108	372	1,095	54	533	158	1,022	7,098	1.7	2.1	1.1	0.6	0.4	1.0	0.3	4.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	0.40	<0.5	<0.3	<0.3	<0.1	0.8	<0.8	<0.1	3.7	9.5	1.5	12	<5.0	<0.5	2,000
	c	10	9	34	168	215	253	215	244	126	198	46	157	375	18	222	73	334	2,697	0.5	0.6	0.5	0.3	0.2	0.5	0.2	2.7	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	0.3	n.o.	n.o.	1.8	4.2	n.o.	6.4	n.o.	n.o.	459
	d	7	7	24	131	166	192	164	178	95	150	34	128	277	14	166	57	241	2,054	0.3	0.4	0.4	0.3	0.2	0.4	0.1	1.9	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	0.2	n.o.	n.o.	1.6	3.1	n.o.	5.2	n.o.	n.o.	215
	e	7	6	19	108	141	180	145	178	79	123	33	111	202	16	165	64	168	1,744	0.3	0.5	0.5	0.3	0.2	0.4	0.2	2.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	0.1	<0.8	<0.1	1.8	3.8	<0.5	6.0	<5.0	<0.5	190
SWB Czerniejówka (RW20000624669) n = 7	a	<1	<1	1	10	9	11	9	8	5	9	<5	4	17	<1	7	<3	16	106	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	<0.1	<0.8	<0.1	0.1	0.2	<0.5	0.3	<5.0	<0.5	<10.0
	b	32	28	126	529	685	738	624	690	411	626	141	486	1,178	68	679	256	1,040	8,337	14.3	3.5	0.6	1.1	0.5	0.7	0.9	21.5	<0.5	<0.5	0.50	<0.5	0.50	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	2.1	<0.8	<0.1	16	22	2.0	40	<5.0	<0.5	1,400
	c	7	6	27	118	147	155	132	140	82	132	28	116	258	17	137	63	225	1,789	2.2	0.7	0.3	0.3	0.2	0.3	n.o.	3.9	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	0.5	n.o.	n.o.	2.9	4.9	n.o.	8.2	n.o.	n.o.	271
	d	3	2	11	57	62	65	56	53	32	58	10	55	119	7	51	24	103	777	0.2	0.2	0.2	0.1	0.1	0.2	n.o.	0.7	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	0.2	n.o.	n.o.	0.9	1.9	n.o.	2.9	n.o.	n.o.	55.8
	e	2	3	10	53	61	61	51	46	32	53	10	50	112	7	48	44	94	750	0.2	0.2	0.2	0.1	0.2	0.2	<0.1	1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.3	<0.3	<0.1	0.1	<0.8	<0.1	0.7	1.8	<0.5	2.5	<5.0	<0.5	50.7
Numerical sediment quality guidelines[1), 2)]																																																					
TEC		≤6.7	≤5.9	≤57.2	≤108	≤150	≤240	≤150	≤170	≤240	≤166	≤33	≤204	≤423	≤77.4	≤200	n.d.	≤195	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	≤60	≤6	≤5	≤3	n.d.	n.d.	n.d.	≤2	n.d.	n.d.	≤1.9	n.d.	n.d.	≤2.2	2.5	n.d.	n.d.	n.d.	4.9	3.2	4.2	5.3	n.d.	n.d.	n.d.
PEC		>89	>128	>845	>1,050	>1,450	>13,400	>1,450	>3,200	>13,400	>1,290	>135	>1,170	>2,230	>536	>3,200	n.d.	>1,520	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	>676	>100	>210	>5	n.d.	n.d.	n.d.	>80	n.d.	n.d.	>62	n.d.	n.d.	>207	16	n.d.	n.d.	n.d.	28	31	63	572	n.d.	n.d.	n.d.

a – minimum
b – maximum
c – arithmetic mean
d – geometric mean
e – median
n – number of samples
n.d. – not applicable
n.o. – not calculated in the case when the percentage of the results below determination limit exceeded 50%
SWB – surface water body
TEC (Threshold Effect Concentration) – treshold value defining content of substance below which adverse effects to benthic organisms are not expected to occur
PEC (Probable Effect Concentration) – treshold value defining content of substance above which adverse effects to benthic organisms are expected to occur more often than not

[1)]MacDonald i in., 2000

[2)]Contaminated Sediment Standing Team, 2003

Descriptive statistics for elements and other physico-chemical parameters in surface water **Table 7**

Surface water	Statistical measures	EC [mS/cm]	pH [–]	Ag [µg/dm³]	Al [µg/dm³]	As [µg/dm³]	B [mg/dm³]	Ba [mg/dm³]	Be [µg/dm³]	Br⁻ [mg/dm³]	Ca [mg/dm³]	Cd [µg/dm³]	COD [mg/dm³]	Cl⁻ [mg/dm³]	Co [µg/dm³]	Cr [mg/dm³]	Cu [µg/dm³]	F⁻ [mg/dm³]	Fe [mg/dm³]	HCO_3^- [mg/dm³]	K [mg/dm³]	Li [µg/dm³]	Mg [mg/dm³]	Mn [mg/dm³]	Mo [µg/dm³]	Na [mg/dm³]	NH_4^+ [mg/dm³]	Ni [µg/dm³]	NO_2^- [mg/dm³]	NO_3^- [mg/dm³]	TOC [mg/dm³]	P [mg/dm³]	Pb [µg/dm³]	Sb [µg/dm³]	Se [µg/dm³]	SiO_2 [mg/dm³]	Sn [µg/dm³]	SO_4^{2-} [mg/dm³]	Sr [mg/dm³]	Ti [mg/dm³]	Tl [µg/dm³]	U [µg/dm³]	V [µg/dm³]	Total suspended solids [mg/dm³]	Zn [mg/dm³]
Total surface water n = 182	a	0.14	6.92	<0.05	<0.5	<2	<0.01	0.002	<0.05	<0.1	12.7	<0.05	<2.0	5.2	<0.05	<0.003	0.22	<0.1	<0.01	43	<0.5	0.4	0.8	<0.001	0.10	2.4	<0.05	<0.5	<0.01	0.07	<1.0	<0.05	<0.05	<0.05	<2	0.5	<0.5	<0.5	0.032	<0.002	<0.05	<0.05	<1	<5	<0.003
	b	1.09	10.76	<0.05	133.5	11	0.09	0.161	<0.05	<0.1	195.2	0.22	77.0	240.0	3.84	<0.003	33.87	<0.1	13.70	590	19.1	7.7	31.4	2.527	26.57	148.1	2.23	10.8	0.74	34.20	34.0	0.90	0.73	2.45	9	38.0	3.9	76.9	1.618	0.003	0.06	4.11	5	156	0.096
	c	0.57	8.02	n.o.	5.7	n.o.	0.03	0.041	n.o.	n.o.	91.9	n.o.	6.0	28.6	n.o.	n.o.	1.08	n.o.	0.13	255	3.3	4.7	9.7	0.091	1.82	10.2	0.20	1.6	0.14	7.32	2.5	0.13	n.o.	0.18	n.o.	20.9	n.o.	29.6	0.652	n.o.	n.o.	1.00	n.o.	21	0.014
	d	0.55	8.01	n.o.	2.3	n.o.	0.03	0.032	n.o.	n.o.	84.4	n.o.	4.0	25.4	n.o.	n.o.	0.67	n.o.	0.02	238	2.9	4.5	8.2	0.028	1.16	8.6	0.11	1.3	0.08	3.23	1.6	0.09	n.o.	0.14	n.o.	16.3	n.o.	24.8	0.575	n.o.	n.o.	0.79	n.o.	15	0.007
	e	0.57	7.97	<0.05	2.2	<2	0.03	0.035	<0.05	<0.1	98.7	<0.05	3.0	23.5	<0.05	<0.003	0.61	<0.1	0.02	267	2.7	4.8	7.0	0.033	1.03	7.8	0.11	1.4	0.11	5.94	1.5	0.12	<0.05	0.12	<2	24.7	<0.5	27.7	0.664	<0.002	<0.05	0.83	<1	18	0.008
SWB Bystrzyca from the Zemborzycki Reservoir to the river's mouth (RW20000824699) n = 48	a	0.14	6.92	<0.05	0.9	<2	<0.01	0.002	<0.05	<0.1	12.7	<0.05	<2.0	10.6	<0.05	<0.003	0.32	<0.1	<0.01	43	1.4	0.4	0.8	<0.001	0.21	2.4	<0.05	<0.5	<0.01	0.13	<1.0	<0.05	<0.05	0.07	<2	0.5	<0.5	<0.5	0.032	<0.002	<0.05	<0.05	<1	5	<0.003
	b	1.09	10.76	<0.05	133.5	11	0.09	0.161	<0.05	<0.1	195.2	0.08	59.0	240.0	3.84	<0.003	4.99	<0.1	13.70	590	19.1	6.1	31.4	2.527	26.57	148.1	2.23	10.8	0.26	22.80	33.0	0.43	0.34	2.45	9	38.0	3.9	45.5	1.618	0.003	<0.05	3.83	4	100	0.048
	c	0.52	7.90	n.o.	10.0	n.o.	0.04	0.056	n.o.	n.o.	75.2	n.o.	6.0	31.0	n.o.	n.o.	0.78	n.o.	0.35	221	3.5	4.5	8.8	0.189	3.68	13.6	0.27	1.9	0.12	2.99	2.9	n.o.	n.o.	0.22	n.o.	14.4	n.o.	24.7	0.627	n.o.	n.o.	0.85	n.o.	26	0.020
	d	0.49	7.88	n.o.	3.5	n.o.	0.03	0.043	n.o.	n.o.	68.8	n.o.	3.0	26.0	n.o.	n.o.	0.64	n.o.	0.03	202	3.0	4.0	7.5	0.036	1.64	9.9	0.18	1.2	0.08	1.66	1.4	n.o.	n.o.	0.17	n.o.	9.9	n.o.	18.3	0.544	n.o.	n.o.	0.68	n.o.	22	0.014
	e	0.51	7.90	<0.05	2.9	<2	0.03	0.053	<0.05	<0.1	72.7	<0.05	3.0	24.7	<0.05	<0.003	0.61	<0.1	0.02	200	2.8	5.1	7.7	0.033	1.12	8.4	0.19	1.7	0.14	1.91	1.3	<0.05	<0.05	0.15	<2	10.8	<0.5	25.7	0.633	<0.002	<0.05	0.87	<1	20	0.025
SWB Bystrzyca to the Zemborzycki Reservoir (RW20000624653) n = 48	a	0.25	7.17	<0.05	0.8	<2	0.01	0.007	<0.05	<0.1	34.4	<0.05	<2.0	8.8	<0.05	<0.003	0.22	<0.1	<0.01	82	0.7	1.2	5.7	0.001	0.31	3.8	<0.05	0.6	<0.01	0.08	<1.0	<0.05	<0.05	0.07	<2	2.0	<0.5	4.3	0.445	<0.002	<0.05	0.25	<1	<5	<0.003
	b	0.62	10.09	<0.05	10.8	5	0.05	0.126	<0.05	<0.1	118.2	<0.05	77.0	35.3	0.78	<0.003	1.00	<0.1	1.25	328	5.5	6.0	7.4	0.540	1.29	12.9	0.94	2.7	0.73	17.40	34.0	0.37	0.21	0.25	<2	29.6	3.7	42.7	1.036	<0.002	<0.05	1.06	1	74	0.036
	c	0.48	8.36	n.o.	3.1	n.o.	0.03	0.040	n.o.	n.o.	78.1	n.o.	7.0	22.0	n.o.	n.o.	0.45	n.o.	0.06	213	2.8	4.7	6.6	0.045	0.87	7.8	0.21	1.2	0.14	5.53	2.8	0.13	0.05	0.12	n.o.	18.3	n.o.	23.8	0.613	n.o.	n.o.	0.68	n.o.	14	0.009
	d	0.47	8.34	n.o.	2.6	n.o.	0.03	0.032	n.o.	n.o.	74.3	n.o.	4.0	21.3	n.o.	n.o.	0.43	n.o.	0.02	204	2.6	4.7	6.6	0.013	0.85	7.5	0.13	1.1	0.04	1.29	1.7	0.08	<0.05	0.11	n.o.	13.7	n.o.	22.6	0.605	n.o.	n.o.	0.65	n.o.	10	0.005
	e	0.49	8.20	<0.05	3.0	<2	0.03	0.034	<0.05	<0.1	93.6	<0.05	4.0	21.1	<0.05	<0.003	0.43	<0.1	0.02	243	2.6	4.8	6.7	0.024	0.90	7.3	0.13	1.1	0.08	0.72	1.6	0.12	0.06	0.11	<2	24.9	<0.5	22.8	0.610	<0.002	<0.05	0.67	<1	14	0.005
SWB Ciemięga (RW20000624689) n = 5	a	0.42	7.89	<0.05	0.9	3	0.03	0.020	<0.05	<0.1	50.9	<0.05	3.0	26.6	<0.05	<0.003	0.49	<0.1	0.01	215	2.2	5.3	18.0	0.002	2.17	10.4	<0.05	1.5	0.02	0.14	1.5	<0.05	<0.05	0.09	<2	16.5	<0.5	24.8	0.423	<0.002	<0.05	1.28	<1	<5	<0.003
	b	0.66	8.32	<0.05	13.1	3	0.03	0.024	<0.05	<0.1	103.6	<0.05	6.0	27.6	0.09	<0.003	1.04	<0.1	0.02	342	2.7	5.6	18.9	0.058	2.78	11.2	0.06	2.5	0.14	10.90	3.0	0.13	0.11	0.22	<2	27.6	0.6	27.1	0.568	<0.002	<0.05	2.08	5	29	<0.003
	c	0.60	8.10	n.o.	3.5	3	0.03	0.023	n.o.	n.o.	91.7	n.o.	4.0	27.0	n.o.	n.o.	0.68	n.o.	0.01	307	2.4	5.4	18.6	0.034	2.44	11.0	n.o.	2.2	0.06	8.34	2.1	0.11	0.06	0.12	n.o.	25.0	n.o.	26.2	0.518	n.o.	n.o.	1.58	n.o.	15	n.o.
	d	0.59	8.10	n.o.	1.8	3	0.03	0.023	n.o.	n.o.	88.7	n.o.	4.0	27.0	n.o.	n.o.	0.65	n.o.	0.01	303	2.4	5.4	18.6	0.022	2.43	11.0	n.o.	2.1	0.05	4.38	2.0	0.09	0.05	0.11	n.o.	24.6	n.o.	26.2	0.516	n.o.	n.o.	1.56	n.o.	11	n.o.
	e	0.63	8.07	<0.05	1.1	3	0.03	0.023	<0.05	<0.1	101.3	<0.05	4.0	26.8	<0.05	<0.003	0.55	<0.1	0.01	325	2.3	5.4	18.8	0.035	2.42	11.0	<0.05	2.4	0.05	10.70	1.9	0.13	0.06	0.09	<2	27.3	<0.5	26.6	0.537	<0.002	<0.05	1.52	<1	13	<0.003
SWB Czechówka (RW200006246729) n = 39	a	0.14	7.10	<0.05	<0.5	<2	0.01	0.010	<0.05	<0.1	15.8	<0.05	<2.0	5.2	<0.05	<0.003	0.46	<0.1	<0.01	52	1.0	1.4	0.8	0.005	0.10	4.4	<0.05	<0.5	<0.01	0.07	<1.0	<0.05	<0.05	<0.05	<2	1.6	<0.5	2.2	0.039	<0.002	<0.05	<0.05	<1	<5	<0.003
	b	0.91	9.43	<0.05	80.9	3	0.07	0.104	<0.05	<0.1	137.1	0.14	33.0	81.6	0.60	<0.003	33.87	<0.1	0.45	388	7.6	7.7	21.9	0.456	4.08	37.0	1.83	5.1	0.74	23.40	19.0	0.90	0.73	1.24	<2	29.5	3.8	65.5	0.750	0.003	0.06	1.82	4	156	0.096
	c	0.66	7.90	n.o.	8.1	n.o.	0.03	0.048	n.o.	n.o.	97.3	n.o.	5.0	38.0	0.13	n.o.	2.61	<0.1	0.06	284	3.7	4.8	15.5	0.093	1.03	13.4	0.27	1.7	0.21	7.76	2.6	0.21	0.11	0.28	n.o.	21.6	n.o.	32.8	0.421	n.o.	n.o.	0.94	1	30	0.016
	d	0.61	7.89	n.o.	2.2	n.o.	0.03	0.043	n.o.	n.o.	86.5	n.o.	4.0	32.6	0.07	n.o.	1.12	<0.1	0.03	261	3.4	4.5	11.7	0.062	0.82	12.4	0.17	1.5	0.15	4.86	1.8	0.17	0.06	0.21	n.o.	18.0	n.o.	26.7	0.344	n.o.	n.o.	0.67	1	24	0.009
	e	0.73	7.85	<0.05	1.7	<2	0.02	0.044	<0.05	<0.1	105.9	<0.05	3.0	31.1	0.08	<0.003	0.74	<0.1	0.03	320	3.1	4.6	19.1	0.063	0.79	12.5	0.17	1.4	0.16	6.61	1.5	0.16	0.06	0.23	<2	23.2	<0.5	31.7	0.411	<0.002	<0.05	1.09	1	22	0.011
SWB Czerniejówka (RW20000624669) n = 28	a	0.55	7.61	<0.05	<0.5	<2	0.02	0.009	<0.05	<0.1	100.0	<0.05	<2.0	11.3	<0.05	<0.003	0.42	<0.1	<0.01	181	1.7	3.9	5.7	0.004	1.11	3.7	<0.05	<0.5	0.05	10.10	<1.0	0.09	<0.05	0.06	<2	27.0	<0.5	25.8	0.743	<0.002	<0.05	0.71	<1	<5	<0.003
	b	0.88	8.30	<0.05	4.9	<2	0.04	0.061	<0.05	<0.1	115.0	0.22	6.0	28.0	<0.05	<0.003	1.37	<0.1	0.07	303	3.1	4.8	7.6	0.060	1.99	6.9	0.17	2.2	0.23	16.20	2.4	0.15	0.08	0.16	<2	30.5	<0.5	37.1	1.039	<0.002	<0.05	1.29	1	16	0.030
	c	0.61	7.98	n.o.	1.6	n.o.	0.02	0.023	n.o.	n.o.	107.8	n.o.	3.0	20.4	n.o.	n.o.	0.71	n.o.	0.02	276	2.4	4.3	6.3	0.029	1.39	5.4	0.06	1.2	0.10	14.05	1.3	0.13	n.o.	0.10	n.o.	29.4	n.o.	29.0	0.868	n.o.	n.o.	0.86	n.o.	8	0.012
	d	0.61	7.98	n.o.	1.3	n.o.	0.02	0.019	n.o.	n.o.	107.7	n.o.	3.0	20.1	n.o.	n.o.	0.66	n.o.	0.02	275	2.4	4.3	6.3	0.026	1.37	5.3	<0.05	1.1	0.10	13.97	1.2	0.13	n.o.	0.09	n.o.	29.4	n.o.	28.9	0.865	n.o.	n.o.	0.85	n.o.	6	0.006
	e	0.58	8.02	<0.05	1.2	<2	0.02	0.023	<0.05	<0.1	107.4	<0.05	3.0	20.2	<0.05	<0.003	0.58	<0.1	0.02	277	2.4	4.3	6.1	0.027	1.28	5.3	0.06	1.1	0.10	14.25	1.2	0.13	<0.05	0.10	<2	29.6	<0.5	28.0	0.860	<0.002	<0.05	0.83	<1	10	0.006
SWB Dopływ spod Świdnika (RW20000624674) n = 9	a	0.78	7.42	<0.05	0.7	3	0.03	0.014	<0.05	<0.1	152.0	<0.05	4.0	34.4	<0.05	<0.003	0.66	<0.1	0.03	364	5.8	5.8	10.7	0.021	1.75	6.6	<0.05	2.5	0.04	6.03	1.8	0.06	<0.05	0.13	<2	32.7	<0.5	63.4	1.187	<0.002	<0.05	2.88	1	<5	<0.003
	b	0.88	7.98	<0.05	3.2	4	0.05	0.029	<0.05	<0.1	168.7	<0.05	9.0	40.0	0.08	<0.003	1.42	<0.1	0.07	411	9.1	6.4	12.1	0.175	1.99	11.8	0.10	3.3	0.16	23.30	4.5	0.24	0.07	0.21	3	34.6	0.7	76.9	1.310	<0.002	<0.05	4.11	2	52	0.015
	c	0.84	7.79	n.o.	1.2	3	0.04	0.020	n.o.	n.o.	162.3	n.o.	7.0	36.4	0.05	n.o.	0.85	n.o.	0.05	400	7.0	6.1	11.2	0.072	1.86	8.4	n.o.	2.8	0.08	10.73	3.2	0.14	n.o.	0.15	n.o.	33.4	n.o.	68.2	1.247	n.o.	n.o.	3.61	1	40	n.o.
	d	0.84	7.79	n.o.	1.1	3	0.04	0.019	n.o.	n.o.	162.3	n.o.	7.0	36.3	<0.05	n.o.	0.83	n.o.	0.05	400	6.9	6.1	11.2	0.062	1.85	8.2	n.o.	2.8	0.07	9.87	3.0	0.12	n.o.	0.15	n.o.	33.4	n.o.	68.0	1.247	n.o.	n.o.	3.59	1	32	n.o.
	e	0.85	7.85	<0.05	0.8	3	0.03	0.017	<0.05	<0.1	163.2	<0.05	7.0	36.3	0.07	<0.003	0.75	<0.1	0.05	405	6.5	6.2	11.2	0.064	1.83	7.4	<0.05	2.8	0.07	9.45	3.0	0.16	<0.05	0.14	<2	33.5	<0.5	66.5	1.248	<0.002	<0.05	3.63	1	42	<0.003
Limit values for surface water quality indicators from the group of specific pollutants (Annex 26)[1)]																																													
Limit values for class I and II		n.d.	n.d.	≤5	≤400	≤50	≤2	≤0.5	≤0.8	n.d.	n.d.	n.d.	n.d.	n.d.	≤50	≤0.05	≤50	≤1.5	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	≤40	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	≤2	≤20	n.d.	n.d.	n.d.	n.d.	≤0.05	≤2	n.d.	≤50	n.d.	≤1
Environmental quality standards for chemical status indicators of uniform parts of the surface water (Annex 14)[1)]																																													
Maximum allowable concentration		n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.45 (class I and II) 0.6 (class III) 0.9 (class IV) 1.5 (class V)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	34	n.d.	n.d.	n.d.	n.d.	14	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Limit values for quality classes of surface water indicators of uniform parts of the surface water (RW_wap) (Table 4)[1)]																											≤0.13 (class I) ≤0.30 (class II) not set (class III,IV,V)*			≤1.30 (class I) ≤2.00 (class II) not set (class III,IV,V)	≤4.0 (class I) ≤7.0 (class II) not set (class III,IV,V)	≤0.13 (class I) ≤0.25 (class II) not set (class III,IV,V)														
Limit values																																													
Limit values for quality classes of surface water indicators of uniform parts of the surface water (RW_wap) (Table 8)[1)]																																													
Limit values																											≤0.14 (class I) ≤0.35 (class II) not set (class III,IV,V)*			≤1.40 (class I) ≤2.00 (class II) not set (class III,IV,V)	≤4.5 (class I) ≤7.0 (class II) not set (class III,IV,V)	≤0.15 (class I) ≤0.33 (class II) not set (class III,IV,V)														

a – minimum
b – maximum
c – arithmetic mean
d – geometric mean
e – median
n – number of samples
n.d. – not applicable
n.o. – not calculated in the case when the percentage of the results below determination limit exceeded 50%
* – limit value provided for ammonium nitrogen
[1)]Rozporządzenie…, 2021

(according to Tkaczyk, Bednarek, 2011). Very acidic soils (pH<4.5) account for only 5% of arable soils and are found near the villages of Konopnica and Stasin. The percentage of acidic and very acidic arable soils in the Lublin district in the period 1999–2008 averaged 44.3% (Tkaczyk, Bednarek, 2011). Alkaline pH (pH>7.2) was found in 18.6% of all analysed soil samples. The median pH values of arable soils in the study area is lower than those of soils from Poznań and Warsaw, which are 6.8 (Lis, Pasieczna, 2005) and 7.1 (Tomassi-Morawiec, 2016), respectively. The pH measured in the soil sample taken in the village of Świdniczek (municipality Wólka) is 7.32, which is similar to the value determined as part of the *Monitoring of the chemistry of arable soils in Poland*. The pH values at measurement and control point No. 283 (location changed in 2015 within the same village) ranged from 5.8 to 7.5 in the period 1995–2020 (https://www.gios.gov.pl/chemizm_gleb/index.php?mod=pomiary&p=283). Neutral and alkaline soils, which are mainly of anthropogenic origin, are found in urban areas of Lublin and Świdnik, as well as near the villages of Dąbrowica (in the north-western part of the study area), Elizówka, Kolonia Pliszczyn and Zagrody (northern part). These areas are represented mainly by urban residential (both low-rise and high-rise) and industrial development, as well as by landscaped green spaces such as parks, gardens and lawns. The anthropogenic soils are characterized by a pH range of 5.24–8.51. The median pH of soil samples (7.53) is slightly lower than the median pH of soils in the Poznań and Warsaw regions, which were 7.8 and 7.9, respectively (Lis, Pasieczna, 2005; Tomassi-Morawiec, 2016). The lower pH of anthropogenic soils in the Lublin agglomeration may be related to the lower urbanization index of this region compared to Poznań and Warsaw. Industrial soils occur to the south of Lublin city centre in the Wrotków quarter, to the east in the Tatary quarter, and to the north of Świdnik city centre. The most alkaline soils (pH>8.0) were found in the surroundings of Lublin Airport. The impact of anthropopression on soil pH can be seen by comparing the pH values of soil samples taken from undeveloped areas (median 5.64) and rural areas (6.8) with those from areas of urban low- and high-rise housing and industrial development (medians: 7.37, 7.50 and 7.50, respectively).

Surface waters: Plate 7, Table 7

Surface waters, which are represented in the research area by rivers, ditches, ponds, artificial reservoirs and settling basins, show little variation in pH – from slightly alkaline to alkaline. The median pH of all analysed surface water samples is 7.97, which is slightly higher than the median pH of 7.6 obtained for waters from the Warsaw and Poznań regions (Lis, Pasieczna, 2005; Tomassi-Morawiec, 2016). The calculated median pH values for individual SWBs in the survey area vary insignificantly within a range of 7.85–8.20. Slightly alkaline pH (pH 7–9) is found in 95.6% of all analysed surface water samples, alkaline pH (pH 9–14) in 3.85% of water samples, and neutral pH (6.5–7) in only 0.55% of samples (according to the classification by Kleczkowski and Różkowski, 1997). Alkaline waters occur mainly in the right-bank side of the Zemborzycki Reservoir and in two settling ponds/reservoirs. One of them is located near the Dopływ z Konopnicy stream (in its lower course) in Lublin, and the other is situated in the northern part of the study area in Elizówka (in the Niemce municipality). The highest pH value of 10.76 was measured in waters of the latter reservoir. This reservoir is located on wasteland and fallow land (understood in this study as undeveloped areas, roadsides or agricultural land left without agricultural production) near a commercial and service complex, collecting rainwater. Neutral pH waters (pH 6.92) are found in a ditch in the village of Bystrzyca (in the Wólka municipality). It is located alongside a cycle path in the Bystrzyca Valley. Waters of the Zemborzycki Reservoir have a pH ranging from 7.86 to 10.09, with most samples showing a pH above 8.

EC – ELECTRICAL CONDUCTIVITY

Surface waters: Plate 8, Table 7

Electrical conductivity (EC) is a quantitative parameter used to assess water mineralization and quality. The EC value of natural, flowing waters is typically up to 1 mS/cm. However, in contaminated waters (e.g. introduced with wastewater), this value can be many times higher, reaching 10 mS/cm (Augustyn et al., 2012; Szczykowska, Siemieniuk, 2020). The maximum permissible electrical conductivity of surface waters, which are used to supply the population with waters, should not exceed the quality index limit of 1 mS/cm for classes A1–A3 (Rozporządzenie..., 2019).

The electrical conductivity of the tested surface water samples is less than 1 mS/cm, except for one sample taken from a ditch in the village of Sobianowice (in the Wólka municipality), where the highest conductivity value of 1.092 mS/cm was found. The ditch is located at the boundary between farmland, fallow land in the meandering valley of the Bystrzyca River, in the north-eastern part of the study area. The median specific electrical conductivity of all analysed surface water samples is 0.57 mS/cm. This is slightly lower than the median value obtained for waters in the Warsaw area (0.67 mS/cm), and significantly lower than the median value for waters in Poznań (0.87 mS/cm) (Lis, Pasieczna, 2005; Tomassi-Morawiec, 2016). The electrical conductivity of the Zemborzycki Reservoir waters ranges from 0.250 mS/cm to 0.603 mS/cm. These values are similar to those recorded for impounding reservoirs: 0.217 mS/cm in the Goczałkowice Reservoir and 0.891 mS/cm in the Rybnik Reservoir (Rzętała, 2008). The highest median EC values (0.850 mS/cm) were found in the SWB Dopływ spod Świdnika. Relatively equal conductivity values ranging from 0.784 mS/cm to 0.875 mS/cm were measured in all nine water samples taken from this watercourse. The watercourse flows through rural housing and agricultural areas (fallow land and arable fields). In its lower course, the Hajdów Wastewater Treatment Plant is located, but no treated wastewater is discharged into it. The water sampling sites are covered by dense vegetation. Elevated conductivity values were also measured in waters of the SWB Czechówka (median 0.730 mS/cm) and SWB Ciemięga (median 0.630 mS/cm). None of the tested SWBs meets the surface water quality requirements specified for this type of river (Rozporządzenie..., 2021).

Ag – SILVER

Soils: Plate 9, Table 3

The mean concentration of silver in soils generally does not exceed 0.1 mg/kg. Due to its low mobility, silver accumulates in the topsoil layer, especially in contaminated horizons (Kabata-Pendias, Pendias, 1999). Sources of silver contamination include electroplating plants and other industries that use silver salts. Increased amounts of silver may also be introduced into the soil through municipal wastewater (Żelazowska, Pasternak, 2007).

The silver concentration in the study area soils ranges from below 0.05 mg/kg to 1.48 mg/kg (median <0.05 mg/kg). Elevated levels of this metal were observed at the WSK PZL-Świdnik plant and in Lublin city centre, particularly in the Old Town and Bronowice quarters, as well as in the southern part of the Tatary quarter. These areas have been under intense anthropogenic pressure for decades. The maximum level of silver was found in a soil sample taken from allotment gardens in the Kośminek quarter. This suggests the intensive use of organic and mineral fertilizers, as well as plant protection products (Anand, Bhagat, 2019). Soils collected from allotments typically show the highest median silver concentration (0.08 mg/kg). A similar situation was observed in Warsaw. The site with the highest silver concentration measured in soils of the capital city was also located in allotment gardens (Tomassi-Morawiec, 2016). In the study area, anthropogenic soils are characterized by slightly higher concentrations of silver (median 0.06 mg/kg) than those in forest and agricultural areas (median <0.05 mg/kg). The data obtained for soils in the Lublin region are consistent with those acquired during the implementation of the European GEMAS project (*Chemistry of Europe's agricultural soils*), covering agricultural soils in Europe. The median concentration of this element in Polish soils was 0.023 mg/kg in cultivated land and 0.027 mg/kg in meadows (Reimann et al. (eds.), 2014).

Aquatic sediments: Plate 9, Table 5

The silver concentration in aquatic sediments ranges from below 0.05 mg/kg to 5.22 mg/kg (median 0.06 mg/kg). Significantly elevated levels were found in the Bystrzyca River sediments, mainly downstream of Lublin city. The highest value was measured in a sample also taken from the Bystrzyca River. The sampling site was located within the SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth, downstream of Lublin city and upstream of the Hajdów Wastewater Treatment Plant's discharge point. Therefore, the treatment plant cannot be identified as the source of the sediment contamination by this metal. The reasons for the increased levels of silver at this location can be sought in the activities of the company involved in the purchase and trade of steel and non-ferrous metals (scrap metal dealer). The company's plot of land is located approximately 40 m from the sampling site and around 25 m from the Bystrzyca River channel. Much of the plot is paved and used for storage and manoeuvring. The sediment sample taken from this location also showed the highest levels of Cr, Cu, Ni, Zn, Co, Cd, Ti and Pb, and almost the highest levels of Ba and Se. However, the concentration of 5.22 mg/kg is many times lower than the highest values measured in sediments from the Warsaw and Poznań areas, 208 mg/kg and 18.9 mg/kg, respectively (Lis, Pasieczna, 2005; Tomassi-Morawiec, 2016). Referring the obtained results to ecotoxicological risk indices (MacDonald et al., 2000), it can be concluded that only two sediment samples show silver levels above the TEC (*Threshold Effect Concentration*) value – 1.6 mg/kg. Only at one location did the levels exceed the PEC (*Probable Effect Concentration*) index – 2.2 mg/kg, above which the metal is expected to have a harmful effect on benthic organisms (MacDonald et al., 2000).

Surface waters: Plate 10, Table 7

Laboratory analyses of all surface water samples taken in the study area show that the concentrations do not exceed the limit of determination (0.05 µg/dm^3). Therefore, all of the waters meet the standards for surface water quality classes I and II (the limit value for silver is ≤5 µg/dm^3, Rozporządzenie..., 2021).

Al – ALUMINIUM

Soils: Plate 11, Table 3

Aluminium is a major component of most minerals found in soils. Its content is depends on the lithology of the parent rock and the type of soil, and usually ranges from 1% to 3.5% (Kabata-Pendias, Pendias, 1999). The migration of aluminium in the soil profile is a natural process associated with podzolization. In acidic soils (pH 3–4.5), aluminium displaces other cations from the sorption complex, resulting in soil nutrient depletion. This phenomenon is especially evident in mineral horizons of forest soils, and is one of the main factors leading to podsolization and degradation of soil (Kabata-Pendias, Pendias, 1999).

The aluminium content determined in the topsoil layer in Lublin and its environs ranges from 0.08% to 1.66%. The median value for this element in soils of this area is 0.68%, which is approximately twice the median value calculated for the Poznań – median 0.31% (Lis, Pasieczna, 2005) and Warsaw – median 0.34% (Tomassi-Morawiec, 2016) regions, and for Poland – median 0.27% (De Vos, Tarvainen (eds.), 2006). The highest content of aluminium is found in the north-western part of the study area in soils formed on Pleistocene loess. The median value for loamy soils is twice that of peaty and sandy soils (0.79%, 0.41% and 0.44%, respectively). The elevated content of aluminium in loamy soils is directly related to the concentration of this element in till containing significant amounts of aluminosilicate minerals. The presence of carbonate rocks in the bedrock, which are rich in Ca^{2+}, Mg^{2+}, K^+, and Na^+, contributes to the predominance of slightly acidic, neutral and alkaline soils. Therefore, acidification does not play a significant role in the dissolution of aluminium compounds and the release of aluminium from minerals present in the soil. The soil samples collected from forest areas were found to have a low median value (0.40%).

Soils in industrial and urban areas of Lublin do not show elevated levels of aluminium compared to rural areas. The soil sample taken in the village of Świdniczek (in the Wólka municipality) had an aluminium content of 0.80%. In the last two cycles of the *Monitoring of the chemistry of arable soils in Poland*, the aluminium content measured at measurement and control point No. 283, which is located in the same village, was 0.68% and 1.18%, respectively (https://www.gios.gov.pl/chemizm_gleb/index.php?mod=pomiary&p=283). The spatial distribution of aluminium in soils of Lublin and environs is similar to that of some lithophile elements, such as potassium, lithium, titanium and vanadium. The variability of these elements in topsoil is not dependent significantly on anthropogenic processes. Spatial variability of aluminium content in the soils is related to the variability of soil's grain size composition. In general, an aluminium content above the median value (0.68%) was observed in soils where the proportion of fine fractions (grain sizes of 0.02< d ≤0.063 mm and ≤0.02 mm) exceeded the 50th percentile. However, this was not the case in the Stary Gaj forest complex, which is located in the Zemborzyce quarter, in the south-western part of Lublin.

Aquatic sediments: Plate 11, Table 5

In the study area, the content of aluminium in aquatic sediments, ranging from 0.04% to 1.65% (median 0.49%), is similar to its content in soils. The 50th percentile value for aluminium content in sediments in the Lublin agglomeration is higher than the median value for this metal in sediments in Warsaw – 0.33% (Tomassi-Morawiec, 2016) and Poznań – 0.31% (Lis, Pasieczna, 2005). The content of aluminium in the sediments of rivers flowing through Lublin city usually does not exceed 0.80%. Its median content calculated for sediment samples taken from the individual SWBs (all on carbonate bedrock) varies little, ranging from 0.41% to 0.57%. Therefore, it can be assumed that the aluminium content in aquatic sediments of this region is influenced primarily by the chemical composition of the parent rocks.

Surface waters: Plate 12, Table 7

The aluminium concentration is low in most of the surface water samples tested. Only around 10% of analysed water samples have a concentration of this element exceeding 5.6 µg/dm^3. The median value for the entire dataset is 2.2 µg/dm^3, which is about five times lower than the median aluminium concentration obtained for surface waters from the Warsaw and Poznań regions – 10 µg/dm^3 (Lis, Pasieczna, 2005; Tomassi-Morawiec, 2016). The median values calculated for the individual SWBs in the study area range from 0.8 to 3.0 µg/dm^3. None of the samples tested exceeded the aluminium limit value of 400 µg/dm^3, specified for surface water quality classes I and II for indicators from the group of specific contaminants (Rozporządzenie..., 2021). The highest concentration of aluminium (133.5 µg/dm^3) was measured in a water sample taken from a pond in Elizówka. It is a standing water reservoir located on sands, silts, and deluvial muds in an area near warehouses, a market hall and a shopping centre. The water body is recharged by rainwater, and its waters are characterized by a distinctly alkaline pH (10.76).

As – ARSENIC

Soils: Plate 13, Table 3

The arsenic concentration in most rocks ranges from 0.5 mg/kg to 2.5 mg/kg. Mean concentrations in soil vary from 0.2 mg/kg to 16 mg/kg. The highest levels are typically found in the clay fraction and organic soils. In soils, arsenic exhibits properties similar to phosphorus and is sorbed by iron and aluminium hydroxides, organic matter, and calcium and phosphorus compounds (Kabata-Pendias, Pendias, 1999; Łożna, Biernat, 2008).

Soils in Lublin and environs show little variation in terms of arsenic content. Levels range from below 3 mg/kg to 18 mg/kg (median 3 mg/kg). These results are similar to those obtained for soils in the Warsaw area, where 75% of samples had an arsenic concentration below the limit of determination – 3 mg/kg (Tomassi-Morawiec, 2016). Elevated concentrations were observed in the topsoil layer in the north-eastern part of Lublin, in the Tatary quarter, where industrial plants were located: a truck factory, the Ursus Mechanical Works, and an iron foundry. Currently, there are a number of smaller production plants in this area, and the Megatem EC-Lublin Sp. z o.o. combined heat and power plant. As metallurgy and coal combustion are the main sources of human activity causing arsenic emissions into the environment (Matschullat, 2000), it is the long-term industrial use of the Tatary quarter that has led to the increase in the amount of this element in the soil. The highest concentration of arsenic (18 mg/kg) was recorded in a sandy soil sample taken from the Tatary quarter, in the middle of the former FSC Lublin Automotive Factory premises. The remaining areas, particularly the forests and agricultural land, but also some within Lublin itself, have low levels of arsenic, with many locations showing concentrations below the detection limit. Low levels of this metalloid were found in soils of the southern and south-eastern parts of the study area. All soils in the Lublin area contain less than the permissible concentration of arsenic (25 mg/kg) for soil group I (Rozporządzenie... 2024). The results of measurements carried out on the soils in Lublin and environs are similar to those found during the GEMAS project implementation. The median arsenic concentration in agricultural soils in Poland was 2.4 mg/kg for cultivated land and 3.1 mg/kg for meadows (Reimann et al. (eds.), 2014). The soil sample taken in the village of Świdniczek (in the Wólka municipality) contained 4 mg/kg of arsenic, which is about double the concentration (2.5 mg/kg and 1.93 mg/kg, respectively) of this element determined in 2015 and 2020 as part of the *Monitoring of the chemistry of arable soils in Poland* at measurement and control point No. 283, which is located in the same village (https://www.gios.gov.pl/chemizm_gleb/index.php?mod=pomiary&p=283).

Aquatic sediments: Plate 13, Table 5

The content of arsenic in aquatic sediments in the study area ranges from below 3 mg/kg to 47 mg/kg (median <3 mg/kg). The spatial distribution of this element in sediments does not suggest that its elevated amounts result from human activity. The maximum concentrations of arsenic measured in two sediment samples taken from the initial section of the Dopływ spod Świdnika stream were 47 mg/kg and 27 mg/kg, respectively. The enrichment of these sediments in arsenic is also accompanied by an increased iron concentration. The high accumulation of arsenic in the sediments of this section of the watercourse is probably natural and related to the presence of both the spring area of the Dopływ spod Świdnika and extensive meadow areas (possibly with bog iron deposits) in this region. In the remaining area covered by the study, the arsenic concentration in aquatic sediments is similar to that determined in soils, ranging from below 3 mg/kg to 13 mg/kg. Referring these results to ecotoxicological risk indices, it can be concluded that there are four sediment samples with arsenic levels above the TEC value (9.8 mg/kg) and two samples with levels above the PEC value (33 mg/kg), indicating a risk of harmful effects of the element on aquatic organisms (MacDonald et al., 2000).

Surface waters: Plate 14, Table 7

Surface waters in the Lublin region are characterized by low concentrations of arsenic. Almost 81% of the analysed water samples show concentrations below the limit of determination (2 µg/dm^3). The maximum concentration of arsenic (11 µg/dm^3) was found in a sample taken from a field drainage ditch near the village of Turka. This watercourse is located within the SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth. All of the tested waters contain ≤50 µg/dm^3 of arsenic and meet the standards for surface water quality classes I and II (Rozporządzenie..., 2021).

B – BORON

Surface waters: Plate 15, Table 7

Boron is a common component of surface water, although its concentration in inland reservoirs is usually lower than in seawater, where it occurs at a concentration of approximately 4.5 mg/dm^3. The main sources of boron emissions into surface waters are municipal and industrial wastewater, and surface runoff from agricultural areas (Kabata-Pendias, Pendias, 1999).

The boron concentration in all surface water samples from Lublin and environs ranges from below 0.01 to 0.09 mg/dm^3. The median value obtained in this study is 0.03 mg/dm^3, which is similar to the median recorded in Polish waters – 0.04 mg/dm^3 (Lis, Pasieczna, 1995), but about half the concentration measured in waters of the of Poznań – median 0.06 mg/dm^3 (Lis, Pasieczna, 2005) and Warsaw – median 0.07 mg/dm^3 (Tomassi-Morawiec, 2016) agglomerations. The highest concentration of boron (0.09 mg/dm^3) was measured in a water sample taken from an unnamed ditch flowing across the north-eastern part of the area, in the village of Sobianowice. The water sample collected from this location also showed the highest levels of several other physicochemical parameters: EC–1.092 mS/cm, Ca–195.2 mg/dm^3, Fe–13.70 mg/dm^3, HCO_3^-–590 mg/dm^3, SiO_2–38 mg/dm^3, and Sr–1.618 mg/dm^3. In water samples from the Lublin region, there is no clear spatial variation in boron concentration. The median concentrations in the individual SWBs are close to the median calculated for the entire population of water samples. No sample exceeded the limit value specified for surface water quality classes I and II for indices from the group of specific contaminants, which is ≤2 mg/dm^3 for boron (Rozporządzenie…, 2021).

Ba – BARIUM

Soils: Plate 16, Table 3

Barium in the Earth's crust is found mainly in acidic volcanic rocks and sedimentary rocks, such as clay shales, in which it tends to concentrate (Kabata-Pendias, Pendias, 1999). In Polish soils, barium generally occurs at low levels of below 100 mg/kg. However, the measurements were obtained after extraction with aqua regia, so the total concentration of the element may be up to four times higher (De Vos, Tarvainen (eds.), 2006). Mean concentrations of barium in agricultural soils range from 20 mg/kg to 130 mg/kg (Swęd, 2017). In arable soils of the Ap (humus) horizon, these values range from 27.20 mg/kg to 104.00 mg/kg. The highest levels (69.61–104.00 mg/kg) are observed in mountainous regions (Sudety Mountains, Podhale, and Beskidy Zachodnie Mountains), as well as in the Silesian Upland. Arable soils in the Lublin region are characterized by a barium concentration ranging from 39.71 mg/kg to 55.40 mg/kg (Tołoczko, 2020).

The study area soils exhibit significant variation in barium concentration (from 8 mg/kg to 1327 mg/kg; median 49 mg/kg). These levels are higher than those measured in soils in Warsaw – median 39 mg/kg (Tomassi-Morawiec, 2016) and Poznań – median 27 mg/kg (Lis, Pasieczna, 2005). Anthropogenic soils in the Lublin region (median 55 mg/kg) are characterized by a higher barium concentration than clay soils (49 mg/kg) and sandy soils (median 38 mg/kg). Urban (including both low- and high-rise housing) and rural areas (medians: 53 mg/kg, 52 mg/kg, and 51 mg/kg, respectively) show similar levels of this element. Higher amounts of barium were found in industrial areas (median 58 mg/kg), mainly in the Bronowice, Kośminek, Abramowice, Wrotków and Sławinek quarters of Lublin, as well as in the Świdnik and Prawiednik areas, which is most likely related to anthropogenic activity. Barium is used in the chemical, pharmaceutical, automotive and electrical engineering industries (Sapota, Skrzypińska-Gabrysiak, 2006). Other sources of barium in the environment include dust from cement and power plants and from car exhaust fumes, as well as fertilizers and pesticides used in agriculture, and building materials (plasters and paints). The higher concentration of barium in areas near the combined heat and power plants in Lublin and Świdnik may be related to industrial emissions of dust from coal combustion in these plants (Kabata-Pendias, Pendias, 1999). This is confirmed by the results of analyses of hard coal samples from the Lublin Coal Basin (LCB), in which the barium levels vary from 26 mg/kg to 572 mg/kg, median 110 mg/kg (Bojakowska, Lech, 2015). Barium concentrations in the range of 400–1200 mg/kg were also recorded in ash originating from the combustion of LCB coal (captured on electrostatic precipitators) (Czech et al., 2017). The highest concentrations of this element were determined in soil samples taken from a lawn near an internal road in the industrial area of WSK PZL-Świdnik, and from wasteland and fallow land in the Wrotków quarter to the north of the Zemborzycki Reservoir (1327 mg/kg and 955 mg/kg, respectively). These concentrations may be anthropogenic in nature. Only seven soil samples have been found to have barium levels above the permissible limit of 400 mg/kg for soil group I (Rozporządzenie…, 2024). The lowest levels of barium (median 26 mg/kg) were recorded in forest areas extending southeast of the Zemborzycki Reservoir. The barium concentration in the soil sample collected in the village of Świdniczek (in the Wólka municipality) is 90 mg/kg, which is about three times higher than the value recorded in 2020 (35 mg/kg) as part of the *Monitoring of the chemistry of arable soils in Poland* (https://www.gios.gov.pl/chemizm_gleb/index.php?mod=pomiary&p=283). The results obtained for soil samples from arable fields (median 49 mg/kg) and meadows (median 52 mg/kg) in the Lublin region are slightly higher than those determined as part of the international GEMAS project for agricultural soils of Poland. The median concentrations were found to be 32 mg/kg for arable soils and 38 mg/kg for meadows (Reimann et al. (eds.), 2014).

Aquatic sediments: Plate 16, Table 5

The barium content in aquatic sediments in Lublin and environs ranges from 6 mg/kg to 309 mg/kg. However, 90% of all the samples tested did not exceed 75 mg/kg. The median value calculated for the entire sample set is 40 mg/kg, which is slightly lower than that found in sediments in Warsaw – median 51 mg/kg (Tomassi-Morawiec, 2016) and Poznań – median 46 mg/kg (Lis, Pasieczna, 2005). The maximum concentration of barium (309 mg/kg) was recorded in an outlier sample taken from a stream within the SWB Czechówka, in the Sławina area, south of the Synthaverse SA pharmaceutical company. The surrounding areas were not used for agriculture. The highest median barium concentration (49 mg/kg) was found for the SWB Czechówka and SWB Dopływ spod Świdnika. The lowest concentrations of barium were measured in aquatic sediments of the SWB Ciemięga and SWB Bystrzyca to the Zemborzycki Reservoir. The median values for both these SWBs are identical, 28 mg/kg.

Surface waters: Plate 17, Table 7

Barium concentrations in surface waters of the study area vary from 0.002 mg/dm^3 to 0.161 mg/dm^3. The median barium concentration for all water samples is 0.035 mg/dm^3, which is lower than the median values of 0.050 mg/dm^3 and 0.047 mg/dm^3 determined for waters of Warsaw and Poznań, respectively (Lis, Pasieczna, 2005; Tomassi-Morawiec, 2016). Elevated barium concentrations in surface waters were recorded in the SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth (median 0.053 mg/dm^3) and in the SWB Czechówka (median 0.044 mg/dm^3). These may be related to anthropogenic contamination in the river catchment areas. In the middle course of the Czechówka River, the maximum concentration of barium was recorded at the Synthaverse SA premises. Downstream of the Zemborzycki Reservoir, the Bystrzyca River runs through anthropogenically altered areas, including industrial zones. The maximum concentrations of barium in surface waters (161 mg/dm^3) were found in a rainwater-recharged pond. The pond is located in the north of the research area in Elizówka (in the Niemce municipality) within the SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth. This

water body is situated near a commercial and service complex. The obtained results were compared to the barium limit value, which is one of the surface water quality indices in the group of specific contaminants for classes I and II (Rozporządzenie..., 2021). These results indicate that none of the surface water samples tested exceeded the limit value of ≤0.5 mg/dm^3.

Be – BERYLIUM

Soils: Plate 18, Table 3

In the Earth's crust, beryllium occurs in a dispersed form mainly in acidic volcanic rocks and clay rocks (Kabata-Pendias, Pendias, 1999). Beryllium concentrations in Poland's soils range from 0.03 to 2.80 mg/kg. The highest levels are associated with heavy soils (Kabata-Pendias, Pendias, 1999). In the humus layer (Ap) of arable soils, beryllium concentrations are generally low, up to 0.70 mg/kg. The highest values are observed in the mountainous regions of southern Poland (Sudety Mountains and Podhale). Previous studies on beryllium concentration in arable soils in the Lublin region yielded results ranging from 0.36 to 0.45 mg/kg (Tołoczko, 2020).

The study area soils show little variation in beryllium concentration, ranging from <0.5 mg/kg to 4.71 mg/kg (median 0.43 mg/kg). Anthropogenic soils (median 0.49 mg/kg) and loamy soils (median 0.47 mg/kg) are characterized by significantly higher beryllium concentrations than sandy soils (median 0.26 mg/kg). The highest levels of beryllium were observed in anthropogenically transformed areas. Industrial, urban and rural (including both low- and high-rise housing) areas show similar concentrations of this element (medians: 0.49 mg/kg, 0.48 mg/kg, and 0.47 mg/kg, respectively). Enrichment in beryllium is found in soils of urban areas, especially in the central quarters of Lublin: Old Town, Bronowice and Piaski, as well as in soils around industrial zones (e.g. near the combined heat and power plant Elektrociepłownia Megatem EC-Lublin Sp. z o.o. and to the south of the Hajdów Wastewater Treatment Plant), and in the Świdnik area (south of the WSK PZL-Świdnik plant and the Elektrociepłownia Veolia Wschód Sp. z o.o combined heat and power plant Zakład Świdnik). The elevated levels of this metal may be related to industrial emission of dust into the environment resulting from coal combustion in commercial combined heat and power plants, as well as low-emission coal-fired households in the cities. They may also be linked with the activities of the aviation industry (beryllium alloys are used in engine construction), the electrical engineering industry, and the medical industry (Buszman et al., 1979; Kabata-Pendias, Pendias, 1999; Madej, 1999; Jakubowski, 2008). Coal and ash analyses confirm that they contain elevated amounts of beryllium. The mean concentration of beryllium in hard coal from the Upper Silesian Coal Basin (USCB) is between 2.8 and 4.4 mg/kg (Strugała et al., 2014), whereas LCB coal contains 3.0 mg/kg of beryllium (Augustcik et al., 2016). Ashes from coal combustion in the LCB contain up to 77.2 mg/kg of this element (Strugała et al., 2014). Relatively high concentrations were also recorded in allotment gardens (median 0.51 mg/kg), wastelands, fallow land, and lawns (0.48 mg/kg). The maximum concentration of beryllium (4.71 mg/kg) was measured in an outlier sample collected from wasteland near an asphalt road in the Prawiednik area (south of the Zemborzycki Reservoir). In addition, a high concentration of beryllium (4.05 mg/kg) was found in an outlier sample taken from allotment gardens in the Rury Jezuickie area. These concentrations may be anthropogenic in origin. The lowest amounts of beryllium were recorded in the southern part of the study area near the Zemborzycki Reservoir and the Bystrzyca River valley, as well as in forest complexes to the north of Świdnik Mały and Świdnik Duży. The beryllium concentration measured in the soil sample taken in the village of Świdniczek (in the Wólka municipality) is 0.76 mg/kg. This falls within the range (below 2 mg/kg) determined during research for the *Monitoring of the chemistry of arable soils in Poland* (https://www.gios.gov.pl/chemizm_gleb/index.php?mod=pomiary&p=283). The results obtained for samples taken from agricultural areas and meadows in the Lublin region are approximately twice those measured in Poland's soils, for which the median values were 0.22 mg/kg in arable soils and 0.27 mg/kg in meadow soils, as determined by the international GEMAS project (Reimann et al. (eds.), 2014).

Aquatic sediments: Plate 18, Table 5

The beryllium concentration in aquatic sediments of Lublin and environs ranges from below 0.05 mg/kg to 1.03 mg/kg (median 0.36 mg/kg). The maximum concentration of beryllium (1.03 mg/kg) was found in an outlier sample taken from the upper course of the Dopływ z Konopnicy stream, near the village of Konopnica. The surrounding areas consist of wasteland and fallow land. The highest median value (0.43 mg/kg) was found in aquatic sediments of the SWB Czerniejówka. The lowest concentrations of beryllium were measured in the SWB Ciemięga and SWB Bystrzyca to the Zemborzycki Reservoir, and are similar: 0.28 mg/kg and 0.29 mg/kg, respectively.

Surface waters: Plate 19, Table 7

Beryllium concentration in surface waters is low, usually does not exceed 0.5 µg/dm^3 (Kabata-Pendias, Pendias, 1999). Beryllium can migrate into surface water through infiltration from soils or atmospheric precipitation (Buszman et al., 1979). The level of beryllium concentration in surface waters is controlled by their pH level. At a pH close to neutral, most of this element is hydrolyzed to form insoluble beryllium hydroxide. However, its solubility and mobility increase as the pH rises, due to its ability to form soluble complexes with hydroxide ions (Bolan et al., 2023). The beryllium concentration in surface waters of industrialized areas (in the USCB) ranges from 0.3 to 1.88 µg/dm^3 (Pasieczna et al., 2021).

The present study shows that the concentrations of beryllium in surface waters of the Lublin region are low. In all of the water samples, they were below the limit of determination of the analytical method used (0.05 µg/dm^3). Surface waters in the Lublin region are mainly slightly alkaline, which may limit the solubility and transport of beryllium in them.

Br$^-$ – BROMIDES

Surface waters: Plate 20, Table 7

Bromine in water usually occurs in ionic form as bromide (Br-). The mean concentration of bromides in surface water is generally less than 0.2 mg/dm^3. Higher concentrations of bromides have been observed in waters with increased mineralization, such as brines, thermal waters, and medicinal waters (Macioszczyk, Dobrzyński, 2002). Industrial wastewater discharges may also cause elevated bromide concentrations in water.

The study shows that the bromide concentration in surface waters in the Lublin region is low. The concentration of the ion is below the limit of determination of the analytical method (0.1 mg/dm^3) in all of the analysed samples. This result is consistent with the general trend of bromide levels in weakly mineralized waters, which usually do not exceed the detection limit. In contrast to surface waters in Warsaw and environs, where bromide concentrations in many places were above 0.2 mg/dm^3 (Tomassi-Morawiec, 2016), the watercourses in the Lublin region exhibit no evidence of anthropogenic contamination by bromine.

TOC – TOTAL ORGANIC CARBON

Soils: Plate 21, Table 3

Total organic carbon (TOC) is present in the environment as part of living biomass and organic matter, such as peat, coal and kerogen. It can also originate from anthropogenic sources, including landfills (Salminen, 2005), petrochemical industry wastewater, fuel combustion processes, and coal tar processing residues (Stojanović Bjelić et al., 2022). In water, TOC acts as a metal complexing agent, affecting the solubility and mobility of metals, such as Al, Cu, Pb, Zn and Cd, in the environment. Compared to other European countries, the soils in Poland are characterized by lower TOC content (Salminen, 2005).

The TOC content in soils in the Lublin region varies greatly from 0.13% to 34.66%. The median TOC value calculated for the study area (1.36%) is similar to both the average level of TOC in European soils – 1.73% (Salminen, 2005) and the median TOC value for soils in Warsaw – 1.40% (Tomassi-Morawiec, 2016). The highest organic carbon contents in the survey area were found in peaty soils (median 14.07%). Significantly lower TOC values were recorded in anthropogenic soils (median 2.04%) and sandy soils (median 1.64%). The lowest medians were measured in silty (1.18%) and loamy (1.28%) soils. In terms of land use, the highest TOC values were observed in industrial areas (median 1.94%) and highly urbanized areas (median 1.79%). Elevated levels of organic carbon were found in the Bystrzyca River valley, where the soils, including *fluvic chernozems (phaeozems),* black earths, peats, and proper alluvial soils, are naturally rich in organic matter (Chodorowski et al., 2024). High TOC values in soils near the Megatem EC-Lublin SA and Lublin-Wrotków combined heat and power plants are most likely of anthropogenic origin and related to dust emissions resulting from hard coal combustion. Increased levels of elements such as lead, sulfur, and zinc have also been observed in these areas.

Aquatic sediments: Plate 21, Table 5

The median total organic carbon content in the tested aquatic sediments is 3.05%, which is higher than the median for sediments in Europe – 1.71% (Salminen, 2005). The TOC content in sediments from the Lublin region ranges from 0.11% to 25.32%. The highest TOC median was found in the SWB Dopływ spod Świdnika (6.93%). This percentage is more than twice the median for all of the sediment samples. Elevated TOC levels were also recorded in sediments from the SWB Bystrzyca to the Zemborzycki Reservoir (median 3.79%) and SWB Czerniejówka (median 3.44%). In general, elevated levels of organic carbon are found in sediments of the watercourses located in the north-eastern and south-western parts of the study area. Most of these areas represent wetlands in river valleys, which provide conditions conducive to the accumulation of organic matter. The highest TOC values (above 18%) were recorded at point locations in sediments of the ponds and streams located along the Ciemięga (Krężniczanka) watercourse, in the south-west of the analysed region.

Surface waters: Plate 22, Table 7

Concentration of total organic carbon in surface waters results mainly from the decomposition of natural biological matter. It is usually higher in areas rich in organic compounds.

The TOC concentration in the tested waters ranges from below 1.0 mg/dm^3 to 34.0 mg/dm^3. The median for the entire area is 1.5 mg/dm^3, which is over three times lower than the median calculated for dissolved organic carbon in stream water samples collected in the area of entire Europe – 4.99 mg/dm^3 (Salminen, 2005) and in Warsaw – 5.0 mg/dm^3 (Tomassi-Morawiec, 2016). The highest localized values were recorded in samples taken from ditches near the Ciemięga (Krężniczanka) River, and in the Bystrzyca River in the north-eastern part of the research area (34.0 mg/dm^3 and 33.0 mg/dm^3, respectively). The highest TOC medians were found in the SWB Dopływ spod Świdnika (3.0 mg/dm^3), SWB Ciemięga (1.9 mg/dm^3) and SWB Bystrzyca to the Zemborzycki Reservoir (1.6 mg/dm^3). The lowest TOC concentrations were measured in water samples from the SWB Czerniejówka (median 1.2 mg/dm^3) and SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth (median 1.3 mg/dm^3). No elevated TOC concentrations were found in surface waters within Lublin city centre. However, increased TOC levels were observed in surface waters of the SWB Dopływ z Konopnicy (downstream of Lipniak) and SWB Dopływ spod Świdnika, as well as in the ditches and canals of the Bystrzyca and Ciemięga catchment areas, in the north-eastern and south-western parts of the Lublin agglomeration, respectively. At many of these locations, TOC content in aquatic sediments is also elevated. Exceedances of the standards for class I and class II waters were found at 5 and 12 locations, respectively (Rozporządzenie..., 2021).

Ca – CALCIUM

Soils: Plate 23, Table 3

Calcium is the fifth most abundant element in the continental crust (Salminen, 2005). It is a component of common minerals such as calcite, aragonite, gypsum and anhydrite. Compared to other European countries, Poland's soils are characterized by relatively low calcium content (below 0.5%). Soils that develop on limestone, including those found in the Lublin Upland, contain calcium levels higher than 2% (Lis, Pasieczna, 1995).

The bedrock in the study area is represented predominantly by limestones, marls, gaizes, opokas, and $CaCO_3$-containing loess. The calcium content in the topsoil layer ranges from below 0.01% to 12.89%. The median value of 0.35% calculated for this region is approximately twice the mean value for Poland's soils – 0.18% (Lis, Pasieczna, 1995). It is also higher than the median value obtained for soils in the Warsaw agglomeration – 0.26% (Tomassi-Morawiec, 2016). However, it is almost half the median calcium content in European soils – 0.659% (Salminen, 2005). The spatial distribution of calcium in soils of the Lublin region is similar to that of strontium. Both elements exhibit similar geochemical properties. The content of calcium in the study area soils is related to both the lithology of the parent rocks and anthropogenic factors, as evidenced by its high level in soils from industrial areas (median 1.56%) and highly urbanized areas (median 1.37%). However, the highest content of calcium is found in the soil samples collected in parks (median 1.70%). Anthropogenic and peaty soils are also enriched in calcium (medians of 1.67% and 1.55%, respectively). The lowest calcium contents are found in soils of forests (median 0.04%), cultivated land (0.16%) and undeveloped areas (0.15%). Calcium-rich soils occur in urban areas of the Tatary and Bronowice quarters, near the Lublin breweries (Perła Brewery) and the Magatem EC-Lublin SA combined heat and power plant, as well as in the town of Piaski. Elevated amounts of calcium were also found in the city of Świdnik. Calcium in urban soils originates from dust emissions from coal combustion and admixtures of building materials such as rubble, mortar and cement (Washbourne et al., 2012). Ash from coal combustion, which contains CaO, can also be a source of calcium in soils (Bhatt et al., 2019).

Aquatic sediments: Plate 23, Table 5

The content of calcium in the aquatic sediments varies greatly, ranging from 0.03% to 9.74%. Its median value in Lublin (2.65%) is about three times higher than the median calculated for sediments in Poland – 0.86% (Lis, Pasieczna, 1995) and as much as five times higher than that of aquatic sediments in the Warsaw region – 0.53% (Tomassi-Morawiec, 2016). No significant changes in the amount of calcium in sediments of the Lublin area can be observed when comparing the present-day median value with the median calculated for historical results obtained for this area during the implementation of the *Geochemical Atlas of Poland* – median 2.8% (Lis, Pasieczna, 1995). The highest calcium contents are found in sediments from the SWB Dopływ spod Świdnika, for which the calculated median (4.89%) significantly exceeds the median value obtained for all of the analysed sediment samples. Sediments of the SWB Czerniejówka (median 3.75%) and SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth (median 3.65%) are also clearly enriched in calcium. The maximum calcium content (9.74%) was measured in a sediment sample taken from a ditch located in the Stoka River catchment area. This sample also had a very high strontium concentration (426 mg/kg). The lowest calcium levels were recorded in sediments from the SWB Bystrzyca to the Zemborzycki Reservoir (median 1.45%) and SWB Ciemięga (median 1.61%). Elevated values are observed primarily in watercourses and reservoirs located in heavily urbanized areas. This indicates a significant influence of anthropogenic factors.

Surface waters: Plate 24, Table 7

In the Lublin and its environs, calcium is the main cation in surface waters. Its concentration in varies between 12.7 mg/dm^3 and 195.2 mg/dm^3. The median calcium concentration (98.7 mg/dm^3) is higher than the median values calculated for Polish – 83 mg/dm^3 (Lis, Pasieczna, 1995) and Warsaw – 71.3 mg/dm^3 (Tomassi-Morawiec, 2016) waters, as well as for European stream waters – 40 mg/dm^3 (Salminen, 2005). The highest concentrations of this element were recorded in the SWB Dopływ spod Świdnika (median 163.2 mg/dm^3) and SWB Czerniejówka (median 107.4 mg/dm^3). The lowest calcium medians were recorded in the SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth (72.7 mg/dm^3) and in the SWB Bystrzyca to the Zemborzycki Reservoir (93.6 mg/dm^3). The spatial distribution of calcium concentration in surface waters corresponds to its distribution in sediments. High levels were usually recorded in both water and sediment samples from the same locations. The presence of calcium in water is associated primarily with the drainage of carbonate rocks (limestone, chalk, marl, opoka, gaize and dolomite). The calcium in water can also be of anthropogenic origin, resulting from the leaching of calcium from various building materials, ashes, and mineral fertilizers used to make soil more alkaline (Washbourne et al., 2012; Bhatt et al., 2019).

Cd – CADMIUM

Soils: Plate 25, Table 3

Cadmium is a strongly dispersed element in rocks, with a mean concentration ranging from 0.03 to 0.22 mg/kg (Kabata-Pendias, Pendias, 1999). It is easily mobilized during weathering processes and then bound by clay minerals, iron hydroxides, and organic matter. Cadmium concentration in soils depends on its presence in parent rocks and various anthropogenic factors (e.g. metallurgical industry, corrosion of metal objects, use of phosphate and compound fertilizers, wastewater sediments, vehicle tyre abrasion) (Dar, 1996; Ayres, 1999; Zielazińska, Wyszkowska, 2005). The present-day highest levels of cadmium enrichment ever observed in soils are the result of strong anthropogenic pressure (Kabata-Pendias, Pendias, 1999).

The study area soils show clear variation in the cadmium level, ranging from below 0.05 mg/kg to 15.57 mg/kg (median 0.19 mg/kg). The highest result is significantly lower than that found in soils of the Warsaw – 95.6 mg/kg (Tomassi-Morawiec, 2016) and Poznań – 2770 mg/kg (Lis, Pasieczna, 2005) regions. The highest cadmium concentrations (above 0.62 mg/kg) are recorded in soils along the right bank of the Bystrzyca River. These are mainly industrial and post-industrial areas located within the boundaries of the Kośminek, Bronowice and Tatary quarters, and near the villages of Wólka and Długie, where the large S17 road junction is situated. The effects of anthropogenic pressure from the WSK PZL-Świdnik aircraft factory were also observed in soils of Świdnik, where the highest cadmium concentration was recorded. Although the extent of the impact is relatively limited, it is still quite strong. The median cadmium concentration calculated for the industrial soils (0.45 mg/kg) is more than twice the median value calculated for all soil samples taken from Lublin and environs. Previous studies in Lublin also indicated the presence of elevated cadmium levels in soils from industrial areas. A topsoil sample taken from the area of the former FSC Lublin Automotive Factory contained 5.2 mg/kg of cadmium (Pasieczna, 2003). Lower levels of this element were recorded in soils of the southern and south-western parts of the study area. The lowest cadmium levels were measured in samples taken from forest areas (median 0.07 mg/kg). The cadmium concentration determined in the soil sample collected in the village of Świdniczek (in the Wólka municipality) is 0.46 mg/kg. This is similar to the levels recorded in the last two cycles of the *Monitoring of the chemistry of arable soils in Poland* at measurement and control point No. 283, which is located in the same village, where the cadmium concentrations were 0.18 mg/kg and 0.52 mg/kg (https://www.gios.gov.pl/chemizm_gleb/index.php?mod=pomiary&p=283). Apart from the sample with the highest cadmium concentration, the analytical results of soil samples taken in the Lublin area do not differ from the values found during the implementation of two European projects: FOREGS *(Geochemical Atlas of Europe* and GEMAS *(Chemistry of Europe's Agricultural Soils*). These projects covered uncontaminated and agricultural soils in Europe, including Poland (Salminen, 2005; Reimann et al. (eds.), 2014). The maximum cadmium result obtained during the present study (15.57 mg/kg) from a soil sample taken near the WSK PZL-Świdnik plant exceeds the permissible cadmium concentration for soil group IV (15 mg/kg). Cadmium is present in amounts exceeding the permissible concentration for soil group I (2 mg/kg) in approximately 2.5% of all tested soils (Rozporządzenie..., 2024). These are mainly soils of wasteland, lawns and gardens. Only two samples with a cadmium concentration above 2 mg/kg come from areas used for agriculture.

Aquatic sediments: Plate 25, Table 5

The cadmium concentration in aquatic sediment samples collected in the study area ranges from below 0.05 mg/kg to 85.79 mg/kg. The median cadmium concentration calculated for the entire set of sediment samples is 0.32 mg/kg, which is slightly higher than the median obtained for soils in this region (0.19 mg/kg) and may suggest that cadmium has accumulated in the sediments. Approximately 90% of the samples exhibit a cadmium concentration not higher than 1.62 mg/kg. Similar data were obtained for sediments in the Warsaw agglomeration, where 90% of samples showed cadmium concentrations not exceeding 1.60 mg/kg (Tomassi-Morawiec, 2016). Elevated levels of cadmium were observed in sediments of the Bystrzyca River, especially in areas within the industrial areas of Lublin. This indicates anthropogenic sources of this element, as well as the negative impact of industrial plants on the chemical condition of sediments. No cumulative increase in cadmium concentration in sediments was observed downstream the Bystrzyca River. The maximum value of 85.79 mg/kg was found in a sample taken from the SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth. As the sampling site is located upstream of the Hajdów Wastewater Treatment Plant's discharge point, emissions from the plant cannot be identified as the source of sediment contamination by this metal. The high amounts of cadmium at this location may be linked with the activities of the company involved in the purchase and sale of steel and non-ferrous metals. The company's plot of land is located a short distance (approximately 40 m) from the Bystrzyca River and the sampling site. Much of the plot is paved and used for storage and manoeuvring. The sediments from this location had the highest concentrations of not only cadmium but also Ag, Cr, Cu, Ni, Zn, Co, Ti and Pb, and one of the highest concentrations of Ba and Se. Cadmium concentrations above the TEC value (0.99 mg/kg) were found in 18 sediment samples, and above the PEC value (4.98 mg/kg) in seven samples. This indicates a risk of harmful cadmium effects on benthic organisms (MacDonald et al., 2000).

Surface waters: Plate 26, Table 7

Surface waters in the Lublin region are characterized by low concentrations of cadmium. Approximately 95% of the tested water samples contain cadmium at levels below the limit of determination of the analytical method (0.05 µg/dm^3). The highest concentration, 0.22 µg/dm^3, was measured in a water sample taken from the Dopływ ze Skrzynic watercourse near the village of Głuszczyzna. This watercourse is located within the SWB Czerniejówka. All of the tested waters meet the surface water quality standards for classes I and II specified for cadmium in Rozporządzenie…., 2021.

COD – CHEMICAL OXYGEN DEMAND

Surface waters: Plate 27, Table 7

Chemical oxygen demand (COD) is one of the basic indicators for assessing water quality, enabling an approximate determination of the concentration of organic substances in water (Macioszczyk, Dobrzyński, 2002). It refers to the amount of oxygen (in mg/dm^3) required to chemically oxidize all the organic substances present in a water sample. It is one of the key parameters used to evaluate the efficiency of wastewater treatment processes. High COD values indicate the presence of a large quantity of organic contaminants, such as plant residues, fats, detergents, and biological substances. Conversely, low COD means that the water is relatively clean.

The median COD, calculated from the entire set of analysed surface water samples, is 3.0 mg/dm^3. The highest median COD value was found in the SWB Dopływ spod Świdnika (7.0 mg/dm^3). The maximum COD concentration (77 mg/dm^3) was measured in a water sample collected from a ditch at a village of Krężnica Jara, in the south-western part of the study area. In the remaining SWBs, the median COD values are similar to those determined for the entire set of samples. The COD concentrations in surface waters in Lublin and environs are lower than those in Warsaw – median 9 mg/dm^3 (Tomassi-Morawiec, 2016).

Cl$^-$ – CHLORIDES

Surface waters Plate 28, Table 7

The source of chlorides in surface waters is the leaching of rocks and soils. Chlorides enter watercourses through the discharges of industrial and municipal wastewater, and in significant quantities through mine waters (Dojlido, 1987). The average natural concentration of chlorides in river water is about 8 mg/dm^3, and in highly saline lakes, it can exceed 20%. Over the last century, there has been a significant increase in the salinity of surface waters, with chlorine playing a key role (Kabata-Pendias, Pendias, 1999).

The chloride concentration in surface waters in the Lublin agglomeration ranges from 5.2 mg/dm^3 to 240 mg/dm^3. Higher levels were observed in water samples with high specific electrical conductivity. The median chlorine concentration in the surface waters is 23.5 mg/dm^3, which is half the concentration recorded in waters of the Warsaw agglomeration – median 48.3 mg/dm^3 (Tomassi-Morawiec, 2016) and Poznań agglomeration – median 49.7 mg/dm^3 (Lis, Pasieczna, 2005). The highest median value in the study area was recorded within the SWB Dopływ spod Świdnika (36.3 mg/dm^3). Significantly elevated chloride concentrations were measured in the water samples taken from the upper reaches of the Dopływ z Konopnicy stream (the median for this watercourse is 75.7 mg/dm^3). Several retention basins are located in this area, into which surface runoff from precipitation flows (including from the S19 expressway). This runoff may contribute to the enrichment of the watercourse in chlorides. Near the village of Lipniak, this stream forms overflow areas and comes to an end. From this point onwards, the chloride concentrations are several times lower. The highest chloride concentration (240 mg/dm^3) and the maximum specific electrical conductivity were found in the waters of the retention basin at Elizówka (in the Niemce municipality) near provincial road No. 835 in the north-central part of the study area, a short distance from a commercial and service complex. This reservoir collects rainwater and meltwater flowing from the surrounding area, including road surfaces. Runoff from these surfaces, which also contains road salt, is probably the main source of chloride contamination in the water.

Co – COBALT

Soils: Plate 29, Table 3

Cobalt is present in the Earth's crust in varying concentrations. Its distribution in rocks and soils is linked with the occurrence of iron and manganese compounds. In sedimentary rocks, this metal accumulates mainly in clay deposits (10–20 mg/kg). Its concentration is lower in sandstones,

limestones and dolomites, c.a. 0.1–10 mg/kg (Kabata-Pendias, Pendias, 1999). The mean concentration of cobalt in loess has been estimated to be 11 mg/kg (McLennan, Murray, 1999). The cobalt concentration in most soils of Poland ranges from 10 mg/kg to 15 mg/kg (Boratyński et al., 1981). According to Czarnowska and Gworek (1987), the geochemical background level of cobalt in Polish soils is 4.7 mg/kg. However, studies conducted at the Polish Geological Institute (Lis, Pasieczna, 1995) showed that the median cobalt concentration in Polish soils is around half of that value (2 mg/kg).

The cobalt concentration in the study area soils ranges from 0.32 mg/kg to 20.54 mg/kg. The median cobalt value (4.04 mg/kg) for the entire set of analysed soil samples is more than twice that for soils in the Warsaw and Poznań agglomerations, where this value was 2 mg/kg (Lis, Pasieczna, 1995; Pasieczna, 2003). In the survey area, elevated cobalt concentrations were recorded in soils of industrial and post-industrial areas of the Tatary and Hajdów-Zadębie quarters of Lublin. The highest levels of this metal are found in the immediate vicinity of major industrial plants and railway lines. Elevated concentrations of cobalt, as compared to the surrounding area, were recorded near the WSK PLZ-Świdnik aircraft plant. The plant specializes in manufacturing aircraft structures, including helicopters, and the production requires the use of special alloys containing cobalt, among other things. These materials are used to produce components for aircraft engines and helicopter rotors (Lewicka, 2007). The median cobalt concentration in the industrial soils is 4.35 mg/kg, which is slightly higher than the median value for all soil samples collected in Lublin and environs. Lower concentrations of the metal were recorded in the southern and north-eastern parts of the research area, particularly in compact forest complexes. The lowest levels of the element were observed in sandy (2.43 mg/kg) and forest (2.22 mg/kg) soils. The cobalt concentration in the soil sample taken in the village of Świdniczek (in the Wólka municipality) is 5.11 mg/kg, which is slightly higher than the values of this element (2.82–4.06 mg/kg) measured in 1995–2020 as part of the *Monitoring of the chemistry of arable soils in Poland* at measurement and control point No. 283, which is located in the same village (https://www.gios.gov.pl/chemizm_gleb/index.php?mod=pomiary&p=283). The data obtained in this study for Lublin and environs are higher than the values found for Poland's soils during the implementation of the European FOREGS and GEMAS projects (Salminen, 2005; Reimann et al. (eds.), 2014). In both those projects, the median cobalt values for soil samples from Poland were similar: 2.5 mg/kg in soils used for agriculture (GEMAS, 258 samples) and 2 mg/kg in soils from uncontaminated areas (FOREGS, 55 samples). The present research results indicate that the higher cobalt concentration in the soils of Lublin and environs is primarily due to geogenic factors (geological bedrock). Anthropogenic factors (long-term impact of industrial plants on soils in the central and eastern parts of the study area) play a minor role. The maximum cobalt concentration (20.54 mg/kg) recorded in a soil sample taken from the central part of the Hajdów-Zadębie quarter does not exceed the permissible value for class I soils – 50 mg/kg (Rozporządzenie..., 2024).

Aquatic sediments: Plate 29, Table 5

The cobalt concentrations in aquatic sediments range from 0.09 mg/kg to 40.81 mg/kg. The median value for samples from Lublin and environs is 3.38 mg/kg, which is slightly higher than that calculated for sediment samples collected in the Warsaw area – 2 mg/kg (Tomassi-Morawiec, 2016). In both cases, 97% of the cobalt results were below 10 mg/kg. In the study area, elevated cobalt concentrations were found mainly in the Bystrzyca River sediments. The enrichment of sediments in this element was observed in the lower section of the Bystrzyca River in the industrial areas of Lublin, and further downstream. No cumulative increase in the amount of this metal was observed in sediments along the course of the river. The maximum concentration of cobalt was found in a sediment sample taken from the Bystrzyca River (SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth). This sample also had the highest concentrations of other elements (Ag, Cd, Cr, Cu, Ni, Zn, Ti, and Pb). As there is the company involved in the purchase and trade of steel and non-ferrous metals near the sampling site, the elevated metal concentration in the sediment at this location may be a result of this plant's activities. The cobalt concentration in this sediment sample is more than three times higher than the second highest concentration of this element (12.62 mg/kg). In the remaining area covered by the study, cobalt levels in aquatic sediments are similar to those in soils. Referring the obtained results to the limit values for classifying river and lake sediments according to geochemical criteria (Bojakowska, Sokołowska, 1998), it can be concluded that only two samples containing over 10 mg/kg of cobalt can be classified as "moderately contaminated".

Surface waters: Plate 30, Table 7

Surface waters in the study area are characterized by low concentrations of cobalt. Almost 70% of the water samples tested contained cobalt at levels below the limit of determination of the analytical method (0.05 μg/dm^3). The metal concentrations measured in the remaining 56 samples range from 0.05 μg/dm^3 to 3.84 μg/dm^3. The highest cobalt concentration was measured in a sample taken from a field drainage ditch that flows directly into the Bystrzyca River. This sampling site is situated in the far southeast of the research area, within the SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth. All of the water samples tested meet the standards for surface water quality classes I and II, for which the permissible concentration of cobalt and its compounds is ≤50 μg/dm^3 (Rozporządzenie…, 2021).

Cr – CHROMIUM

Soils: Plate 31, Table 3

Chromium is a common element in the environment. Its highest concentrations are found in ultra-basic igneous rocks (up to 3400 mg/kg). In sedimentary rocks, chromium accumulates mainly in clay deposits (from 60 mg/kg to 120 mg/kg). Its amounts are lower in limestones and dolomites, usually ranging from 5 mg/kg to 16 mg/kg (Kabata-Pendias, Pendias, 1999).

The chromium concentration measured in soil samples from Lublin and environs ranges from 2 mg/kg to 348 mg/kg. The median concentration in the region's soils is 12 mg/kg, which is significantly higher than the values calculated for topsoil in Warsaw –7 mg/kg (Tomassi-Morawiec, 2016) and Poznań – 5 mg/kg (Lis, Pasieczna, 2005). Chromium levels above the 50th percentile, obtained for soils in the analysed region, are present in almost the entire areas of Świdnik and Lublin. Industrial and post-industrial areas of the Abramowice, Kośminek, Tatary and Kalinowszczyzna quarters, as well as of the village of Wólka, show elevated levels of this element. The main sources of positive chromium anomalies in the soils are the emissions from two combined heat and power plants (Lublin-Wrotków and Megatem EC-Lublin), as well the long-term activity of several tanneries, automotive and mechanical industry plants, the Ursus iron foundry, and other enterprises and manufacturers. The highest concentration of chromium (348 mg/kg) was found in a soil sample collected from an industrial area near the WSK PZL-Świdnik aircraft factory. In this case, chromium emissions into the environment most likely occur when installations covered with metallic coatings are used at a facility where aluminium alloys undergo chemical and electrolytic processing https://umwl.bip.lubelskie.pl/upload/pliki/Zmiana_pozwolenia_zintegr._WSK_B3_2020.pdf).

The specific nature of aircraft construction requires using lightweight and durable materials, such as aluminium alloys. Small percentages of refining additives, such as chromium, nickel, iron, titanium and beryllium, can also be applied (Bielawski et al., 2016). Furthermore, when constructing modern turbine engines, it is necessary to protect the nickel alloys, used for making parts that operate at high temperatures, against corrosion. Heat-resistant coatings made of chromium-containing metal alloys are primarily used to galvanize such materials (Szczeciński, 2011). The maximum concentration of chromium (348 mg/kg) does not exceed its permissible level for soil group IV (1000 mg/kg) specified in Rozporządzenie..., 2024. It should also be noted that the permissible standard concentration of chromium for soil group I – 200 mg/kg (Rozporządzenie..., 2024) is exceeded in the case of only two samples. Elevated concentration of chromium (281 mg/kg) was found in a relatively small area in Lublin city centre near the Old Town. The soil sample was taken in the immediate vicinity of a demolished part of a building that used to house the Institute of Dentistry of the Medical University of Lublin. The area is currently used as a partially unpaved car park. Due to the impact of various factors that may determine the chromium concentration at this location, it is difficult to identify the sources of chromium emissions into the soil clearly. Neighbouring areas show chromium levels that are several times lower (10–18 mg/kg). The lowest concentrations of chromium were recorded in large, compact forest complexes within the administrative boundaries of Lublin, in the south-western and southern parts of the city. The median chromium concentration calculated for 128 samples taken from forest areas is 6 mg/kg. Soils in the southern part of the study area are generally characterized by lower levels of this metal. The chromium concentration of 16 mg/kg in the soil sample collected recently in the village of Świdniczek is slightly higher than the values (9.2–13.8 mg/kg) measured in the period 1995–2020 as part of the *Monitoring of the chemistry of arable soils in Poland* at measurement and control point No. 283, which is located in the same village (https://www.gios.gov.pl/chemizm_gleb/index.php?mod=pomiary&p=283). Compared to other studies covering the entire territory of Poland, the present results on the study area soils (median 12 mg/kg) show elevated chromium levels. The median chromium concentrations calculated based on previous research were as follows: 3 mg/kg for uncontaminated soils in Poland (Salminen, 2005), 7 mg/kg for agricultural soils in Poland (Reimann et al. (eds.), 2014), and 4 mg/kg for all soil samples collected in the area of Poland (Lis, Pasieczna, 1995). European soils usually contain higher quantities of chromium at the level 20–22 mg/kg (Reimann et al. (eds.), 2014; Salminen, 2005).

Aquatic sediments: Plate 31, Table 5

The median chromium concentration obtained for aquatic sediment samples is 13 mg/kg, which is similar to the value calculated for this parameter in soils of the study area. The concentration of chromium in the sediments ranges from below 1 mg/kg to 79 mg/kg. In the Lublin agglomeration, it does not exceed 40 mg/kg in approximately 97% of samples, which is similar to the levels determined in the Warsaw (Tomassi-Morawiec, 2016) and Poznań (Lis, Pasieczna, 2005) agglomerations. In Poznań, high chromium levels (above 25 mg/kg) were recorded in aquatic sediments of heavily urbanized areas. The level of 25 mg/kg is exceeded in only 18 sediment samples from the Lublin area. An anthropogenic-related increase in chromium concentrations in sediments is found mainly in the Bystrzyca and Czechówka rivers, near the industrial areas of Lublin, starting from the Kośminek quarter, where, e.g., tanneries, distilleries and manufactories have been located since the end of the 19th century. The maximum chromium concentration (79 mg/kg) is found in a sediment sample from the Bystrzyca River, which was taken outside the city centre. The sampling site is located in the SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth, upstream of the Hajdów Wastewater Treatment Plant's discharge point. It is therefore presumed that the treatment plant's emissions are responsible for the sediment contamination at this location. The likely source of this element is surface runoff from the premises of the company that is involved in the purchase and sale of steel and non-ferrous metals. Due to the proximity of this plant to both the Bystrzyca River channel (25 m) and the sampling site (approximately 40 m), the river is at risk of contamination from the stored scrap metal. Moreover, the sediment from this site has the highest concentration not only of chromium, but also of Ag, Cd, Co, Cu, Ni, Zn, Ti and Pb, and almost the highest concentrations of Ba and Se. The sediment sample collected from the Bystrzyca River in the Tatary quarter also shows an elevated chromium concentration. This situation is probably due to contamination introduced into the river through runoff from the wastewater system that drains rainwater from this area of the city. According to the classification of river and lake sediments, based on geochemical criteria (Bojakowska, 1998), the chromium concentration in 143 samples is higher than 6 mg/kg. This is above the estimated geochemical background level for chromium in sediments of Poland. However, concentrations above 50 mg/kg were found only at two locations. On this basis, these sediments can be classified as moderately contaminated. Referring the obtained results to ecotoxicological risk indices, it can be concluded that only three of the sediment samples contained chromium levels above the TEC value (43 mg/kg). However, there is no sample in which the metal concentration exceeds the PEC limit value – 110 mg/kg (MacDonald et al., 2000), above which chromium has a harmful effect on benthic organisms.

Surface waters: Plate 32, Table 7

Chromium concentration in all the surface water samples taken from the study area is below the limit of determination of the analytical method (0.003 mg/dm^3). All of the tested waters meet the standards for surface water quality classes I and II, for which the chromium limit value is ≤0.05 mg/dm^3 (Rozporządzenie…, 2021).

Cu – COPPER

Soils: Plate 33, Table 3

In parent rock, copper occurs at concentrations of 5–100 mg/kg. In soils, it is strongly bound by organic matter and clay minerals, and precipitates in the form of sulphates, sulfides and carbonates. In carbonate rocks, copper is found at concentrations of approximately 6 mg/kg. The geochemical background level of copper in the soils of Poland is around 50 mg/kg (Kabata-Pendias, Pendias, 1999).

The study area soils exhibit insignificant variation in copper concentration, ranging from 1 mg/kg to 224 mg/kg. The median value calculated for soils in the Lublin region (10 mg/kg) indicates that the amounts of this element are generally higher than those reported in several previous studies on Poland's soils: median 5 mg/kg (Lis, Pasieczna, 1995; Reimann et al., 2014) and median 4 mg/kg (Salminen, 2005). The highest copper concentrations in the study area were found in two samples taken in the Tatary quarter in the immediate vicinity of the railway line (154 mg/kg and 224 mg/kg). The industrial nature of this area and its proximity to a major multi-track railway line probably contribute to the emission of this metal into the environment. Almost the entire areas of Lublin and Świdnik are characterized by soils enriched in copper (above the 75th percentile – 13 mg/kg). Elevated concentrations are found in industrial and post-industrial soils in the quarters of Abramowice, Wrotków, Kośminek, Bronowice, Tatary and Kalinowszczyzna, as well as in the town of Piaski. Localized high copper levels (71 mg/kg) were recorded in a single sample in Prawiedniki, south of Lublin. The copper concentration at this location is several times higher than in samples from the neighbouring area, which contained between 4 mg/kg and 11 mg/kg of copper. A likely cause is the use of soil material of unknown origin for land-levelling works carried out in 2015–2017 (https://www.google.pl/maps/place/Prawiedniki). Elevated levels of copper were also observed in soils in the vicinity of Świdnik, mainly on and near the premises of WSK PZL-Świdnik, with a maximum concentration of 124 mg/kg. This may be related to the use of copper by the aviation industry. Although aircraft construction is based mainly on aluminium, the most durable materials typically contain significant amounts of copper and/or zinc (Galiński, 2020). The highest median copper values were calculated for the anthropogenic and industrial areas of Lublin and Świdnik, at 14 mg/kg each. Research conducted by Pasieczna shows that copper has accumulated in the topsoil layer (down to 0.2 m depth), and that the topsoil enrichment factor in the Lublin area relative to the regional geochemical background level is 3.3 (Pasieczna, 2003). The copper concentration in soil samples collected from forest areas extending to the south-east of the Zemborzycki Reservoir is several times lower. The median copper concentration for the forest soils is 4 mg/kg. Compared with data from 1995–2020, obtained during the implementation of the *Monitoring of the chemistry of arable soils in Poland* at measurement and control point No. 283, which is located in the village of Świdniczek (2.32–8.2 mg/kg), the copper concentration currently measured in a sample taken from the same location is 17 mg/kg (https://www.gios.gov.pl/chemizm_gleb/index.php?mod=pomiary&p=283). However, the differences are not significant, when we consider how widely used this metal is, and how many potential sources of its emissions there are. The highest copper concentration in the study area does not exceed the permissible level specified for soil group IV – 600 mg/kg. All other results are below the permissible concentration level for soil group I – 200 mg/kg (Rozporządzenie…, 2024).

Aquatic sediments: Plate 33, Table 5

The copper concentration in aquatic sediment samples collected in the research area ranges from below 1 mg/kg to 123 mg/kg (median 13 mg/kg). These results are similar to those obtained for soils in this area. Elevated copper levels are found mainly in sediments from the Bystrzyca River. The highest concentrations were recorded in aquatic sediment samples taken from sections of the watercourses located within former industrial areas of Lublin. This suggests that emissions of this element are anthropogenic in origin. The maximum copper concentration (123 mg/kg) in the survey area was recorded in a sample taken from the Bystrzyca River. The sampling site is located within the SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth, upstream of the Hajdów Wastewater Treatment Plant's discharge point. The elevated levels of copper and other metals (Ag, Cd, Co, Cr, Ni, Zn, Ti, Pb, Ba and Se) at this location may be the result of activities of the company involved in the purchase and sale of steel and non-ferrous metals. The company premises are located in close proximity to the sampling site. Analysis of the results and comparison with ecotoxicological risk indices (MacDonald et al., 2000) indicate that copper levels above the TEC value (32 mg/kg) were found in 28 sediment samples. No sample shows a concentration exceeding the PEC value of 150 mk/kg, indicating a risk of harmful effects of copper on aquatic organisms.

Surface waters: Plate 34, Table 7

Surface waters in Lublin and environs are characterized by copper concentrations ranging from 0.22 μg/dm^3 to 33.87 μg/dm^3 (median 0.61 μg/dm^3). The mean values calculated for all SWBs in this region vary insignificantly from 0.43 μg/dm^3 to 0.75 μg/dm^3. The highest concentration was measured in a water sample taken in the village of Lipniak, in the municipality of Konopnica. The sampling site is located in a terrain depression, which serves as the outlet for an underground storm drain. It drains rainwater from higher-elevated areas of the Konstantynów quarter. This part of Lublin consists of single-family housing estates and allotment gardens. Elevated levels of copper in the water from this location may indicate that the residents and/or allotment users are using popular fungicides and bactericidal plant protection products containing copper oxychloride as the active ingredient. The copper concentrations in all tested samples do not exceed the standards for surface water quality classes I and II, the limit value ≤50 μg/dm^3 (Rozporządzenie…, 2021).

F^- – FLUORIDES

Surface waters: Plate 35, Table 7

The concentration of fluorides in surface waters is determined by the geological structure of the area and its anthropopression level (e.g. glass industry, brickworks, phosphate fertilizers). Fluorine in water is bound to clay minerals, phosphates and carbonates. The concentration of fluorides in groundwater is controlled largely by the presence of calcium due to the formation of the virtually insoluble salt, CaF_2. The concentration of fluorine ions in rivers around the world ranges from 0.050 to 2.700 mg/dm^3. The level determined for rivers in Poland is 0.22 mg/dm^3 (Kabata-Pendias, Szteke, 2012).

The concentration of fluorides in all of the surface water samples from Lublin and environs is below the limit of determination of the analytical method (0.1 mg/dm^3). In accordance with the applicable legal regulations (Rozporządzenie..., 2021), the tested waters meet class I surface water quality for fluoride concentration standards (≤1.5 mg/dm^3).

Fe – IRON

Soils: Plate 36, Table 3

Iron is one of the main components of the lithosphere. In its bound form, it is the most common element classified as a heavy metal found in rocks and soil. The mean iron content in the world's soils is approximately 3.5%. In Polish soils, its content is most commonly between 0.8% and 1.8% (Kabata-Pendias, 2011; Górska, Piech, 2018). The median iron content in Poland's soils was found to be 0.51%, based on surveys from the 1990s (Lis, Pasieczna, 1995), which was close to the median value (0.60%) calculated from historical data selected only for the area covered by the present research.

The iron content ascertained in the present study for soils of Lublin and environs ranges from 0.13% to 5.37%, with a median of 0.90%, which is higher than the values obtained for soils from other urban areas, such as Poznań (0.47%) and Warsaw (0.53%) (Lis, Pasieczna, 2005; Tomassi-Morawiec, 2016). A study of European soils (De Vos, Tarvainen (eds.), 2006) showed that the median iron content (1.96%) was more than twice that found in the soils of Lublin and environs. Sandy soils of the study area are poor in iron, containing an average of 0.57% of this element. This figure is similar to that published for light sandy soils in Poland, which contain an average of 0.65% Fe (Kabata-Pendias, 2011). Clay and anthropogenic soils from the Lublin agglomeration contain similar amounts of iron, 0.98% and 0.99% on average, respectively. The lowest amounts of iron were found in soils of the southern part of the research area. These soils are characterized by a very acidic and acidic pH (in the range of 3.27–5.50). Oxidizing and alkaline conditions favour the precipitation of iron, whereas under reducing conditions and higher acidity, its compounds become more soluble and the metal is leached from the soil (Kabata-Pendias, Pendias, 1999; Reimann et al. (eds.), 2014). The presence of iron in soils is also affected by anthropogenic factors, such as emissions from metallurgical and combined heat and power plants (from coal combustion), as well as the corrosion of metal structures (Kabata-Pendias, Pendias, 1999). In the study area, the median iron content calculated for industrial soils (1.04%) is about 20% higher than for cultivated land (0.83%) and over twice as high as for forest soils (0.44%). The highest iron content was found in the central part of the survey area, on the right bank side of Lublin, in the Tatary quarter, where the Ursus Mechanical Works and the FSO Automotive Factory operated in the second half of the 20th century. This part of Lublin remains an industrialized area and home to facilities such as the Megatem EC-Lublin combined heat and power plant and MPC METAL sp. z o.o., as well as companies offering bodywork and painting services. Apart from a few areas within the cities of Lublin and Świdnik, where anthropogenic pressure is evident, the geochemical maps of Fe, Al, Be, Co, Cr, K, Li, Mg, Ni and V distributions show similar spatial variability, which may indicate common sources of origin for these elements. In particular, cobalt and nickel exhibit geochemical behaviour similar to that of iron (Kabata-Pendias, 2011).

Aquatic sediments: Plate 36, Table 5

The iron content in the tested aquatic sediments ranges from 0.02% to 4.21%. The median value (0.84%) is close to that calculated for sediments in Poland – 0.80% (Lis, Pasieczna, 1995). As in the case of soils, the present results for iron content in sediments are higher than the historical data selected for the study area from the *Geochemical Atlas of Poland* – median 0.60% (Lis, Pasieczna, 1995). They are also higher than those measured in sediments of Warsaw and environs – median 0.67% (Tomassi-Morawiec, 2016) and of Poznań and environs – median 0.68% (Lis, Pasieczna, 2005). Similar iron levels in the sediments and soils of the Lublin agglomeration suggest that the geological structure of the catchment area, its development and use, as well as climatic and hydrological conditions, have a key effect on the presence of this metal in the studied components of the environment (Bąk et al., 2014). A comparison of the average content of the most abundant elements in aquatic sediments and soils from the research area shows that there is approximately three times more calcium than iron in sediments. In contrast, the opposite relationship is evident in soils (approximately three times more iron than calcium). In the survey area, the highest iron contents were recorded in sediments from the Dopływ spod Swidnika, which is the main watercourse in the SWB RW20000624674. Consequently, the median iron content (1.42%) calculated for this SWB is the highest when compared to the results obtained for other SWBs in this area. There is only one sediment sample with an iron content (4.21%) exceeding the threshold at which a negative impact on benthic organisms is expected (PEC index >4%). The sample was taken from a ditch flowing into the Bystrzyca River (in its northern stretch). Over 98% of the sediment samples analysed show iron levels that are lower than the TEC index value (≤2%), indicating that no harmful impact of iron on benthic organisms is expected (MacDonald et al., 2000; Contaminated Sediment Standing Team, 2003).

Surface waters: Plate 37, Table 7

The concentration of iron in the surface waters varies, being affected by various factors, including predominantly the pH and redox potential, but also the presence of organic matter and various minerals, particularly clays.

The concentration of iron in river water usually ranges from 0.01 to 1.4 mg/dm^3 (Kabata-Pendias, Pendias, 1999). However, in the surface waters of Lublin and its environs, this range is much wider, varying from below 0.01 mg/dm^3 to 13.70 mg/dm^3. The lowest concentrations were found in the Zemborzycki Reservoir waters, which are also characterized by high pH values, ranging from 7.86 to 10.09. Higher iron concentrations, exceeding the 98th percentile (0.45 mg/dm^3), were recorded locally in a few samples. The median iron concentration in the study area waters is 0.02 mg/dm^3 and is similar to the median values calculated for particular SWBs. This indicates that the iron concentration in watercourses in this area is poorly diverse. Higher median values were recorded for waters in other urbanized areas: in Warsaw and environs – 0.09 mg/dm^3 (Tomassi-Morawiec, 2016), and in Poznań and environs – 0.04 mg/dm^3 (Lis, Pasieczna, 2005). The median iron concentration in the analysed waters is much lower than the median value of this parameter for Polish waters – 0.52 mg/dm^3 (Lis, Pasieczna, 1995) and the median value calculated from historical data selected from the *Geochemical Atlas of Poland* for the area covered by this study (0.42 mg/dm^3). The highest concentrations of iron were recorded locally in the water samples that also showed very high concentrations of total suspended solids. They were taken from the upper reach of the Dopływ z Konopnicy stream and from the initial course of an unnamed watercourse, which is a tributary of the Ciemięga River (near the village of Rudnik). Elevated concentrations of iron in the waters can, for example, increase the amount of suspended solids in water due to the precipitation of low-soluble iron compounds, making the water cloudy and brown (Główny Inspektorat Sanitarny, 2018). Elevated concentrations of manganese and total organic carbon were also found in the waters containing high concentrations of iron. Similar relationships were observed in stream water samples collected in eastern Poland during conducting the European project *Geochemical Atlas of Europe* (De Vos, Tarvainen (eds.), 2006).

HCO_3^- – BICARBONATES

Surface waters: Plate 38, Table 7

Bicarbonates are a common and even dominant anion, especially in near-surface groundwater and surface waters of temperate climates (Macioszczyk, 1987). Therefore, they typically make the greatest contribution to the electrical conductivity of water. They most often originate from

the dissolution of bedrock-forming carbonate minerals, but they can also form when carbon dioxide from the air dissolves in water. HCO_3^- ions can as well come from anthropogenic sources. They can enter the water either as a result of the dissolution of calcium fertilizers being used to deacidify soils, or by migrating to it together with industrial and municipal wastewater containing cleaning agents in the form of carbonates and bicarbonates. The presence of bicarbonates in water is linked with its carbonate hardness because they can precipitate as $CaCO_3$, $MgCO_3$ and $CaMg[CO_3]_2$. Bicarbonate ions affect the alkalinity of water, not only by increasing the pH, but also by stabilizing the pH by increasing the aqueous solution's ability to buffer acids. Additionally, an increase in the water's alkalinity favours the precipitation of certain metals, such as cadmium and lead, thereby reducing their concentration (Salminen, 2005).

The median concentration of bicarbonates in surface waters in Lublin and environs is 267 mg/dm³, with results ranging from 43 mg/dm³ to 590 mg/dm³. These values are higher than those found during previous studies in the Warsaw area, where the median bicarbonate concentration was 210 mg/dm³ (Tomassi-Morawiec, 2016). In the study area, the highest concentrations were recorded for the SWB Dopływ spod Świdnika (median 405 mg/dm³). High values were also measured in waters of the SWB Ciemięga (median 325 mg/dm³) and SWB Czechówka (median 320 mg/dm³). Lower median values were obtained for the SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth (200 mg/dm³) and the SWB Bystrzyca to the Zemborzycki Reservoir (243 mg/dm³). The presence of elevated concentrations of bicarbonates (210–260 mg/dm³) in the Lublin Upland compared to other regions of Poland was highlighted in the *Geochemical Atlas of Europe* (Salminen, 2005). The relatively high amounts of HCO_3 in the study area waters are most likely related to the presence of gaizes, opokas and marls in the bedrock (Jurkowska, Świerczewska-Gładysz, 2022), especially since higher concentrations of calcium, strontium, uranium, silica and EC were also found at the same locations.

Hg – MERCURY

Soils: Plate 39, Table 3

More than half of mercury in the environment originates from the combustion of fossil fuels (Lis, Pasieczna, 1995, as cited in Szpadt, ed., 1994). The mining and textile industries are significant sources of mercury emissions. Mercury is easily sorbed by organic matter in soils (Salminen et al., 2005). It accumulates in soils with high sorption properties, such as loamy and peaty soils (Kabata-Pendias, Pendias, 1995).

The mercury concentration in soils of Lublin and environs ranges from below 0.02 mg/kg to 1.94 mg/kg (median 0.03 mg/kg). The mean concentration value in the study area soils is similar to that obtained for European soils (Salminen et al., 2005). Low amounts of this metal were found in cultivated and forest soils, mainly in the southern and south-western regions of the survey area, with median values of 0.03 mg/kg in both cases. The highest median mercury levels were found in peaty soils (0.07 mg/kg) and in samples taken from allotment gardens (0.06 mg/kg). Elevated levels of mercury in peaty soils are due to its accumulation by organic matter. No significant variation in mercury concentration was observed in loamy, silty, sandy and anthropogenic soils. Analysis of the spatial distribution of mercury concentrations in the soils reveals the impact of urban agglomeration (due to both land use and housing density) on the topsoil layer. The highest concentrations of the metal were found in Lublin city centre and in the area surrounding the WSK PZL-Świdnik factory. The maximum value (1.94 mg/kg) was measured in an anthropogenic soil sample taken from the Bystrzyca River levees and allotment gardens (in Lublin city centre). The second highest result (1.75 mg/kg) was recorded for a soil sample collected in the Konstantynów quarter, south-west of the city centre. Also this sample was taken from embankment soils from a multi-family housing estate. Elevated levels of anthropogenic mercury in soils were also identified in the central areas of the Warsaw and Poznań agglomerations. The highest levels of the metal were recorded in soils of other cities: in Wrocław – 6.60 mg/kg, Łódź – 5.82 mg/kg, Gdańsk – 5.50 mg/kg, Legnica – 5.13 mg/kg, and Tarnów – 3.76 (Pasieczna, 2003). All of the tested soils can be classified as soil group I, since no exceedance of the permissible mercury concentration of 5 mg/kg has been found (Rozporządzenie..., 2024). The concentration of this element in the soil sample taken in the village of Świdniczek (in the Wólka municipality) is 0.09 mg/kg. This concentration is similar to the levels found in 2015 and 2020 as part of the *Monitoring of the chemistry of arable soils in Poland* at measurement and control point No. 283, which is located in the same village (https://www.gios.gov.pl/chemizm_gleb/index.php?mod=pomiary&p=283). The mercury data for agricultural soils in the Lublin region are similar to those recorded in cultivated and meadow soils in Poland, recorded in the GEMAS project. Depending on land use, the median was either 0.02 mg/kg or 0.03 mg/kg (Reimann et al. (eds.), 2014).

Aquatic sediments: Plate 39, Table 5

The mercury concentration in aquatic sediments in the Lublin region ranges from below 0.02 mg/kg to 2.46 mg/kg (median 0.03 mg/kg). These amounts are similar to those obtained for sediments in the Warsaw and Poznań agglomerations, medians below 0.05 mg/kg (Lis, Pasieczna, 2005; Tomassi-Morawiec, 2016). The lowest concentrations of mercury were found in sediments of the SWB Ciemięga and SWB Czechówka. Higher levels of the metal were measured in sediments of the SWB Dopływ spod Świdnika (median 0.07 mg/kg) and SWB Bystrzyca from the Zemborzycki Reservoir (median 0.06 mg/kg). The spatial distribution of this element in sediments indicates the anthropogenic impact of the city of Lublin. Twelve sediment samples with the highest mercury levels (ranging from 0.2 mg/kg to 2.46 mg/kg) were collected from the Bystrzyca River downstream of the city centre. The highest concentrations of mercury (2.46 mg/kg and 2.42 mg/kg) were recorded near the outlets of the storm-water drainage system discharging rainwater from the Tatary and Hajdów-Zadębie quarters. However, due to the area's historical and current land use, numerous industrial and manufacturing plants, and proximity to transport routes, it is difficult to identify clearly the sources of mercury emissions into the environment at this location. Mercury may have a harmful effect on benthic organisms at three locations, as its concentration in sediments exceeds the PEC index – 1.1 mg/kg (MacDonald et al., 2000). According to geochemical criteria, the sediments from these sites can be categorized as heavily contaminated (Bojakowska, Sokołowska, 1998).

K – POTASSIUM

Soils: Plate 40, Table 3

The natural potassium content in soils depends on their mineralogical composition, particularly the content of clay minerals. In general, the greater the proportion of the <0.02 mm fraction in soil, the greater the potassium content (Rutkowska, 2017). Almost all potassium (90–98%) in soil occurs in a mineral form (Bertsch et al., 1985). Soils that formed from loamy deposits, which include sandy loams, loamy sands, tills and clays, are naturally rich in potassium. Soils that developed from sandy deposits (i.e. loose sands, slightly loamy sands, and light loamy sands), limestones and organic deposits (peat) are poor in this component. At present, 42% of Poland's soils have low or very low levels of this component (Rutkowska, 2017).

The potassium content in the study area soils is not highly diverse, ranging from 0.02% to 0.34%. The median calculated for the entire set of samples is 0.13%, which is more than twice the value of this parameter found in the GEMAS project for Polish agricultural soils; cultivated land –0.0538%, and meadows – 0.0421% (Reimann et al. (eds.), 2014). The spatial distribution of potassium content in soils of the Lublin agglomeration is very similar to that of vanadium content (Plate 78). The highest potassium level, 0.34%, was found in a soil sample taken in Lublin close to railway siding No. 67. This result is a single point anomaly, being clearly distinct from the level identified in the adjacent areas. Data analysis indicates that potassium-poor soils are generally found in the southern part of the research area. This is probably due to the higher proportion of sandy soils in this area and, consequently, the lower intensity of agricultural activity. The area is covered by poor-quality soils with lower agricultural suitability, which are dominated by complexes ranging from very good to poor rye, and locally very poor rye. These soils are generally lighter and have lower sorption properties, providing poorer growing conditions that may be accompanied by lower intensity of use and fertilization. In contrast, the soils in the northern and north-western parts of the study area are among the highest quality in Poland. They have been classified as very good and good wheat agricultural suitability complexes, locally as defective wheat (Jadczyszyn, Smreczak, 2017). The lowest concentrations of potassium were recorded in large, compact forest complexes (median 0.06 mg/kg) in the south-western and southern parts of Lublin. The potassium content in the soil sample taken in the village of Świdniczek (Wólka municipality) is 0.17%, being similar to the amount of this element measured in 1995–2020 as part of the *Monitoring of the chemistry of arable soils in Poland* at measurement and control point No. 283 (https://www.gios.gov.pl/chemizm_gleb/index.php?mod=pomiary&p=283), which is located in the same village. The results obtained during the monitoring ranged from 0.09% to 0.20%.

Aquatic sediments: Plate 40, Table 5

The potassium content in aquatic sediments in the Lublin region ranges from 0.01% to 0.23% and is very similar to the amount of this element in soils. The spatial distribution of potassium content in these two environmental components is also similar, indicating a relationship between the presence of potassium and both the geological structure and soil use. The median calculated for this metal from all of the analysed sediment samples is 0.07%. Sediments of the SWB Czechówka (median 0.10%), which is located in the north-western part of the research area, contain slightly higher amounts of this element than sediments of the other SWBs. The Czechówka River catchment area is dominated by high-quality soils that are used intensively for agricultural purposes. This inevitably involves the use of mineral and natural fertilizers. Erosion and leaching of minerals from arable soils can result in potassium loss, especially when excess K^+ cations have not been bound by soil structures (Rutkowska, 2017).

Surface waters: Plate 41, Table 7

The potassium concentration in surface waters of Lublin ranges from 0.7 mg/dm³ to 19.1 mg/dm³ (median 2.7 mg/dm³). Of all the surface water bodies in the region, the SWB Dopływ spod Świdnika has the highest median potassium value (6.5 mg/dm³). The maximum concentration was found in a sample taken from a mid-field pond in a natural depression in the terrain (located north of the city of Lublin). As potassium is a highly mobile element that can penetrate into groundwater (Sapek, 2001), the elevated potassium levels at this location are likely to be caused by intensive agricultural land use and the associated application of potassium fertilizers.

Li – LITHIUM

Soils: Plate 42, Table 3

Lithium occurs in the Earth's crust in a dispersed form. Its highest concentrations are found in acidic volcanic (15–45 mg/kg) and clay (50–75 mg/kg) rocks (Kabata-Pendias, Pendias, 1999). The main source of lithium in soils and sediments is the weathering of silicate minerals (Motowicka-Terelak i in., 1997). Carbonate rocks generally contain low levels of lithium (below 20 mg/kg). The mean lithium concentration in soils around the world ranges from 1.3 to 56 mg/kg. These values are significantly dependent on the proportion of clay fraction. The lowest amounts of this element are found in sandy and organic soils. As lithium is relatively mobile, it is easily leached deep into the soil profile in a humid climate. However, in a dry climate, it seeps to the topsoil layer with the soil solution (Kabata-Pendias, Pendias, 1999). The mobility of lithium in soil is limited due to the stability and poor solubility of its compounds (e.g. carbonates, phosphates and fluorides), but it increases at low pH. Topsoil levels are slightly enriched in lithium in industrial soils (De Vos, Tarvainen (eds.), 2006).

The soils of Poland are relatively poor in lithium. Compared to the concentration of this element in European soils (median 11.7 mg/kg), Polish agricultural soils contain about one-third of this level of lithium – median 3.7 mg/kg (Reimann et al. (eds.), 2014). Generally, its lower levels were observed in soils from areas covered by the last glaciation. Lithium concentrations above 60 mg/kg are considered toxic to plants (De Vos, Tarvainen (eds.), 2006). During the previous cycles of arable soil monitoring, the lithium levels recorded in soil samples taken at the control point in Świdniczek ranged from 2.3 mg/kg to below 10 mg/kg (https://www.gios.gov.pl/chemizm_gleb/index.php?mod=pomiary&p=283).

The study area soils are characterized by little variation in lithium levels, which suggests primarily its geogenic origin in the environment. The concentration of this element in the soils ranges from 0.6 mg/kg to 17.9 mg/kg (median 5.7 mg/kg). Loamy soils (median 6.5 mg/kg) and anthropogenic soils (median 6.1 mg/kg) contain higher amounts of lithium than sandy soils (median 3.8 mg/kg). The median lithium concentration in silty soils (5.4 mg/kg) is similar to the overall average for all analysed soils. The lowest lithium concentrations were observed in peaty soils and in those from forest areas (median 3.4 mg/kg). Soils in the Dąbrowa Forest, covering the southern part of Lublin, east of the Zemborzycki Reservoir, are evidently poor in lithium. Slightly higher concentrations of lithium were recorded in areas of high-rise urban development (6.4 mg/kg), compared to low-rise urban housing, industrial, and rural areas (medians: 6.1, 5.8 and 5.1 mg/kg, respectively). The median concentration of lithium in cultivated soils of the study area is slightly lower (5.3 mg/kg) than in those from wastelands, fallow land, meadows, lawns and parks. Lithium concentrations above the 50th percentile (5.7 mg/kg) were recorded in the north-western part of the survey area, which is dominated by loess and loess-like sediments containing a high proportion of fine fractions. In general, areas to the east of the Bystrzyca River, where sandy silts and loess-like silty sands overlying Upper Cretaceous marls, opokas and gaizes are predominant, are characterized by soils with a lower content of lithium compared to the areas extending west of the Bystrzyca River. The spatial distribution of lithium variability in soils of Lublin and environs shows a clear similarity to the spatial distributions of aluminium, vanadium and titanium, which indicates a geogenic origin of this metal. Although the present research does not prove that the soils are enriched in lithium due to anthropogenic factors, this element has numerous applications (e.g. in construction, medicine, metallurgy, as well as the glass, ceramics, chemical and energy industries) through which it can enter the environment. For example, it is a key component of lithium-ion batteries, which are used in electric vehicles and electronic devices. A typical electric car battery contains about 8 kg of lithium carbonate (Balaram et al., 2024).

Aquatic sediments: Plate 42, Table 5

The lithium concentration in aquatic sediments in Lublin and environs ranges from 0.5 mg/kg to 16.5 mg/kg (median 5.0 mg/kg). These amounts are similar to those found in soils of this region. The highest result was obtained for a sediment sample taken from the Dopływ z Konopnicy stream (in its upper course) near the village of Konopnica. The surrounding areas consist of wasteland and fallow land. The median values calculated for sediments of the individual SWBs are similar, ranging from 4.0 mg/kg for the SWB Ciemięga to 5.2 mg/kg for SWB Czechówka. The results obtained for lithium in the Lublin region sediments are consistent with those covering Poland as a whole. The lithium concentration in sediments of streams and floodplains in Poland, determined by the XRF method, was found to be low, typically below 10.0 mg/kg. In contrast, the median concentration in European sediments was 22.5 mg/kg. There was a good correlation between lithium concentrations in sediments of European countries and beryllium, aluminium, iron, vanadium and cobalt concentrations. This indicates that lithium in this environmental component originates from geogenic sources (De Vos, Tarvainen (eds.), 2006).

Surface waters: Plate 43, Table 7

The lithium concentrations in surface waters of the study area are approximately three orders of magnitude lower than those measured in soils and aquatic sediments, falling within the narrow range of 0.4–7.7 µg/dm³ (median 4.8 µg/dm³). The majority of surface waters in the Lublin region are slightly alkaline, which may restrict the solubility and transport of lithium in these waters. The median values calculated for the individual surface water bodies are also invariable, ranging from 4.3 µg/dm³ (SWB Czerniejówka) to 6.2 µg/dm³ (SWB Dopływ spod Świdnika). In the case of water samples taken from the Dopływ spod Świdnika stream, relatively high concentrations of some other physico-chemical parameters were also found (e.g. Ca, K, Ni, Sr, U, SiO_2, Cl^-, HCO_3^-, SO_4^{2-}, total suspended solids, COD, TOC and EC). As there are production wells and an oil and natural gas mine located near the source of the stream, these facilities may affect the water's chemistry. The lithium concentrations recorded in waters of Lublin and environs are consistent with those obtained for European stream waters, which typically ranged from 1 µg/dm³ to 10 µg/dm³, and the median for European waters is 2.10 µg/dm³ (De Vos, Tarvainen (eds.), 2006).

Mg – MAGNESIUM

Soils: Plate 44, Table 3

Soils typically contain approximately 0.1–1.0% magnesium (Migaszewski, Gałuszka, 2016), but the content of this element in soils of Lublin and environs ranges from 0.01% to 0.93%. The median Mg content (0.15%) in these soils is almost twice that in the soils of Poland, Poznań and Warsaw, which contained 0.06%, 0.06% and 0.07% Mg, respectively (Lis, Pasieczna, 1995; Lis, Pasieczna, 2005; Tomassi-Morawiec, 2016). The lowest content of magnesium is found in light sandy soils, while the highest level is observed in heavy loamy soils (Kabata-Pendias, Pendias, 1999). A similar trend is evident in the analysed soils, with the median magnesium content of 0.08% in sandy soils and 0.17% in loamy soils. The mean content of Mg in loess is 0.68% (McLennan, Murray, 1999). Variations in the content of magnesium in soils depend on the chemistry of the underlying bedrock. Its high levels (as well as of Ba, Ca and Sr) may indicate the presence of carbonate rocks (De Vos et al., 2006; Reimann et al. (eds.), 2014). In Poland, elevated contents of magnesium were recorded in soils that developed on carbonate deposits (Lis, Pasieczna, 1995). Higher magnesium content is observed in the north-western part of the study area, where loess soils occur (Plate 1), than in the south-eastern part, which is characterized by different lithologies, such as sandy silts and loess-like silty sands. The lowest Mg contents were found in soil samples from forest areas (median 0.06%), which typically show a pH below 5.50 (Plate 7). Low magnesium contents in forest complexes were also reported in other studies that covered the territory of Poland (Lis, Pasieczna, 1995; De Vos et al., 2006). Magnesium deficiency is often found in light and acidified soils (Baran et al., 2001). The distribution of magnesium content in the studied soils may also be affected by anthropogenic factors. These sources of magnesium include dust fallout, mainly from coal combustion (Lis, Pasieczna, 1995), and the use of artificial fertilizers and liming (De Vos et al., 2006). In the study area, the highest contents of this element occur mainly in two areas: in the vicinity of Rury Jezuickie and between Czechów and Kalinowszczyzna. Numerous brickyards operated in both of these areas in the past (https://teatrnn.pl/leksykon/artykuly/lubelskie-cegielnie/). The likely sources of magnesium that migrated into the environment may have been both coal combustion and the release of magnesium oxide during the brick firing process. After World War II, the brickworks were gradually closed down and the chimneys were demolished, which may also have contributed to the dispersal of building materials to the area around the brickworks. In the area of Piaski, north of the Lublin-Wrotków Heat and Power Plant (currently known as PGE Energia Ciepła Oddział Elektrociepłownia w Lublinie), a small spot with a higher magnesium content than in the neighbouring areas was also identified. A possible cause of this anomaly is the emission of MgO-containing dust due to coal combustion (Pasieczna, 2003).

Aquatic sediments: Plate 44, Table 5

In the study area, the magnesium content in aquatic sediments is very similar to that measured in soils. It varies from below 0.01% to 0.93%. The median content of this element in Lublin (0.18%) is higher than in Warsaw, Poznań and Poland, as determined by previous geochemical studies, where the median magnesium values were at a similar level – 0.11%, 0.12% and 0.11%, respectively (Tomassi-Morawiec, 2016; Lis, Pasieczna, 2005; Lis, Pasieczna, 1995). The highest levels of this element are found in the SWB Czechówka sediments (median 0.33%). These sediments have a magnesium content approximately twice that of all other sediments in the research area. Sediments of the SWB Bystrzyca to the Zemborzycki Reservoir and SWB Ciemięga (median 0.23%) also contain elevated amounts of this element compared to the other SWBs. The variation in the content of this metal in the sediments may be related to the geological structure of the area. The SWB Czechówka within the boundaries of the study area is characterized by bedrock consisting largely of loess, which is extremely susceptible to denudation processes. Therefore, clay and silt suspensions, which are the main components of rocks and soils, can have a significant impact on the composition of surface waters and aquatic sediments (Turski et al., 1985).

Surface waters: Plate 45, Table 7

Magnesium is one of the most common elements found in water. Many magnesium compounds are highly soluble and mobile in water, regardless of environmental conditions. Under the typical pH, redox and conductivity conditions in streams, magnesium is likely to occur exclusively as Mg^{2+} ions. In freshwater, its concentration is usually between <10 mg/dm³ and 50 mg/dm³ (De Vos, Tarvainen (eds.), 2006).

The concentration of this metal in surface waters of Lublin and environs vary between 0.8 mg/dm³ and 31.4 mg/dm³. The median magnesium concentration in the study area (7.0 mg/dm³) is lower than that in Warsaw – median 9.9 mg/dm³ (Tomassi-Morawiec, 2016) and Poznań – median 17.5 mg/dm³ (Lis, Pasieczna, 2005) and is almost two-thirds the level for Polish waters – median 11.6 mg/dm³ (Lis, Pasieczna, 1995). Analysing the 50th percentile values of magnesium in the individual surface water bodies reveals its highest value in the SWB Czechówka (19.1 mg/dm³), as is the case with aquatic sediments. In contrast, the lowest median value (6.1 mg/dm³) is characteristic of the SWB Czerniejówka. The difference is probably caused by both the presence of different lithologies of the geological bedrock between these areas and the way the soils are used. In addition, the adsorption onto negatively charged clay mineral surfaces may reduce the concentration of Mg^{2+} ions in water more than that of Ca^{2+} and monovalent cations, as Mg^{2+} is more strongly bound to these surfaces (De Vos et al., 2006).

Mn – MANGANESE

Soils: Plate 46, Table 3

Manganese is a common element in the Earth's crust. Its presence in soils depends on its concentration in the parent rock, the soil formation process that controls its vertical distribution, climatic conditions, terrain relief, and the type of vegetation. In general, organic and loamy soils tend to be richer in manganese than sandy and mineral soils. The mean concentration of this element in different soil types ranges from 100 to 1300 mg/kg (Kabata-Pendias, Pendias, 1999). The Mg concentration in soils of Lublin and environs ranges from 8 mg/kg to 1142 mg/kg. The median value in this area is 305 mg/kg, which is almost double the average concentration of this element in Warsaw's soils – 157 mg/kg (Tomassi-Morawiec, 2016). It is also higher than the median manganese concentration in Poznań's soils – 200 mg/kg (Lis, Pasieczna, 2005) and Poland's soils – 217 mg/kg (Lis, Pasieczna, 1995). Silty soils are characterized by a significantly higher manganese concentration (median 352 mg/kg) than sandy soils (median 227 mg/kg) and peaty soils (median 148 mg/kg). The highest levels of manganese are found in cultivated land (median 368 mg/kg).

In urban (both low- and high-rise housing) areas, manganese levels were similar to those in industrial areas (median 291 mg/kg). They are however lower than in rural areas (median 358 mg/kg). Increased manganese levels may occur in soils subjected to intensive fertilization with manure, especially when mineral feed additives containing elevated levels of this element were used (Kabata-Pendias, Pendias, 1999). Anthropogenic soils in the analysed region are not enriched in manganese. Its elevated concentrations are typically found outside the most urbanized areas. The relatively low concentrations in urban soils (e.g. in Lublin city centre's quarters: Old Town, Kalinowszczyzna, Kośminek and Majdanek) are probably related to a higher proportion of sand fraction. The lowest concentration was found in the southern part of Lublin in a forested area (Dąbrowa Forest) near the Zemborzycki Reservoir. This is also the area of the lowest soil's pH, where mainly sandy silts and loess-like silty sands occur. The maximum concentration of manganese (1142 mg/kg) measured near the construction site in the Sławin quarter (in the Dzbenin area) is of anthropogenic origin.

Aquatic sediments: Plate 46, Table 5

Manganese concentration in aquatic sediments of the Lublin agglomeration varies greatly, from 3 mg/kg to 3530 mg/kg, with a median value of 215 mg/kg. The variation in the concentration of this element is smaller than in sediments of Warsaw or Poznań, but the median manganese concentrations in sediment samples collected in these regions are similar, approximately 200 mg/kg (Lis, Pasieczna, 2005; Tomassi-Morawiec, 2016). Of the eight SWBs identified the study area, the highest median manganese concentration (421 mg/kg) in aquatic sediments were found in the SWB Dopływ spod Świdnika, while the lowest one (133 mg/kg) was recorded in the SWB Bystrzyca to the Zemborzycki Reservoir. The median value calculated from 16 sediment samples taken from the Zemborzycki Reservoir was low, 22 mg/kg. The highest concentrations, above 3000 mg/kg, were recorded in two samples: one was represented by sludge collected from a stream flowing near the cemetery between Krężnica Jara and Nowiny, and the other by mud from a ditch in the village of Rudnik, near a street and railway tracks. The latter sample also exhibits a high content of total organic carbon (18.9%).

Surface waters: Plate 47, Table 7

The manganese concentration in surface waters in Lublin and environs is diverse ranging from below 0.001 mg/dm³ to 2.527 mg/dm³. The median concentration calculated for the entire set of samples is 0.033 mg/dm³, which is about four times lower than that of Warsaw waters – median 0.123 mg/kg (Tomassi-Morawiec, 2016) and more than twice as low as that Poznań waters – median 0.079 mg/kg (Lis, Pasieczna, 2005). The median values calculated for the water samples collected from the SWB Czechówka and SWB Dopływ spod Świdnika are almost double the average manganese concentration found in the Lublin agglomeration waters. The Zemborzycki Reservoir is characterized by low manganese concentrations, ranging from 0.001 mg/dm³ to 0.034 mg/dm³ (26 samples analysed). The highest concentrations of the element, above 1 mg/dm³, were recorded in the water samples taken from ditches and ponds from the SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth. The results obtained in the present study are consistent with those recorded for this region in the *Geochemical Atlas of Poland*, which were below 0.137 mg/dm³ (Lis, Pasieczna, 1995).

Mo – MOLIBDENUM

Soils: Plate 48, Table 3

Molybdenum is a trace element dispersed in the Earth's crust. It is found mainly in acidic igneous rocks and clay deposits, and concentrated predominantly in sulfide and oxide parageneses (Pasieczna, Markowski, 2014). Molybdenum exhibits diverse geochemical properties (Kabata-Pendias, Pendias, 1999). In soils, it readily forms mobile complex anionic compounds under neutral and alkaline conditions. In acidic environments, it is however bound by aluminium, iron, manganese hydroxides, organic matter, and clay minerals. This limits the availability of this microelement to plants, posing a negative effect on their development (Pasieczna, Markowski, 2014). Observations conducted over several decades show that the topsoil layer of cultivated land is becoming depleted in molybdenum due to irrigation and the migration of the element into drainage water (Kabata-Pendias, Pendias, 1999). In European topsoil, the molybdenum concentration ranges from <0.1 mg/kg to 17.2 mg/kg (De Vos, Tarvainen (eds.), 2006). Soils in Poland generally contain less than 0.45 mg/kg of molybdenum. Regional increases (0.45–0.75 mg/kg) are found in the Carpathians and their foothills.

In the Lublin agglomeration, the molybdenum concentration ranges from 0.12 mg/kg to 18.41 mg/kg, with a median of 0.26 mg/kg. The highest concentration (18.41 mg/kg) was measured in a peaty soil sample taken from wasteland in the south-western part of the study area. In the other samples, molybdenum concentrations are lower and do not exceed 4.06 mg/kg. The highest median value was found in peaty soils (1.01 mg/kg), while the lowest one was recorded in soils taken from forest areas (0.19 mg/kg). Higher amounts of molybdenum in Lublin soils are observed in the Tatary quarter, especially around the Megatem EC-Lublin combined heat and power plant, in the Bronowice and Wrotków quarters, as well as at Lublin Airport in Świdnik. These areas have been under anthropogenic pressure for decades, and the main sources of molybdenum are emissions from the combustion of hard coal in combined heat and power plants and in domestic furnaces. Molybdenum is subject to bioaccumulation and accumulates in coal. During combustion, it disperses and penetrates into soils and sediments. It is used in the aviation, electronics, and arms industries, as well as in the production of components for incandescent lamps (Pasieczna, 2012).

Aquatic sediments: Plate 48, Table 5

Molybdenum tends to accumulate in aquatic sediments (Bojakowska et al. 2007). The median molybdenum concentration in sediments of the Lublin agglomeration (0.41 mg/kg) was found to be almost twice as high as in soils of this area. The results for this element in sediment samples taken from watercourses and reservoirs in the study area (ranging from 0.03 mg/kg to 5.40 mg/kg) does not differ from those recorded for river sediments in Poland (ranging from <0.40 mg/kg to 8.19 mg/kg; https://www.gov.pl/web/gios/monitoring-osadow-dennych). Sediments of the Zemborzycki Reservoir contain comparable amounts of molybdenum (ranging from <0.05 mg/kg to 0.72 mg/kg) to those published for the Zegrze Reservoir sediments, which were from <0.1 mg/kg to 1.0 mg/kg (Bojakowska et al. 2007).

Surface waters: Plate 49, Table 7

Both the chemical form of molybdenum and its concentration in aquatic environments depend on the pH of the water, oxidation-reduction potential, and salinity. These factors affect the solubility of molybdenum and thus its bioavailability to plants. Molybdenum concentration in surface waters is generally low because it is easily sorbed in acidic or slightly acidic environments. However, as the alkalinity of the water increases, so does the amount of molybdenum dissolved in it (Kabata-Pendias, Szteke, 2012; Smedley, Kinniburgh, 2017).

The molybdenum concentration in surface water samples from the Lublin region ranges from 0.10 µg/dm³ to 26.57 µg/dm³. These values are similar to the results obtained during the implementation of the *Geochemical Atlas of Warsaw and Environs 1:100,000* (Tomassi-Morawiec, 2016). All of the waters tested meet the standards for classes I and II surface water quality, for which the molybdenum limit is ≤40 µg/dm³ (Rozporządzenie…, 2021). The highest concentrations of molybdenum, ranging from 22.77 µg/dm³ to 26.57 µg/dm³, were recorded in three samples collected from the Bystrzyca River within the SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth. The sampling sites were located in the municipality of Wólka, specifically in the villages of Sobianowice and Długie. The presence of elevated concentrations of molybdenum at these locations may indicate agricultural contamination resulting from the intensive use of mineral fertilizers, as well as from surface runoff from agricultural fields.

Na – SODIUM

Soils: Plate 50, Table 3

Sodium is one of the most abundant elements in the Earth's crust. Due to their similar ionic radii, the Na^+ and Ca^{2+} ions exhibit a clear geochemical affinity to each other. (Migaszewski, Gałuszka, 2016). Sodium is a highly mobile element. During rock weathering, it quickly passes into water and is subsequently transported to the seas and oceans, where it becomes the main cation responsible for seawater salinity. The total sodium content in Polish soils is low. Soil analysis results obtained using the XRF method indicate that the sodium content generally did not exceed 0.52% (Reimann et al. (eds.), 2014). However, the content of sodium determined by the ICP-MS method following *aqua regia* extraction was less than 1% of its total amount. The average salinity measured during studies of Poland's soils has remained at a low level that is harmless to plants and soil quality, and did not change in subsequent monitoring periods. For example, in 2020, the sodium content measured in 216 samples of Poland's soils used for agricultural purposes ranged from 0.001 to 0.029%, with a mean value of 0.005% (https://www.gios.gov.pl/chemizm_gleb/index.php?mod=wyniki&cz=F).

The sodium content in soil samples taken from the Lublin agglomeration ranges from 0.004 to 0.172%, with a median value of 0.008%. Soils in the southern part of the study area typically have a sodium content below the median value. Anthropogenic, peaty and industrial soils show higher median contents (0.013% and 0.012%), while forest soils exhibit the lowest median (0.005%). In general, samples taken in rural areas (including cultivated fields and undeveloped land) have a lower median sodium content than those collected in urban areas. This indicates that land use and housing density affect the presence of this element in the soils. A higher sodium content was found in topsoil of Lublin city centre, particularly in the Old Town and Bronowice quarters, due to exposure to anthropogenic pressure resulting from intensive urbanization and the development of transport infrastructure. These densely built-up areas have a well-developed road network. Sodium chloride is mainly used here for de-icing roads, pavements and squares in winter. Surface runoff from streets causes contaminants to penetrate the soil and groundwater. In city centres, where there is heavy car and pedestrian traffic, salt doses are highest and salt accumulation in the environment is more visible. The highest sodium content was recorded at two locations in allotment gardens: 0.172% in the Rury quarter and 0.148% in the Bronowice quarter.

Aquatic sediments: Plate 50, Table 5

The sodium content in aquatic sediments of the Lublin agglomeration ranges from 0.003% to 0.077%, with a median value of 0.011%. The lowest median value (0.006%) was recorded in aquatic sediments of the SWB Ciemięga, while the highest one (0.017%) was found in sediments of the SWB Czechówka. Sodium-enriched sediments were usually observed in areas where higher levels of this element were measured also in soils.

Surface waters: Plate 51, Table 7

The sodium concentration in surface waters of the study area varies widely from 2.4 mg/dm³ to 148.1 mg/dm³. The spatial variability of this element is similar to that of chlorides in surface waters. The median sodium concentration for the entire set of water samples is 7.8 mg/dm³, which is half of the median value recorded for surface waters in Poland – median 16 mg/dm³ (Lis, Pasieczna, 1995), three times lower than for Poznań waters – median 26.6 mg/dm³ (Lis, Pasieczna, 2005) and almost four times lower than for Warsaw waters – median 30.1 mg/dm³ (Tomassi-Morawiec, 2016). The highest median value (12.5 mg/dm³) is found in surface waters of the SWB Czechówka, as is the case for aquatic sediments. Sodium in this area probably originates from the geological bedrock. However, factors related to human activity, particularly agriculture and urbanization, should also be taken into account. The maximum sodium concentration of 148.1 mg/dm³ was recorded in the Elizówka retention reservoir located near road No. 835. Several other contaminants were also detected in the reservoir, such as: Al, Ba, Cl^- i NH_4^+. The high sodium concentration at this location may be the result of surface runoff containing road contaminants, including sodium chloride used for winter road maintenance. As the reservoir collects rainwater and meltwater from nearby transport routes, this indicates an anthropogenic, transport-related source of the contaminants.

$NH4^+$ – AMMONIUM ION

Surface waters: Plate 52, Table 7

Elevated concentration of ammonium ions in surface water is a significant indicator of recent contamination by domestic or industrial wastewater. The concentration of ammonium ions ranges from 0.05 mg/dm³ to 2.23 mg/dm³ in the study area. The median concentration calculated for the entire set of samples is 0.11 mg/dm³, which is lower than the median concentration in waters of the Warsaw agglomeration – 0.18 mg/dm³. In Lublin and its environs, the highest concentration of ammonium ions was observed in a pond in Elizówka (in the Niemce municipality), near a commercial and service complex. In such closed water reservoirs or in those with restricted flow, high concentrations of ammonium ions may indicate the anaerobic decomposition of deposited organic matter. The highest median ammonium ion concentration (0.19 mg/dm³) was calculated for water samples collected from the SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth, while the lowest one (below 0.05 mg/dm³) was found in water samples from the SWB Dopływ spod Świdnika and SWB Ciemięga. To refer the obtained results to the limit values for surface water quality classes specified in the Regulation of the Minister of Infrastructure on the classification of ecological status, ecological potential and chemical status, and the method of classifying the status of surface water bodies (Rozporządzenie ..., 2021), the concentrations ammonium ions were converted to ammonium nitrogen (using a factor of 0.7765). On this basis, it was determined that, the ammonium nitrogen concentrations measured in 48 water samples taken from rivers and streams exceeded the limit values for surface water quality class I (≤0.13 mg/dm³ or ≤0.14 mg/dm³ depending on the type of watercourse). Ammonium nitrogen concentrations that exceeded the limit values for class II surface water quality were found in only 16 samples (≤0.30 mg/dm³ / ≤0.35 mg/dm³).

Ni – NICKEL

Soils: Plate 53, Table 3

The nickel concentration in soils depends on the origin of the parent rock and the granulometric composition. The range of mean nickel concentrations in surface layers of various soil types is 4–50 mg/kg. Lower concentrations are found in light sandy soils (mean value 15 mg/kg), while higher concentrations are observed in loamy soils (mean value 30 mg/kg). Geochemical properties of nickel are similar to those of iron and cobalt. Nickel is easily mobilized during weathering processes, but is usually quickly bound by iron and manganese hydroxides (Kabata-Pendias, Pendias, 1999; Jasiewicz, Antonkiewicz, 1997; Pelczar et al., 2005).

Nickel concentrations in the study area soils vary significantly, ranging from 1 mg/kg to 649 mg/kg. The median calculated for the entire set of samples is 10 mg/kg. This element is more common in urban soils of Lublin and Świdnik, particularly in industrial and densely populated regions. The study results indicate that nickel concentration in 98% of the soil samples is equal to or lower than 24 mg/kg. Similar data were obtained for soils in Warsaw, where 97% of samples showed concentrations equal to or lower than 23 mg/kg (Tomassi-Morawiec, 2016). The spatial distribution of nickel concentrations in the study area soils is similar to that of iron and chromium concentrations. The highest level of nickel (649 mg/kg) was recorded in a soil sample taken near the WSK PLZ-Świdnik aircraft factory and Lublin Airport. Significant amounts of Ni in the aircraft factory area are anthropogenic in origin and result from the specific process of aircraft construction. The process requires light and durable materials, e.g. aluminium alloys, which contain refining additives such as chromium, nickel, iron, titanium and beryllium (Bielawski et al., 2016). Nickel is also found in materials used in the construction of modern turbine engines (Szczeciński, 2011). Elevated levels of nickel in topsoil (up to 56 mg/kg) were also observed in the north-eastern part of Lublin, specifically in the Kośminek and Tatary quarters. This area has been an industrial zone since the 1950s, and home to the Truck Factory, Ursus Mechanical Works, and Poland's largest iron foundry. The area is currently home to a number of smaller production plants and the Megatem EC-Lublin combined heat and power plant. Elevated levels of nickel were also recorded in the village of Prawiedniki, which is located south of Lublin. Its concentration in a sample collected from this location is 35 mg/kg, which is several times higher than that measured in soil samples taken from the surrounding area (3–14 mg/kg). The probable cause of the anomalous nickel concentration in the soil is the use of material of unknown origin to level the area between 2015 and 2017. The lowest concentrations of nickel were recorded in large, compact forest complexes in the south-western and southern parts of Lublin. Soils in the south of the study area generally have a nickel concentration below the 50th percentile (10 mg/kg). The nickel concentration in the soil sample from the village of Świdniczek (16 mg/kg) is similar to the results obtained during the *Monitoring of the chemistry of arable soils in Poland* at measurement and control point No. 283, which is located in the same village (8.3–14.3 mg/kg) (https://www.gios.gov.pl/chemizm_gleb/index.php?mod=pomiary&p=283). The median nickel concentration in soils from the Lublin region is approximately twice the values determined for this parameter on the basis of data obtained in the European FOREGS and GEMAS projects, which covered uncontaminated and agricultural soils in Europe, including Poland (Salminen, 2005; Reimann et al. (eds.), 2014). Only one soil sample, taken from industrial areas in Świdnik, exceeded the permissible nickel concentration for soil group IV (500 mg/kg). The remaining samples contained nickel at concentrations ranging from 1 to 73 mg/kg, meeting the standards specified for soil group I –permissible concentration 150 mg/kg (Rozporządzenie…, 2021).

Aquatic sediments: Plate 53, Table 5

The nickel concentration in aquatic sediments of the survey area ranges from below 1 mg/kg to 154 mg/kg. The median calculated for all sediment samples is 11 mg/kg. Approximately 97% of the samples collected from Lublin and environs contain less than 30 mg/kg of nickel. These amounts are similar to those obtained for sediments from the Warsaw area (Tomassi-Morawiec, 2016). The cartographic picture of nickel concentration in aquatic sediments in Lublin and environs indicates the city's anthropogenic impact on the chemical condition of the sediments, particularly in the Bystrzyca River. Elevated concentrations of the metal were recorded in sediment samples taken from the section of the river that runs through former industrial areas of Lublin and further towards the river's mouth. In the study area, the highest result (154 mg/kg) was obtained from a sediment sample taken in the SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth. The sampling site is located upstream of the Hajdów Wastewater Treatment Plant's discharge point and close to the company involved in the purchase and trade of steel and non-ferrous metals. The abnormally high content of nickel (and of several other elements: Ag, Cd, Cr, Cu, Co, Zn, Ti, Pb, Ba and Se) at this location is probably related to the activities of this company. High nickel (and chromium) concentrations at another sampling site in the Bystrzyca River (61 mg/kg) may result from the inflow of storm-water runoff from the Tatary quarter. Referring the obtained data to ecotoxicological risk indices, it can be concluded that 14 of the aquatic sediment samples contained nickel levels above the TEC value (23 mg/kg). Only at two locations were the levels above the PEC value – 49 mg/kg (MacDonald et al., 2000).

Surface waters: Plate 54, Table 7

Surface waters in the Lublin region are characterized by low nickel concentrations ranging from 0.5 µg/dm³ to 10.8 µg/dm³. The median calculated for the entire set of samples is 1.4 µg/dm³, and the highest concentration was measured in a sample taken from a field drainage ditch near the village of Turka. It is located within the SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth. The ditch is a tributary of the Bystrzyca River. The maximum permissible concentration of nickel (34 µg/dm³) specified for surface water bodies is not exceeded in any of the water samples (Rozporządzenie…2021).

NO_2^- – NITRATES (III)

Surface waters: Plate 55, Table 3

Nitrates (III) can enter surface waters from various sources, primarily agricultural soils, wastewater discharges, and industrial processes. The concentration of NO_2^- ions in the tested waters of Lublin and environs varies from below 0.01 mg/dm³ to 0.74 mg/dm³, with a median of 0.11 mg/dm³, which is higher than in the waters of Warsaw – median 0.07 mg/dm³ (Tomassi-Morawiec, 2016) and Poznań – median 0.05 mg/dm³ (Lis, Pasieczna, 2005). The highest concentration of NO_2^- ions was recorded in the Dopływ z Konopnicy stream, in the Sławin quarter. The highest median of anion concentration (0.16 mg/dm³) is found in the waters of the SWB Czechówka, the lowest one (0.05 mg/dm³) in the SWB Ciemięga.

NO_3^- – NITRATES (V)

Surface waters: Plate 56, Table 3

Nitrates (V) enter surface waters primarily through soil fertilization, municipal wastewater discharges, leaking septic tanks, and industrial emissions. Elevated levels of these ions favour eutrophication, which degrades water quality and destabilizes aquatic ecosystems.

The concentration of NO_3^- ions in waters of Lublin and its environs varies from 0.07 mg/dm³ to 34.20 mg/dm³. The median concentration for the entire set of samples is 5.94 mg/dm³, which is higher than in Poznań waters – median 3.21 mg/dm³ (Lis, Pasieczna, 2005) and Warsaw waters – median 2.24 mg/dm³ (Tomassi-Morawiec, 2016), as well as in European waters – median 2.82 mg/dm³ (De Vos, Tarvainen (eds.), 2006). The maximum concentration of NO_3^- ions (34.20 mg/dm³) was recorded in cultivated land in an unnamed ditch at Krępiec (eastern part of the study area). This is probably due to surface runoff from intensively farmed fields where nitrogen fertilizers are used, and subsequent nitrate leaching from soils during rainfall. In the analysed sample set, the highest median concentration of nitrates (14.25 mg/dm³) was observed in the SWB Czerniejówka waters, while the lowest one (0.72 mg/dm³) – in waters of the SWB Bystrzyca to the Zemborzycki Reservoir.

P – PHOSPHORUS

Soils: Plate 57, Table 3

Phosphorus in soil typically originates from parent rocks (Kholodov, 2002), although fertilization can also affects its presence (Bednarek et al., 2017). A significant proportion of phosphorus is sorbed by soil's organic matter, meaning that peaty soils may be richer in this element (Holtan et al., 1985). The presence of phosphorus in soils is extremely important because it is one of the three main macronutrients necessary for plant life. Compared to other European countries, Poland's soils are less rich in phosphorus than, for example, those in Germany (De Vos, Tarvainen (eds.), 2006).

The phosphorus content in soils of Lublin and environs ranges from 0.005% to 1.290%. The median value in these areas is 0.044%, which is slightly higher than the median values for Poland's soils – 0.034% (Lis, Pasieczna, 1995) and Warsaw's soils – 0.036% (Tomassi Morawiec, 2016). The study results indicate that the phosphorus content in the Lublin region soils is currently higher than that recorded in the 1990s during the implementation of the *Geochemical Atlas of Poland* – median 0.031% (Lis, Pasieczna, 1995). The geochemical data show that the highest contents of the element are found in the most urbanized areas of Lublin (including the oldest quarters of the city) and in industrial areas, primarily around the Megatem EC-Lublin combined heat and power plant and to the south of the Perła-Browary Lubelskie S.A. breweries. Soils in these areas are characterized by the phosphorus content above 0.075%. This may be due to emissions from industrial plants operating in the area, as well as the combustion of fossil fuels, as indicated by the co-occurrence of elevated levels of sulfur, sodium and PAHs. These substances are likely emitted by coal-fired power plants (Jackson et al., 1996; Kravchenko et al., 2024). Elevated levels of phosphorus were also recorded near the villages of Turka, Długie and Wólka in the northeast of the study area, and these probably originate from anthropogenic sources. Areas where phosphorus levels exceed the median value (0.044%) are also found in the north-western part of the research area, in the vicinity of the villages of Barak, Jakubowice Konińskie, Dębówka, and Choiny. These are agricultural areas where elevated levels of phosphorus in soil may result from the use of artificial fertilizers and/or organophosphorus insecticides. Another factor that may contribute to increased phosphorus content in soil is the bedrock lithology, in particular the presence of loess (Blake et al., 2000). The lowest content of phosphorus was found in forest soils (median 0.021%), mainly in the forest complex extending to the southeast of the Zemborzycki Reservoir (Dąbrowa Forest), as well as in sandy soils (median 0.037%).

Aquatic sediments: Plate 57, Table 5

The phosphorus contents in aquatic sediments and soils in the Lublin region are fairly similar, with slightly lower contents found in sediments than in soils. In the study area, the median phosphorus content in aquatic sediments of watercourses and reservoirs is 0.059% and is higher than the average content of this element in sediments of the Warsaw area – median 0.036% (Tomassi-Morawiec, 2016). By comparing the present research results with data from the 1990s, when the median phosphorus content in the same area was 0.052% (Lis, Pasieczna, 1995), an upward trend in the content of this element can be seen in sediments of the Lublin agglomeration. High phosphorus (and TOC) contents were recorded in most of the sediment samples taken from the SWB Dopływ spod Świdnika. The median value calculated for these samples is twice that for all the sediment samples (0.119%). The phosphorus content in the Bystrzyca River sediments is lower upstream of the city of Lublin than downstream. Sediments of the SWB Bystrzyca to the Zemborzycki Reservoir show the lowest median value (0.046%) of all the SWBs studied. This may be due to the area's geological structure or the type of land use in the surrounding expanses (there are mainly meadows in this portion of the study area). Elevated levels of phosphorus were usually found in sediment samples containing abundant organic matter, which were collected from watercourses flowing through marshy areas.

Surface waters: Plate 58, Table 7

The phosphorus concentration in surface waters of Lublin and environs range from below 0.05 mg/dm³ to 0.90 mg/dm³. The median phosphorus concentration is 0.12 mg/dm³ and is higher than the median value calculated for Warsaw's waters – 0.070 mg/dm³ (Tomassi-Morawiec, 2016) and Poznań's waters – 0.100 mg/dm³ (Lis, Pasieczna, 2005). However, the mean phosphorus values obtained for each of the agglomerations are lower than the country's overall median phosphorus value of 0.160 mg/dm³ (Lis, Pasieczna, 1995). The highest concentration (0.90 mg/dm³) was found in a water sample taken from a canal in Konstantynów. The SWB Czechówka and SWB Dopływ spod Świdnika show the highest levels of phosphorus (in both cases the median is 0.16 mg/dm³). Most of the water samples collected from the SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth are characterized by low concentrations of phosphorus (below 0.05 mg/dm³). With the exception of one sample, they can be classified as class I quality waters (Rozporządzenie..., 2021). The studies lead to the conclusion that the elevated concentrations of phosphorus in soils of the heavily urbanized city centre does not result in a significant increase in phosphorus concentrations in the Bystrzyca River. The median phosphorus values in waters of the SWB Bystrzyca to the Zemborzycki Reservoir (0.12 mg/dm³), SWB Czerniejówka and SWB Ciemięga (0.13 mg/dm³) show similar levels. The Zemborzycki Reservoir waters are characterized by relatively low concentrations of phosphorus, ranging from below 0.05 mg/dm³ to 0.21 mg/dm³ (median below 0.05 mg/dm³).

Pb – LEAD

Soils: Plate 59, Table 3

Native lead is extremely rare in the natural environment. This is because it tends to bind with sulfur to form galena (lead sulfide), the most common mineral containing this metal (Cabała et al., 2021). Lead poses a significant environment threat and often has adverse biological effects. The mean concentration of this metal in the Earth's crust is estimated at 10–14 mg/kg. Higher concentrations of lead are typically found in clay deposits (10–40 mg/kg). In alkaline rocks and carbonate sediments, lead concentrations usually do not exceed 10 mg/kg (Kabata-Pendias, Pendias, 1999).

The lead concentration in the study area soils ranges from 3.35 mg/kg to 340.79 mg/kg. The median value of this element (12.97 mg/kg) calculated for all of the samples is similar to the median values found for soils in the Warsaw – 15 mg/kg (Tomassi-Morawiec, 2016) and Poznań agglomerations – 11 mg/kg (Lis, Pasieczna, 1995). It also does not differ from the median value found for European soils (median 15.0 mg/kg; De Vos, Tarvainen, 2006). In the survey area, anthropogenically elevated lead concentrations were recorded in the oldest regions of Lublin city and its industrial areas, as in the case of Warsaw and Poznań. Locally, lead concentrations exceed 200 mg/kg. The highest level of the metal was recorded in the central part of the Kośminek quarter of Lublin, where a delivery van repair service station had operated for several years. One of the highest results (313.62 mg/kg) was recorded to the east of the village of Wólka, at the side of a local road and close to a vehicle repair company. Low levels of lead in soils were found in the southern and western parts of the research area. Soil samples taken from large, compact forest complexes and agricultural areas at the villages of Mętów, Kąty and Głuszczyzna are characterized by very low concentrations. The lead concentration determined currently in the soil sample taken in the village of Świdniczek is 19.99 mg/kg, which is slightly higher than the values measured between 1995 and 2020 as part of the *Monitoring of the chemistry of arable soils in Poland* at measurement

and control point No. 283. The results obtained during the course of five measurement cycles ranged from 6.69 mg/kg to 16.9 mg/kg. (https://www.gios.gov.pl/chemizm_gleb/index.php?mod=pomiary&p=283). The highest concentrations of lead determined in soils from the Lublin region (above 250 mg/kg) do not exceed the permissible lead concentration for soil group IV (600 mg/kg) because the measurements were taken in industrial or transportation areas. In over 99% of all soil samples tested, lead is present in amounts not exceeding 200 mg/kg, which is the permissible concentration limit for soil group I (Rozporządzenie…, 2024).

Aquatic sediments: Plate 59, Table 5

The lead concentration in aquatic sediments in Lublin and environs ranges from 1.09 mg/kg to 127.53 mg/kg. The median calculated for all sediment samples is 13.31 mg/kg and is similar to the median calculated for soils in this region (12.97 mg/kg). It is also similar to the median lead concentration for sediments in Warsaw – 15 mg/kg (Tomassi-Morawiec, 2016) and Poznań – 13 mg/kg (Lis, Pasieczna, 2005). Elevated lead concentrations in aquatic sediments, as in the case of nickel, copper, zinc and chromium, are found mainly in the Bystrzyca River, in the stretch of the river that passes through former industrial areas of Lublin and further towards the river's mouth. The resulting cartographic visualization indicates anthropogenic impact of the city on the condition of the aquatic sediments. A maximum lead concentration of 127.53 mg/kg is found in a sediment sample taken from the Bystrzyca River within the SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth. This sampling site is located northeast of Lublin and upstream of the Hajdów Wastewater Treatment Plant's discharge point. Therefore, emissions from the plant cannot be responsible for the sediment contamination by this metal. The presence of elevated lead concentrations at this location is probably the result of the activities of the company involved in the purchase and trade of steel and non-ferrous metals. Its premises are located around 40 m from where the sediment sample taken from the Bystrzyca riverbed. The sediments at this location show the highest levels of not only lead, but also Ag, Cd, Cr, Cu, Co, Ni, Zn and Ti, and almost the highest levels of Ba and Se. Referring the results obtained for all of the sediment samples to ecotoxicological risk indices, it was found that 79 samples exhibited lead levels exceeding the TEC value (36 mg/kg), and 12 samples showed levels above the PEC value (130 mg/kg). A risk of harmful effects of lead on aquatic organisms (MacDonald et al., 2000) is ascertained only in the case of 12 samples.

Surface waters: Plate 60, Table 7

Surface waters from Lublin and environs are characterized by low concentrations of lead. Measurement results obtained for 84 water samples are below the limit of determination of the analytical method (0.05 μg/dm^3). The concentrations of this metal in the remaining surface water samples range from 0.05 μg/dm^3 to 0.73 μg/dm^3. The highest result was obtained for a sample taken from a canal in the Lipniak colony area in the municipality of Konopnica. This sampling site is located within the SWB Czechówka, in a terrain depression that serves as the outlet for an underground storm drain carrying rainwater from the Lublin's quarter of Konstantynów. This quarter comprises allotment gardens, a housing estate for single-family homes, and roads and other paved surfaces, from which contaminants are washed away. In addition, the elevated metal concentration in the water may have resulted from its stagnant state at the time of sampling. However, no water sample exceeded the permissible limit value for lead, which is 14 μg/dm^3 in surface water bodies (Rozporządzenie…, 2021).

S – SULFUR

Soils: Plate 61, Table 3

Sulfur is a highly mobile element in an oxidizing environment. Under reducing conditions, it precipitates in the form of metal sulfides. Its content in soils varies depending on the chemistry of the parent rocks, the degree of fertilization, and the amount of precipitation. Sulfur contents in mineral soils are typically between 0.005% and 0.008%, while in organic and peaty soils, it can be several times higher about 0.35–0.45% (Siuta, Rejman-Czajkowska, 1980). The sulfur content in topsoil in Poland's undeveloped areas generally ranged from 0.005% to 0.016%. Elevated levels (up to 0.035%) were observed in peaty soils of river valleys. In urban soils, the sulfur content did not differ significantly from the regional geochemical background level – median 0.012% (Lis, Pasieczna, 1995). Soil enrichment in sulfur is usually the result of natural processes and is commonly found in the cities that are located in river valleys, where the soil has formed from alluvial mud and peat. Nevertheless, anthropogenic enrichment of topsoil in sulfur was also observed in some cases (Pasieczna, 2003).

In Lublin and its environs, the sulfur content in soils ranges from 0.004 to 0.726%, with a median value of 0.016%, which is identical to the median value calculated for soils in the Warsaw area. The maximum sulfur content (0.726%) was found in a peaty soil sample taken from bogland in the Wrotków quarter. In the study area, the lowest sulfur content (median 0.011%) was recorded in forest soils. The highest levels were measured in peaty soils (median 0.159%). The spatial distribution of sulfur in soils of the Lublin agglomeration indicates the contribution of anthropogenic factors to the content of this element. The Lublin city area is characterized by sulfur contents that are above the 50th percentile. An increasing trend can be observed by comparing the median sulfur values calculated for soils in undeveloped, rural, low-rise urban, high-rise urban and industrial areas. The median sulfur content of industrial soils is approximately 60% higher than that of soils in undeveloped areas (0.014%). The results obtained for meadow and arable soils in the Lublin region are comparable to those acquired for Poland's agricultural soils in the GEMAS project: median for arable fields – 0.0139% and median for meadows – 0.0225% (Reimann et al., 2014).

Aquatic sediments: Plate 61, Table 5

The sulfur content in aquatic sediments in Lublin and environs ranges from 0.006% to 1.135% (median 0.100%). The median sulfur content in sediments of the study area is comparable to the value of this parameter in the Poznań agglomeration – median 0.096% (Lis, Pasieczna, 2005), but higher than in the Warsaw area – median 0.066% (Tomassi-Morawiec, 2016). Sediments in the SWB Dopływ spod Świdnika are characterized by the highest median value (0.301%), which is about six times higher than that calculated for the SWB Czechówka (0.051%). Based on the obtained spatial distributions of sulfur variability in aquatic sediments and soils, it can be concluded that higher contents of this element generally occur in sediments from areas where the soils are also richer in sulfur.

Sb – ANTIMONY

Soils: Plate 62, Table 3

Antimony is a sulfophilic element whose presence in soils can be correlated with the presence of sulfur and other metals that form sulfides, in particular arsenic, which can partially replace antimony in mineral structures. Higher amounts of antimony, up to 2 mg/kg, are found in clay rocks (Kabata-Pendias, Mukherjee, 2007).

The antimony concentration in soils in Lublin and environs ranges from 0.06 mg/kg to 10.70 mg/kg. The median value calculated for the entire set of soil samples is 0.25 mg/kg. This is similar to the median value obtained for Poland's soils (0.32 mg/kg), but lower than the median concentration of antimony in European topsoil – 0.60 mg/kg (Salminen et al., 2005). In the study area, the highest antimony medians were recorded in industrial soils (0.49 mg/kg) and peaty soils (0.48 mg/kg). Higher values are present in peaty soils because this element is bound by organic matter (Kabata-Pendias, Pendias, 1999) and shows sulfophilic properties. No variation in the antimony concentration was observed in loamy, sandy and silty soils (medians: 0.23 mg/kg, 0.23 mg/kg and 0.22 mg/kg, respectively). Slightly elevated concentrations of this metal are found in anthropogenic soils (median: 0.41 mg/kg), as well as in garden soils (median: 0.37 mg/kg) and lawn soils (median: 0.32 mg/kg). This may be due to surface runoff carrying dust and contaminants from roofs, streets and pavements. The lowest levels are recorded in soils of forests (median 0.20 mg/kg) and undeveloped areas (median 0.21 mg/kg). Soils with elevated levels of antimony are concentrated mainly in the most urbanized part of Lublin near the Megatem EC-Lublin and Lublin-Wrotków combined heat and power plants. Antimony is probably sourced from the combustion of fossil fuels, particularly coal, which can contain up to 30 mg/kg of this element. Its concentration in ash can reach 100 mg/kg (Kabata-Pendias, Pendias, 1999; Kabata-Pendias, Mukherjee, 2007; Niedzielski et al., 2000). The maximum antimony concentration was found in an anthropogenic soil sample collected in an industrial area, near the village of Wólka. The spatial distribution of antimony concentrations in soils of the study area is similar to that of lead.

Aquatic sediments: Plate 62, Table 5

The antimony concentration in aquatic sediments in the Lublin agglomeration ranges from below 0.05 mg/kg to 5.63 mg/kg, with a median value of 0.34 mg/kg. This is lower than the median concentration of antimony in European stream sediments, which is 0.62 mg/kg (Salminen et al., 2005). The highest median values were recorded in sediments of the SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth (0.75 mg/kg), as well as in the SWB Czechówka (0.41 mg/kg) and SWB Dopływ spod Świdnika (0.40 mg/kg). The lowest values were found in the SWB Ciemięga (0.12 mg/kg) and SWB Bystrzyca to the Zemborzycki Reservoir (0.18 mg/kg). Elevated amounts of this metal were observed in the river sections crossing areas covered by soils containing slightly higher levels of antimony, primarily in industrial areas of Lublin city centre. The spatial distribution of antimony in aquatic sediments and soils of this area can be illustrated by the example of the Bystrzyca River. The lowest levels of antimony in aquatic sediments are found upstream of the Zemborzycki Reservoir. Downstream of the reservoir, where urbanized areas predominate, the level significantly increases. This probably indicates the accumulation of antimony in bottom sediments as a result of both the deposition of industrial contaminants from the air and surface runoff from urbanized areas.

Surface waters: Plate 63, Table 7

The antimony concentrations in surface waters in the Lublin agglomeration are low, ranging from below 0.05 μg/dm^3 to 2.45 μg/dm^3. The median value is 0.12 μg/dm^3, which is almost twice the median value calculated for European surface waters – 0.07 μg/dm^3 (Salminen et al., 2005), but almost three times lower than the value for waters in the Warsaw agglomeration – median 0.34 μg/dm^3 (Tomassi-Morawiec, 2016). A comparison of all the surface water bodies in this region shows the lowest concentrations of antimony in the SWB Ciemięga waters (median 0.09 μg/dm^3). The increase in the amount of this element in watercourses flowing through urbanized areas – particularly evident in the SWB Bystrzyca from the Zemborzycki Reservoir – indicates the impact of Lublin city and industrial activity on the presence of antimony in surface waters. Also in the case of the Dopływ z Konopnicy, it is clear that the antimony concentrations in water are about twice as low upstream of the village of Lipniak as they are downstream of this village and further towards Czechówka. This is caused by the washing away of contaminants, including those from paved surfaces, from urban areas, by rainwater that is subsequently transported through storm drains. Antimony concentrations in the Czechówka River are typically low upstream of its confluence with the Dopływ z Konopnicy stream. However, downstream of the confluence, the waters of these two watercourses, belonging to the same SWB, have the highest median antimony concentration of all SWBs. The antimony limit value (≤2 μg/dm^3) specified for surface water quality classes I and II (Rozporządzenie..., 2021) was exceeded in only one sample taken from a retention and infiltration reservoir to which rainwater from the S19 expressway is discharged.

Se – SELENIUM

Soils: Plate 64, Table 3

Selenium is dispersed throughout the Earth's crust, and its concentration in rocks rarely exceeds 0.5 mg/kg. In soils, it is generally found at concentrations of between 0.2 and 0.6 mg/kg (Kabata-Pendias, Pendias, 1999).

Almost 90% of all soil samples collected in the Lublin region contain less than 2 mg/kg of selenium, which is below the method's determination limit (2 mg/kg), with the highest concentration being 10 mg/kg. These results are consistent with the measurements made for Poland's agricultural soils in European studies – median 0.3 mg/kg (Pasieczna, Markowski, 2014). In the study area, the highest selenium concentration was found in a sample taken from a bog in the Bystrzyca River valley, to the south-west of the Zemborzycki Reservoir. The same sample also showed the highest levels of TOC (34.7%), molybdenum (15.41 mg/kg) and sulfur (0.726%), as well as high concentration of uranium (6.16 mg/kg) when consider its levels in the Lublin area. Peaty soils typically exhibit the highest median selenium value (3 mg/kg) and the maximum selenium concentration across the research area. Elevated amounts of this element in marshy areas may be due to the binding of this element by organic matter (Kabata-Pendias, Szteke, 2012). In peats, selenium may be stabilized as a result of the formation of selenides and selenium sulfides (Kabata-Pendias, Pendias, 1999).

Aquatic sediments: Plate 64, Table 5

The selenium concentration in aquatic sediments of the study area ranges from below 2 mg/kg to 8 mg/kg (median is below the determination limit – 2 mg/kg). The only exception is sediments in the SWB Dopływ spod Świdnika, which stand out with a median value of 4 mg/kg. Sediments with elevated concentrations of selenium occur in areas rich in organic matter. The highest concentration (8 mg/kg) was measured in a sample taken from the Ciemięga River (also known as the Krężniczanka) in the village of Krężnica Jara. The sediment collected from this location also had the highest amounts of manganese (3530 mg/kg) and strontium (445 mg/kg), as well as high levels of TOC (18.9%), barium (131 mg/kg), iron (1.88%), nickel (29 mg/kg), phosphorus (0.356%), sulfur (0.628%), vanadium (20 mg/kg), molybdenum (3.76 mg/kg) and uranium (1.16 mg/kg).

Surface waters: Plate 65, Table 7

As with soils and sediments, selenium concentrations in surface waters in the Lublin agglomeration are low (from below 2 μg/dm^3 to 9 μg/dm^3). For approximately 95% of water samples, the results obtained do not exceed the determination limit of the analytical method – 2 μg/dm^3. There was no variation in selenium levels in waters of the individual SWBs. Similarly low concentrations of selenium were recorded in stream waters of Poland during the international project FOREGS (Salminen, 2005).

SiO_2 – SILICA

Surface waters: Plate 66, Table 7

The weathering of minerals is the main source of silicon in inland waters. Surface waters in Poland have varying concentrations of silica. The highest values, above 14 mg/dm^3, were recorded in south-eastern Poland (including the Lublin Upland). The likely cause of high concentrations of silica in water is the intensive leaching of sandy soils and geological substrates. Poland's soils contain some of the highest amounts of silica in Europe, mostly above 72% (De Vos, Tarvainen (eds.), 2006).

The silica concentrations in surface waters in the study area range from 0.5 mg/dm^3 to 38.0 mg/dm^3, with a median of 24.7 mg/dm^3. Similar results were obtained during the implementation of the *Geochemical Atlas of Poland*. The median, calculated based on archival data selected for the Lublin area and environs, was 22.2 mg/dm^3. The average concentration of silica in surface waters of Lublin, as determined both in the 1990s and during this study, is about double those calculated for waters from the entire territory of Poland – median 12.5 mg/dm^3 (Lis, Pasieczna, 1995) and from the Warsaw agglomeration – 9.6 mg/dm^3 (Tomassi-Morawiec, 2016). The probable source of the elevated concentrations of silica in the study area is bedrock (gaizes and decalcified opokas) containing significant amounts of amorphous silica, whose solubility under natural conditions exceeds that of quartz by a factor of 20 (Macioszczyk, 1987). The highest silica concentrations (median 33.5 mg/dm^3) were found in the SWB Dopływ spod Świdnika. Elevated concentrations of this parameter may result from both natural and anthropogenic factors. The Dopływ spod Świdnika stream flows through the Świdnik Plateau, which is composed of Upper Cretaceous opokas and marls, as well as Palaeogene gaizes with marl and limestone interbeds, generally occurring at relatively shallow depths (Chodorowski et al., 2024). The proximity of the airport at Świdnik, WSK PZL-Świdnik, and an oil and natural gas mine may also affect the chemical condition of the stream water, as indicated by elevated levels of other chemical parameters, including calcium, bicarbonates, chlorides, nickel, sulphate (VI) ions and total suspended solids. The lowest median silica concentration (10.8 mg/dm^3) was recorded in water samples collected from a number of watercourses and small reservoirs within the SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth.

Sn – TIN

Soils: Plate 67, Table 3

Tin is one of the poorly mobile elements in the environment. Its higher amounts are found in clay rocks (6–10 mg/kg), while significantly lower levels are recorded in sandy and carbonate rocks –approximately 0.5 mg/kg (Kabata-Pendias, Pendias, 1999; Reimann et al., 2003). Released from mineral structures during weathering processes, it is sorbed by clay minerals, iron and aluminium oxides, and organic matter. This results in its secondary accumulation in sediments and coals, where tin concentrations can reach 2.3 mg/kg (Llorens et al., 2000). Significant sources of environmental tin contamination include the combustion of coal and waste, industrial wastewater discharges, the production of tinplate and solder alloys (Sn-Pb), as well as the production of plastics, dyes, pesticides and wood preservatives (Paulo, Strzelska-Smakowska, 1994; Pasieczna, 2012).

The tin concentration in the study area soils ranges from below 0.5 mg/kg to 17.7 mg/kg, and the median calculated for the entire set of samples is 0.6 mg/kg. There is no variation in the tin concentration in sandy, loamy and silty soils (all medians are ca. 0.6 mg/kg). Soils in the southern and north-eastern parts of the area typically show the lowest concentrations of tin. In contrast, soils in Lublin city centre, particularly in industrial and densely built-up areas, are enriched in this element. Soil samples taken from gardens also have elevated concentrations of tin (median 1.2 mg/kg). The spatial distribution of tin concentration in the study area soils is similar to those of silver, zinc and arsenic concentrations. The highest amounts of this metal in soil (17.7 mg/kg) were found at point locations near industrial plants and railway line No. 68, in the south-western part of Lublin in the Wrotków quarter. Elevated anthropogenic tin concentrations were observed in the topsoil layer in the central and north-eastern parts of the city, in the quarters of Kośminek, Bronowice and Tatary. These areas have been industrial zones since the mid-19th century, and home to numerous manufacturing, production and processing plants. The area around the WSK PZL-Świdnik company is also notable for its high concentration of tin, with a maximum recorded value of 6.7 mg/kg. The median calculated for the industrial soils is 1.1 mg/kg, which is slightly higher than the median calculated for soils in areas with high-rise (0.9 mg/kg) and low-rise (0.7 mg/kg) urban development, and in rural areas (0.6 mg/kg). The medians obtained for soils in undeveloped areas and cultivated land are at the same level (0.5 mg/kg). Soils of large, compact forest complexes extending in the south-western and southern parts of Lublin within its administrative boundaries, are also characterized by low concentrations (median below 0.5 mg/kg). The median tin concentrations currently recorded for cultivated land (0.5 mg/kg) and meadows (0.7 mg/kg) in the Lublin region are slightly higher than those measured for Polish agricultural soils. The international GEMAS project determined the median concentrations of tin in cultivated land and meadows to be 0.36 mg/kg and 0.42 mg/kg, respectively (Reimann et al. (eds.), 2014).

Aquatic sediments: Plate 67, Table 5

The tin concentration in aquatic sediment samples collected in the study area ranges from below 0.5 mg/kg to 10.9 mg/kg (median 0.9 mg/kg), which is similar to the level found in soils of Lublin and environs. The spatial distribution of tin concentration in the aquatic sediment samples indicates elevated levels of this metal in the Bystrzyca and Czechówka rivers in highly urbanized and industrialized areas. The median tin concentrations calculated for the aquatic sediment samples are 2.7 mg/kg for the SWB Bystrzyca from Zemborzycki Reservoir to river's mouth, and 1.2 mg/kg for the SWB Czechówka. The maximum tin concentration was recorded in a sample taken from the SWB Bystrzyca from Zemborzycki Reservoir to river's mouth, in the river's stretch flowing through the Tatary quarter. The likely source of tin, chromium and nickel emissions is runoff from the storm-water drainage system in the Tatary quarter.

Surface waters: Plate 68, Table 7

Surface waters in the Lublin region are characterized by very low concentrations of tin. Only 17 of the water samples contained more than 0.5 μg/dm^3 of this metal. The water sample with the highest tin concentration (3.9 μg/dm^3) was collected from the Bystrzyca River, on the border between the Tatary and Kalinowszczyzna quarters. Six other water samples, in which the concentrations ranged from 2.7 μg/dm^3 to 3.8 μg/dm^3, were taken from the SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth, and from the SWB Czechówka (one sample). Elevated concentrations of this metal in the surface waters are due to high anthropopression level.

SO_4^{2-} – SULPHATES (VI)

Surface waters: Plate 69, Table 3

Sulphates in surface water originate from natural processes, such as the leaching of soil and rock, as well as from human activity. Significant sources of contamination include the discharge of municipal and industrial wastewater, surface runoff carrying fertilizers from fields, and dust emissions from power plants and other industrial facilities. Poland's waters are characterized by significantly higher sulphate concentrations compared to other regions of Europe (Lis, Pasieczna, 1995). The concentration of sulphates (VI) in surface waters in the study area ranges from below 0.5 mg/dm^3 to 76.9 mg/dm^3, with a median of 27.7 mg/dm^3. This level is almost twice the median for European surface waters – 16 mg/dm^3 (De Vos, Tarvainen (eds.), 2006). By comparing the results of studies on the concentration of sulphate ions in surface waters throughout Poland, it can be concluded that waters from the Lublin region have a median value approximately twice as low as that of Polish waters – median 56 mg/dm^3 (Lis, Pasieczna, 1995) and waters in the Warsaw agglomeration – median 47.5 mg/dm^3 (Tomassi-Morawiec, 2016). The median value is also more than four times lower than that determined for surface waters in Poznań – median 116 mg/dm^3 (Lis, Pasieczna, 2005). The sample containing the maximum concentration of sulphates (76.9 mg/dm^3) was taken from the SWB Dopływ spod Świdnika (in the village of Wólka). Of all the SWBs in the study area, the SWB Dopływ spod Swidnika stands out with the highest median of 66.5 mg/dm^3.

Sr – STRONTIUM

Soils: Plate 70, Table 3

The strontium concentration in soils depends largely on the chemical composition of parent rocks and climatic conditions (Kabata-Pendias and Szteke, 2012). The geochemical properties of strontium are similar to those of calcium, resulting in their co-occurrence in sedimentary rocks and the possibility of mutual substitution in minerals (Kabata-Pendias, Pendias, 1999; Salminen, 2005). On average, calcareous sedimentary rocks contain between 460 and 600 mg/kg of strontium (Kabata-Pendias, Szteke, 2012). However, the strontium concentration in Poland's soils generally does not exceed 10 mg/kg, although values above 30 mg/kg have been found in the Lublin Upland, where the bedrock is composed of carbonates (Lis, Pasieczna, 1995). Strontium can also be introduced into the environment as a result of soil liming (Salminen, 2005). The spatial distribution of strontium in Poland's soils is similar to that of calcium (Lis, Pasieczna, 1995).

The strontium concentration in soils of Lublin and environs ranges from 1 mg/kg to 545 mg/kg, with a median of 18 mg/kg. These levels are similar to those obtained in previous studies in this region, conducted in the 1990s, based on data from the *Geochemical Atlas of Poland* (Lis, Pasieczna, 1995). Compared to the median strontium value of 11 mg/kg for soils in the Warsaw agglomeration (Tomassi-Morawiec, 2016), the median value for soils in Lublin is about 60% higher. Forest soils are poor in this element (median 4 mg/kg). Undeveloped areas (median 9 mg/kg), cultivated land (median 10 mg/kg) and rural housing areas (median 14 mg/kg) also contain small amounts of strontium (median 9 mg/kg). In contrast, peaty soils (median 103 mg/kg), as well as anthropogenic and industrial soils (both with a median of 55 mg/kg), are enriched in strontium. Elevated concentrations were recorded mainly in Lublin city centre (in the Tatary and Bronowice quarters), near the Perła-Browary Lubelskie brewery, to the south of the Hajdów Wastewater Treatment Plant, and in Świdnik. This suggests that anthropopression, particularly factors related to urbanization, construction, and industrial activity, has a significant impact on the presence of strontium in the soils. Coal combustion is a common source of this metal in the Earth's surface environments (Pasieczna, 2003).

Aquatic sediments: Plate 70, Table 5

When considering aquatic sediments throughout Poland – median 20 mg/kg (Lis, Pasieczna, 1995), it is evident that sediments in the Lublin region are distinguished by a higher concentration of strontium (median 89 mg/kg). The highest levels of this element were found in sediments from the SWB Dopływ spod Świdnika (median 203 mg/kg), SWB Czerniejówka (median 143 mg/kg) and SWB Bystrzyca from the Zemborzycki Reservoir (median 131 mg/kg). These SWBs have also elevated levels of calcium. The remaining surface water bodies are characterized by significantly lower levels of strontium (the median for each of them is below that calculated for the entire set of water samples). Generally, lower levels of strontium were recorded in sediments from watercourses and reservoirs located to the west of Lublin. This is probably due to the lower concentration of this element in the region's soils. When the spatial distribution of strontium

concentration in stream sediments across European countries is examined, it is evident that aquatic sediments from Poland and the Lublin region are characterized by low levels of this metal. The median value for European stream sediments was 124 mg/kg (Salminen et al., 2005).

Surface waters: Plate 24, Table 7

The strontium concentration in Lublin's waters ranges from 0.032 to 1.618 mg/dm³. The median value calculated for surface waters in Lublin and environs is 0.664 mg/dm³, approximately three times higher than the value for Polish waters – 0.243 mg/dm³ (Lis, Pasieczna, 1995) and the value for Warsaw's waters – 0.202 mg/dm³ (Tomassi-Morawiec, 2016). This element's presence in the survey area waters is attributed primarily to the presence of calcite-bearing parent rocks (Salminen et al., 2005). The highest median value was recorded in waters of the SWB Dopływ spod Świdnika (1.248 mg/dm³). Elevated levels were also observed in the SWB Czerniejówka (median 0.860 mg/dm³) and SWB Bystrzyca from the Zemborzycki Reservoir (SWB (median 0.633 mg/dm³). The spatial distribution of strontium in the waters corresponds to the distribution of this element in sediments. Both the sediments and waters of the Łazęga, Czechówka and Dopływ z Konopnicy, flowing in the area west of Lublin, are characterized by lower concentrations of strontium. Relatively low concentrations of strontium in surface waters in this part of the study area may be due to the presence of strontium in the form of poorly soluble carbonates.

Ti – TITANIUM

Soils: Plate 72, Table 3

In the Earth's crust, titanium is found mainly in alkaline volcanic rocks and, to a lesser extent, in sedimentary rocks. The content of titanium in Poland's soils ranges from 0.1% to 0.6%. Its lowest levels are found in sandy soils, ranging from 0.02% to 0.24% (Kabata-Pendias, Pendias, 1999).

Soils in the Lublin area and environs contain between 19 mg/kg and 530 mg/kg of titanium. The median concentration of this element in the study area soils (111 mg/kg) is more than twice that in Warsaw's soils – 46 mg/kg (Tomassi-Morawiec, 2016) and higher by a factor of 1.5 than in Poznań – 84 mg/kg (Lis, Pasieczna, 1995). Elevated levels of titanium were observed in the north-western, central and eastern regions of the research area. The spatial distribution of titanium in the soils is similar to that of potassium and vanadium, supporting its geogenic origin. Loamy soils (median 133 mg/kg) and anthropogenic soils (median 130 mg/kg) are characterized by a significantly higher titanium concentration than peaty soils (median 50 mg/kg) and sandy soils (63 mg/kg). The maximum concentration of the element (530 mg/kg) was found in a sample taken from a lawn next to an asphalt road in the Piaski area (north-west of the Lublin-Wrotków Heat and Power Plant), and is likely to be related to emissions from the plant. It should be noted that the titanium concentration in soil samples collected from lawns is similar (median 137 mg/kg) to that found in soil samples taken from both high-rise and low-rise urban areas (medians 143 mg/kg and 127 mg/kg, respectively). Elevated levels of titanium in these areas may be of anthropogenic origin. A significant source of this metal's emissions is the leaching of paints used to cover building facades by precipitation. These paints contain titanium (IV) oxide, which increases their resistance to UV radiation, weather conditions, abrasion and dirt. Slightly lower concentrations of titanium, with a median of 119 mg/kg, are typically observed in the industrial areas. The widespread use of titanium, mainly in the aerospace, automotive, construction, paper, pharmaceutical, medical and cosmetics industries, may affect its presence in topsoil (Dudek et al., 2016; Gruszka, 2023). In the past, titanium may have also been introduced into soils alongside wastewater sludge used for fertilization purposes (Gruszka, 2023). Lower amounts of the element were recorded in the southern and north-eastern parts of the study area, where there are low-quality soils with lower agricultural suitability. Forest soils exhibit one of the lowest median titanium values of 59 mg/kg. The present results of titanium concentrations in soils of cultivated land (median 100 mg/kg) and meadows (95 mg/kg) in the Lublin region are approximately twice those recorded in agricultural soils of Poland, determined in the GEMAS project. The median values were 45 mg/kg for cultivated land and 44 mg/kg for meadows (Reimann et al. (eds.), 2014).

Aquatic sediments: Plate 72, Table 5

The titanium concentration in aquatic sediments (12–426 mg/kg) in the Lublin region is similar to the levels found in soils. The median titanium concentration in sediments collected in the research area is 87 mg/kg, which is higher than the median concentration in the Warsaw agglomeration – 58 mg/kg (Tomassi-Morawiec, 2016) and slightly lower than in the Poznań agglomeration – 105 mg/kg (Lis, Pasieczna, 1995). The maximum concentration of titanium (423 mg/kg) was found in a sample taken from the Czechówka River upstream of its confluence with the Bystrzyca River and downstream of Lublin's Old Town, in the area of allotment gardens. The highest median value (131 mg/kg), exceeding the median value of all tested sediment samples by a factor of 1.5, was found for the SWB Czechówka. The higher amounts of titanium in watercourses of the north-western part of the study area are linked with the geological setting of the basement in this region. Elevated levels of titanium (median 112 mg/kg) were also observed in aquatic sediments of the SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth, which is mainly due to urbanization of this area. The lowest concentration of titanium was found in aquatic sediments of the SWB Bystrzyca to the Zemborzycki Reservoir and the SWB Dopływ spod Świdnika. The median values for the two SWBs were similar, at 56 mg/kg and 59 mg/kg, respectively. Catchment areas of these watercourses contain wetlands and peaty soils, which are characterized by the lowest titanium concentrations.

Surface waters: Plate 73, Table 7

Titanium concentrations in surface waters are low, typically not exceeding 10 µg/dm³ (Kabata-Pendias, Pendias, 1999). In the United Kingdom, titanium was found in rivers draining rural, agricultural, urban and industrial areas at levels ranging from 0.55 to 6.48 µg/dm³ (mean value 2.1 µg/dm³), with the highest mean values recorded immediately downstream of wastewater treatment plants. This element may have migrated into surface waters through discharges of treated municipal and industrial wastewater (Solymos, 2024; Gruszka, 2023).

The present research revealed very low concentrations of titanium in surface waters in the Lublin region. Its levels in almost all water samples (with the exception of two) were below the limit of determination of the analytical method (0.002 µg/dm³). Low levels of titanium in the waters are due to the adsorption of titanium compounds onto aquatic sediments. Therefore, it is not transported by the flow of water, but rather accumulates in sediments (Gruszka, 2023). No exceedances of the limit value specified for surface water quality classes I and II for indices from the group of specific contaminants have been found, which is ≤0.05 mg/dm³ for titanium (Rozporządzenie…, 2021).

Tl – THALLIUM

Soils: Plate 74, Table 3

Thallium exhibits both chalcophilic and lithophilic properties, and it is bound primarily by iron and manganese hydroxides, as well as by clay minerals and organic matter (Salminen et al., 2005; Kabata-Pendias, Mukherjee, 2007; Kabata-Pendias, Szteke, 2012). Thallium is often found in dust emitted by cement plants, and in coal dust (Kabata-Pendias, Pendias, 1999). It is assumed that the limit value indicating the possibility of soil contamination with thallium is 1 mg/kg (Kabata-Pendias, Szteke, 2012).

The spatial distribution of thallium in soils of the Lublin agglomeration indicates low and invariable amounts of this element. The measured values range from below 0.05 mg/kg to 0.34 mg/kg. The median thallium concentration in the tested soils (0.10 mg/kg) is more than six times lower than the median value obtained for European soils – 0.66 mg/kg (Salminen et al., 2005). In the study area, slightly higher thallium concentrations were recorded in soil samples collected from parks (median 0.11 mg/kg). The lowest concentrations of the element were measured in sandy and peaty soils, as well as in forests (median 0.08 mg/kg). Elevated concentrations of thallium were found in the area surrounding the Megatem EC-Lublin SA combined heat and power plant, suggesting the influence of anthropogenic sources (e.g. coal combustion). Thallium levels above the 75th percentile (0.11 mg/kg) were recorded across a fairly large area in the west of the region, primarily outside the administrative boundaries of Lublin. This is most likely due to the presence of loess that shows natural ability to accumulate thallium in clay minerals.

Aquatic sediments: Plate 74, Table 5

The thallium concentration in the tested samples ranges from below 0.05 mg/kg to 0.24 mg/kg. The median thallium concentration in aquatic sediments from Lublin and environs is 0.07 mg/kg. This is over five times lower than the value obtained for stream sediments in Europe – 0.39 mg/kg (Salminen et al., 2005). The thallium concentration in 31% of the sediment samples was below the limit of determination of the analytical method (0.05 mg/kg). The highest median concentrations were found in sediments from the SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth and from the SWB Czechówka (0.08 mg/kg).

Surface waters: Plate 75, Table 7

Thallium concentration in surface waters of the Lublin agglomeration is very low. With the exception of one sample, all concentrations are below the limit of determination of the analytical method (0.05 µg/dm³). For comparison, the median value for this element in European stream waters was even lower – 0.005 µg/l (Salminen et al., 2005). The thallium concentrations measured in Warsaw's surface waters did not exceed 0.24 µg/dm³ (Tomassi-Morawiec, 2016). No variation in thallium levels was observed in surface waters of the study area. The limit value for surface water quality classes I and II, which is 2 µg/dm³ for thallium, has not been exceeded in any case (Rozporządzenie…, 2021).

U – URANIUM

Soils: Plate 76, Table 3

Uranium concentration in the topsoil layer in Poland generally does not exceed 2 mg/kg (the highest recorded result is 13.3 mg/kg). In the Lublin region, the concentration ranges from 1 to 3 mg/kg, and the presence of uranium is associated with the loess cover underlain by carbonate rocks (Strzelecki et al., 1993). A similar level of uranium concentration in Poland's soils was presented in the *Geochemical Atlas of Europe* (De Vos, Tarvainen (eds.), 2006).

Soil samples collected from the Lublin region are characterized by a uranium concentration ranging from 0.13 mg/kg to 8.73 mg/kg (median 0.66 mg/kg). Approximately 98% of the tested samples have a uranium concentration of less than 1.21 mg/kg. Sandy soils contain low levels of uranium (median 0.46 mg/kg). The highest concentrations were found in peaty soils, with a median value of 1.45 mg/kg. These soils occur in the form of small patches mainly in the Bystrzyca valley and around the Zemborzycki Reservoir. The maximum concentration of uranium (8.73 mg/kg) was recorded in a peaty soil sample taken from a forest complex near Nowiny in the Ciemięga and Bystrzyca river basins. However, analysis of the obtained data shows that forest soils have the lowest median uranium concentration (0.46 mg/kg) of all the analysed soils.

Considering the land use structure, it was noted that elevated levels of uranium occur only in some areas that have been anthropogenically altered, e.g. in the quarters of Tatary, Wrotków and Abramowice. The main source of uranium enrichment in the soils is the energy industry (specifically coal combustion in combined heat and power plants). There was also a waste disposal site at Abramowice in the early days of the Lublin-Wrotków CHP plant (https://lublin.naszemiasto.pl/zrodlo-ciepla-od-wielu-lat/ar/c3-2957538). Test results show that the amount of uranium in hard coal ranges from 0.1 to 8.5 mg/kg (Bojakowska et al., 2008). It is also present in fly ash produced by coal combustion. In ash without flue gas desulfurization, the uranium concentration ranges from 7.8 mg/kg to 13.2 mg/kg, while in ash after flue gas desulfurization, it is between 5.7 mg/kg and 10.9 mg/kg (Ratajczak et al., 1999). Despite the fact that the soil samples collected in the vicinity of combined heat and power plants exhibit elevated amounts of uranium, the median values for this element in soils from industrial, rural and urban areas are at similar levels and do not differ from the median value obtained for all samples. The lack of clear variation in uranium concentration in soils between rural, urban and industrial areas may be due to the dispersed sources of uranium emissions in these areas. Examples include coal combustion in domestic boilers and the use of fly ash for sprinkling on pavements and access roads to properties in winter (a practice that was commonly used in the past). Furthermore, there is no clear variation in the amount of uranium in soils depending on their use. The results obtained for samples taken from cultivated land (median 0.71 mg/kg) and meadows (median 0.66 mg/kg) in the Lublin region are slightly higher than the uranium concentrations in Poland's soils, determined as part of the international GEMAS project, for which the medians were 0.42 mg/kg for cultivated field soils and 0.51 mg/kg for meadow soils (Reimann et al. (eds.), 2014). The use of phosphate fertilizers in crop cultivation is a significant anthropogenic source of uranium in both soils and aquatic sediments (De Vos, Tarvainen (eds.), 2006). Another anthropogenic factor may be the use of ash to fertilize the soil to improve water migration or change the pH from acidic to alkaline (Piotrowski, Uliasz-Bocheńczyk, 2008).

Aquatic sediments: Plate 76, Table 5

The uranium concentration in aquatic sediments in Lublin and environs varies insignificantly, ranging from 0.12 mg/kg to 3.95 mg/kg, with a median of 0.56 mg/kg. The highest median uranium value (0.79 mg/kg) was found in sediments from the SWB Dopływ spod Świdnika, and the lowest value was calculated for the SWB Ciemięga (0.47 mg/kg). The maximum concentration of uranium was observed in an aquatic sediment sample collected from an unnamed ditch in the SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth. The median uranium concentration in this SWB is 0.62 mg/kg, which is about 50% higher than in the SWB Bystrzyca to the Zemborzycki Reservoir (0.44 mg/kg). The higher uranium concentrations in sediments of the Bystrzyca River in its lower section, which flows near the Lublin-Wrotków Heat and Power Plant and the Megatem EC-Lublin, may be related to surface runoff from areas containing higher amounts of this element, which is subsequent accumulated in river's bottom sediments.

Surface waters: Plate 77, Table 7

Uranium is a metal that usually behaves in water differently to other metals because its compounds are generally more soluble under oxidizing and alkaline conditions rich in carbonates than under acidic reducing conditions. Uranium ions tend to form strong associations with organic matter (rich in humic and fulvic acids), iron oxides and dissolved phosphates. The latter cause its co-precipitation with Ca and Pb, as well as Fe oxides. Studies of elemental content in soils, aquatic sediments and stream waters in Europe have shown that higher concentration of uranium in sediments was generally accompanied by its lower concentration in surface waters (De Vos, Tarvainen (eds.), 2006).

The uranium concentration in surface waters in Lublin and environs varies from below 0.05 µg/dm³ to 4.11 µg/dm³. The median uranium concentration for all analysed water samples is 0.83 µg/dm³, and is higher than the median value obtained for waters from the Warsaw area, which is 0.53 µg/dm³ (Tomassi-Morawiec, 2016). In the study area, the highest concentrations of uranium in surface waters were recorded for the SWB Dopływ spod Świdnika (median 3.63 µg/dm³). The relatively high levels of uranium in this SWB may be due to the geological structure of the bedrock, which consists mainly of sandy muds (silts) and loess-like silty sands. There are also minor outcrops of marls rich in clay minerals that exhibit sorption properties and may contribute to the retention of uranium in the soil. The leaching of uranium from soils and its subsequent release into the aquatic environment can result in an increase in the concentration of this element in surface waters (Jęczalik, 1959; Strzelecki et al., 1993; Tomassi-Morawiec, 2016). The SWB Ciemięga waters stand out due to their median uranium value being twice as high as that found in the total population of analysed water samples

V – VANADIUM

Soils: Plate 78, Table 3

Vanadium levels in soils around the world range from 10 mg/kg to 500 mg/kg (Kabata-Pendias, Szteke, 2012). Studies covering European countries have shown that Polish soils are relatively poor in vanadium. Its concentration in uncontaminated soils generally did not exceed 16 mg/kg (De Vos, Tarvainen (eds.), 2006).

The concentration of this element in soil samples collected from the study area ranges from 2 to 36 mg/kg (median 14 mg/kg), which is slightly higher than in soils of the Warsaw and Poznań regions – median 8 mg/kg (Tomassi-Morawiec et al., 2016; Lis, Pasieczna, 2005). The highest concentrations of vanadium in the research area are found in loamy (median 16 mg/kg) and anthropogenic (median 15 mg/kg) soils, while the lowest levels are recorded in peaty (median 11 mg/kg) and sandy (median 9 mg/kg) soils. The presence of vanadium in the soils may be influenced by anthropogenic activities, particularly by the energy, electrical engineering, machinery, and automotive industries, as well as by rail transport (Staisz et al., 2000; Kordowiak, Holko, 2009; Jurek, 2014; Bojakowska, Lech, 2015). Slightly elevated levels of vanadium (above 30 mg/kg) are observed at point locations in industrial areas of Lublin, particularly in the environs of the combined heat and power plant and the Huttenes-Albertus Polska Sp. z o.o. facility. This area was previously home to the metallurgical and automotive industries. Soil samples taken from wasteland and fallow land near the railway tracks to the south of the Megatem EC-Lublin SA combined heat and power plant, contained 30 and 33 mg/kg of vanadium, respectively. The highest concentration (36 mg/kg) was measured in a soil sample taken from allotment gardens in the Rury quarter. Local elevated concentrations of vanadium are also observed in soils of the western part of the map sheet area in the Pietrzakowizna, Szerokie, Dębówka, Barak and Rudnik regions. When the different forms of soil use in Lublin and environs are considered, it is evident that soils from meadows, lawns, fallow land and wastelands are characterized by the highest vanadium levels (median 16 mg/kg). The lowest level was found in forest soils (median 8 mg/kg), which occur in the southern and north-eastern parts of the map sheet. The vanadium concentration determined in the soil sample taken in the village of Świdniczek (in the Wólka municipality, Lublin district) is 18 mg/kg and is similar to the results (10.2–34.8 mg/kg) obtained in 1995–2020 as part of the project *Monitoring of the chemistry of arable soils in Poland* (https://www.gios.gov.pl/chemizm_gleb/index.php?mod=pomiary&p=283). In the study area, vanadium concentrations in soil samples collected from cultivated land (4–23 mg/kg) are similar to those reported in other studies covering arable soils in the Lublin region: 17.71–22.40 mg/kg (Tołoczko, 2020).

Aquatic sediments: Plate 78, Table 5

The vanadium concentration in aquatic sediments from the Lublin region ranges from below 1 mg/kg to 28 mg/kg (median 11 mg/kg). In the vast majority of the samples tested (over 95%), the vanadium level does not exceed 20 mg/kg. The highest concentrations were found in aquatic sediments of the SWB Czechówka and SWB Dopływ spod Świdnika. The median value in both SWBs was the same and amounted to 13 mg/kg. The maximum concentration of vanadium (28 mg/kg) was measured in a sample collected from the Dopływ z Konopnicy (in its upper course) near the village of Konopnica. The surrounding areas consist of wasteland and fallow land. Elevated concentrations of vanadium were also found in sediments of the Czechówka watercourse (near the Lublin Village Open Air Museum, at the confluence of the Czechówka and the Dopływ z Konopnicy stream), which is a left-bank tributary of the Bystrzyca River. The presence of vanadium in these sediments may be linked with anthropogenic contamination and the geological structure of the catchment area (Gierszewski, 2018). Near the confluence with the Czechówka River, the Dopływ z Konopnicy stream channel has been engineered and adapted to drain rainwater (https://lublin.eu/mieszkancy/srodowisko/woda-w-miescie/rzeki-w-miescie/). Moreover, the Czechówka River valley has been for decades the recipient of wastewater from this area of Lublin city (https://teatrnn.pl/leksykon/artykuly/rzeka-czechowka-w-lublinie/).

Surface waters: Plate 79, Table 7

The vanadium concentration in surface waters of Lublin and environs ranges from below 1 µg/dm³ to 5 µg/dm³. The median value is below 1 µg/dm³ and is similar to that for waters in Warsaw (Tomassi-Morawiec et al. 2016). In most of the water samples tested (70%), the vanadium concentration was below the limit of determination of the analytical method used (1 µg/dm³). Localized elevated concentrations of this element were recorded in waters of the SWB Czechówka and SWB Dopływ spod Świdnika. The highest concentration of vanadium was recorded in a sample taken from a pond in the Turek area, in the north-east of the study area on the Bystrzyca River valley wetlands. All of the tested samples meet the standards for surface water quality classes I and II (the vanadium limit value is ≤50 µg/dm³; Rozporządzenie…2021).

TOTAL SUSPENDED SOLIDS

Surface waters: Plate 80, Table 7

The concentration of total suspended solids is one of the basic indicators of surface water quality. Suspended solids transport contaminants and may contain larger amounts of them than aquatic sediments (Barbusiński et al., 2012). They consist of both mineral and organic substances. Suspended solids are an integral part of a properly functioning river ecosystem, significantly influencing the physical and chemical conditions of moving water masses. From a biological point of view, their presence in water also has a direct impact on aquatic ecosystems. Suspended solids transport substances necessary for the proper functioning of entire food chains over long distances. Concentrations of suspended solids in water can vary widely. In lowland rivers and fertile (eutrophic) lakes, ponds, and impounding reservoirs, their concentrations significantly exceed 20 mg/dm³. The highest concentrations of suspended solids in water occur during flood periods, often clearly exceeding 1000 mg/dm³ (Nocoń, 2017).

The concentrations of suspended solids in surface waters of the study area vary, ranging from below 5 mg/dm³ to 156 mg/dm³. Around 14% of the analysed water samples contain less than 5 mg/dm³ of suspended solids. The median calculated for the entire set of samples is 18 mg/dm³, which is almost three times lower than the median value obtained for surface waters in the Warsaw agglomeration – 47 mg/dm³ (Tomassi-Morawiec, 2016). The highest concentration of suspended solids was recorded in a sample taken from a canal near Lipniak in the municipality of Konopnica. It is located within the SWB Czechówka and flows through agricultural land (meadows, pastures and wasteland). In the Lipniak area, this watercourse receives water from, among others, girdling ditches. A few hundred metres from its mouth, the watercourse channel has been engineered to facilitate the drainage of rainwater (https://lublin.eu/mieszkancy/srodowisko/woda-w-miescie/rzeki-w-miescie/). The highest concentrations of suspended solids are found in waters of the SWB Dopływ spod Świdnika (median 42 mg/dm³). This is probably related to the presence of peaty soils in this area. Elevated concentrations of suspended solids (83–67 mg/dm³) were also observed in surface water samples taken from ditches and ponds on wasteland between Rudnik and Trzęśniów. In contrast, relatively low concentrations of suspended solids (from below 5 mg/dm³ to 24 mg/dm³, median 16 mg/dm³) were recorded in water samples taken from the Zemborzycki Reservoir.

Zn – ZINC

Soils: Plate 81, Table 3

The average zinc concentration in Poland's soils is 40 mg/kg. Highest levels are found in brown soils and alluvial soils, while the lowest ones are recorded in podzolic soils and lessive soils (Kabata-Pendias, Pendias, 1999). In arable soils of the Lublin region, the zinc concentrations range from 21.20 mg/kg to 33.50 mg/kg (Tołoczko, 2020).

In Lublin and its environs, the zinc concentration in soils ranges from 4 mg/kg to 1435 mg/kg. The median value is 35 mg/kg, which is similar to that obtained for Poland's soils (Lis, Pasieczna, 1995) and slightly lower than the median determined for Warsaw's soils – 44 mg/kg (Tomassi-Morawiec, 2016). The highest levels of zinc are found in the central part of the study area, in the urbanized areas of Lublin, in the quarters of Kośminek, Bronowice and Old Town, as well as in the industrial areas around Wrotków and Tatary. These areas are characterized by anthropogenic soils, which exhibit zinc concentrations ranging from 17 mg/kg to 1435 mg/kg (median 76 mg/kg). The highest concentration of zinc was found in allotment garden soils on the left bank of the Czerniejówka River, upstream of Abramowice in the upper course of the river. The high median values for allotment garden soils (78 mg/kg), anthropogenic soils (76 mg/kg) and industrial soils (71 mg/kg) indicate a significant anthropopression level influencing the presence of zinc in urban soils. Zinc is introduced into the environment through coal combustion processes, and the application of zinc coatings to steel sheets and iron castings to protect against corrosion, as well as through general emissions from urban and industrial areas. Furthermore, producing and using plant protection products containing this element may increase the amount of zinc in soil, including in allotment gardens (Pasieczna, 2003; Kaszubkiewicz et al., 2011; Tomassi-Morawiec, 2016). The lowest concentrations of zinc were measured in the southern and north-eastern parts of the study area, where there are forests, arable fields and meadows. Soils of the forest complexes are distinguished by the lowest median zinc value (16 mg/kg). The soil sample taken in the village of Świdniczek (in the Wólka municipality, Lublin district) contained 93 mg/kg of zinc. These amounts are approximately twice the average values found in the project *Monitoring of the chemistry of arable soils in Poland* (https://www.gios.gov.pl/chemizm_gleb/index.php?mod=pomiary&p=283). Slightly higher zinc concentrations were recorded in soils collected from arable fields (median 28 mg/kg) and meadows (median 38 mg/kg) of the Lublin region than in agricultural soils and meadows of Poland, which were survyed as part of the GEMAS project and had the median zinc concentrations of 24 mg/kg and 25 mg/kg, respectively (Reimann et al. (eds.), 2014). Approximately 1.4% of the obtained zinc results exceeds 500 mg/kg. A significant amount of the metal was measured in soils collected from lawns, fallow land, and gardens. In the case of aerable soils, none of the analysed samples exceeded the 300 mg/kg limit for soil group I (Rozporządzenie…, 2024).

Aquatic sediments: Plate 81, Table 5

The zinc concentration in aquatic sediments in the Lublin region varies from 1 mg/kg to 510 mg/kg. The median value is 66 mg/kg and is similar to that obtained for sediments in the

Warsaw agglomeration – median 68 mg/kg (Tomassi-Morawiec, 2016). The highest concentration was recorded in a sediment sample collected from the Bystrzyca River (510 mg/kg), upstream of the Hajdów Wastewater Treatment Plant, within the SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth. This SWB also had the highest median zinc concentration (139 mg/kg). Aquatic sediments of the SWB Czechówka also stand out with high levels of this metal (median 74 mg/kg). Some of the highest concentrations (410 mg/kg and 397 mg/kg) were recorded in aquatic sediment samples collected downstream of the Lublin Village Open Air Museum and at the Polfa Lublin S.A. plant. These samples were taken from a ditch near the expressway and a settling tank located on wasteland and fallow land. Due to its widespread use in various industries, zinc is emitted into the environment from many sources (including car tyre abrasion, wastewater discharges and rainwater runoff). The elevated zinc levels were found in the Bystrzyca River where it flows through industrialized and urbanized areas. In turn, the Czechówka River catchment area has received wastewater from this part of Lublin city of (https://teatrnn.pl/leksykon/artykuly/rzeka-czechowka-w-lublinie/). The lowest levels of zinc are found in aquatic sediments of the SWB Ciemięga. The median value is 27 mg/kg.

Surface waters: Plate 82, Table 7

The zinc concentration in surface waters in Lublin and environs ranges from below 0.003 mg/dm³ to 0.096 mg/dm³. The median value calculated for all tested samples is 0.008 mg/dm³ and is higher than the median values for Warsaw and Poznań, which are <0.003 mg/dm³ and 0.006 mg/dm³, respectively (Lis, Pasieczna, 2005; Tomassi-Morawiec, 2016). The amount of zinc in 30% of the samples analysed was found to be below the limit of determination of the analytical method used (0.003 mg/dm³). Elevated concentrations of zinc were recorded in waters of the SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth (median 0.025 mg/dm³) and the SWB Czechówka (median 0.011 mg/dm³). The highest concentration of zinc was measured in waters of the Dopływ z Konopnicy stream, which is a tributary of the Czechówka River. The sample was taken in the Lipniak region near the Polfa Lublin S.A. pharmaceutical plant. Elevated levels of zinc were found in samples collected from the area of confluence of the Dopływ z Konopnicy and Czechówka River. Relatively high levels of zinc were also recorded in the Tatary industrial quarter, near the Hajdów Wastewater Treatment Plant (Trzęśniów), and in the vicinity of Turka. These may be related to anthropogenic contamination, such as municipal and industrial wastewater discharges, as well as surface runoff within these catchment areas (Lis, Pasieczna, 2005). All surface water samples tested in Lublin and environs meet the standards for surface water quality classes I and II (zinc limit value is ≤1 mg/dm³; Rozporządzenie…, 2021).

ORGANIC COMPOUNDS IN SOILS AND AQUATIC SEDIMENTS

PAHs – POLYCYCLIC AROMATIC HYDROCARBONS

Polycyclic aromatic hydrocarbons (PAHs) are widespread in the natural environment, always occurring in the form of multicomponent mixtures (Teixeira et al., 2024). To date, over a hundred chemical compounds have been identified within the PAH group (Premnath et al., 2021). Their characteristic feature is the presence of two or more aromatic rings in various configurations. Hydrocarbons with the same number of rings are structural isomers that exhibit different chemical, biological, and environmental properties. PAHs are classified as persistent organic contaminants/pollutants (POCs/POPs) due to their high resistance to chemical, biological and photolytic degradation (UNEC, 1998). PAH molecules are hydrophobic, resulting in poor solubility in water and a tendency to adsorb onto solid surfaces (such as atmospheric dust particles, soils, sediments and plants). Compounds with lower molecular weights, comprising up to four benzene rings, are more volatile than those with a greater number of aromatic rings. They degrade more easily in the environment. Less volatile compounds are more likely to bind to airborne particles, enabling them to be transported over longer distances. Compounds with four or more rings are practically non-volatile. They have a long half-life, promoting their accumulation in soils and aquatic sediments, but in the aquatic environment they are metabolized much slower (Bojakowska, Sokołowska, 2003; Bojakowska et al., 2018). The composition of PAH mixtures in various components of the environment is determined mainly by the type of emission source, the volatility of these substances, and their resistance to oxidation and reduction. The mixtures are biodegradable by microorganisms living in soil, sediment and water. The degradation process depends on the type of compound and the environmental conditions (pH, temperature, oxygen content, redox potential of the environment) (Premnath et al., 2021). In urban and industrial areas, PAHs are common contaminants that directly affect the condition of ecosystems and human health (Oliveira et al., 2019, Montano et al., 2025). Due to their proven carcinogenic, mutagenic and toxic properties, as well as their negative impact on living organisms, the US Environmental Protection Agency (USEPA) has included 16 polycyclic aromatic hydrocarbon compounds on its list of priority contaminants to be monitored in various environmental components (USEPA, 2005). The presence of PAHs in the environment is influenced by both natural factors (e.g. forest wildfires, volcanic eruptions, diagenesis of sediments, decomposition of organic matter by microorganisms) and anthropogenic factors. The main anthropogenic sources of these compounds include the combustion of fossil fuels, wood, and biomass; heavy industrial activities related to the processing of coal and crude oil (coking plants and refineries); iron, aluminium and copper smelters; road transport (exhaust fumes, tire and asphalt abrasion); the uncontrolled burning of various types of waste; and accidental spills of oil and liquid fuels resulting from industrial or mining accidents. The quantitative and qualitative composition of PAH mixtures depends on the type of fuel or organic material that is combusted, as well as the conditions under which the combustion takes place. A serious problem is the presence of exhaust fumes and dust from low-emission sources. These are formed due to incomplete combustion at relatively low temperatures, which favours the production of increased amounts of PAHs (Bojakowska, 2003). PAHs that are emitted into the atmosphere can easily spread throughout the environment. As much as 90% of them are deposited in soils, where they can undergo processes such as leaching, sorption, oxidation, photodegradation, and biological degradation. They are also used as intermediates in many technological processes, particularly in the pharmaceutical industry and in the production of plasticisers, thermosetting plastics, photographic materials, pigments, and drying and lubricating agents (Jameson, 2019). The highest contents of PAHs are found in soils near busy roads and in industrial areas (Trapido, 1999). Studies of PAHs in soil profiles of forest complexes indicate that these substances accumulate mostly in the organic layers of soils due to their affinity for organic matter, and their content decreases with increasing depth. However, no correlation has been found between PAHs accumulation and soil pH or grain size (Chaber, Gworek, 2020). Changes in the amount of PAHs in agricultural soils in Poland over a period of 25 years show a downward trend (Maliszewska-Kordybach i in., 2008; Maliszewska-Kordybach i in., 2009). A decrease in the PAHs content in soils has also been recorded for the Lublin Voivodeship (https://www.gios.gov.pl/chemizm_gleb/index.php?mod=pomiary&p=283). This is evidenced by data obtained as part of the arable soil quality monitoring carried out between 1995 and 2020. At the measurement point in Świdniczek, the sum of 13 PAHs content recorded in six soil-testing cycles ranged from below 25.0 µg/kg to 517.3 µg/kg. According to the results of the latest monitoring cycle, the concentration of each of the PAHs detected in the soil at this location was below 25 µg/kg. Measurements of the concentration of 16 PAH compounds in Lublin city soils, conducted by Baran and Oleszczuk (2001), showed that they were less contaminated with PAHs than soils in other cities in Poland and around the world. Those authors identified transport as the main source of contamination in the Lublin agglomeration. The dominant compounds were two-, three- and four-ring hydrocarbons (naphthalene, phenanthrene, fluoranthene, fluorene and pyrene). High concentrations of these substances (Σ16PAHs in the range of 3039.8–3791.5 µg/kg) were recorded in soils near busy streets with limited atmospheric airflow (dense housing and trees). Lower levels (Σ16PAHs in the range of 1381.0–1613.3 µg/kg) were found in open areas, where contaminants can disperse over longer distances (Chaber, Gworek, 2020). Other studies also confirm the significant impact of transport on the presence of PAHs in urban soils (Bojakowska et al., 2018).

Soils: Plates 83–99, Table 4

During the development of the *Geochemical Atlas of Lublin and Environs at a scale of 1:50,000*, concentrations of 17 organic compounds belonging to the PAH group were measured in 237 soil samples collected in 2023 (Table 2). The concentrations of individual PAHs vary significantly, ranging from less than 1 µg/kg to 10,000 µg/kg. Taking the median values of individual compounds into account, which were calculated for the entire population of analysed samples, it was found that the most abundant compound was fluoranthene (median 54 µg/kg). For the other compounds, the medians are as follows: pyrene – 45 µg/kg, benzo(a)pyrene – 37 µg/kg, benzo(b)fluoranthene – 36 µg/kg, phenanthrene – 31 µg/kg, benzo(e)pyrene – 30 µg/kg, benzo(a)anthracene – 28 µg/kg, chrysene – 28 µg/kg, indeno(1,2,3-c,d)pyrene – 28 µg/kg, benzo(g,h,i)perylene – 26 µg/kg, benzo(k)fluoranthene – 15 µg/kg, perylene – 6 µg/kg, dibenzo(a,h)anthracene – 6 µg/kg, anthracene – 3 µg/kg, fluorene – 3 µg/kg, acenaphthene – 1 µg/kg and acenaphthylene – 1 µg/kg. Similar levels of the individual PAHs were observed in Warsaw's soils (Tomassi-Morawiec, 2016). As illustrated on the geochemical maps, the spatial distributions of individual PAH compounds in soils of Lublin and its environs are similar (Plates 83–99). This suggests that the same potential anthropogenic factors are expected to affect the presence of each compound in the environment. A characteristic feature is the presence of elevated levels of individual PAH compounds in four areas: between Bronowice and Kośminek (in Lublin city centre), on the border between Głusk and Wólka Abramowicka, between Sławin and Sławinek, and in the environs of Franciszków (Świdnik). The median concentration of Σ17PAHs for the entire set of soil samples is 383 µg/kg, which is less than half the concentration measured in Warsaw's soils – 818 µg/kg (Tomassi-Morawiec, 2016). No influence of lithology on the presence of PAHs in Lublin agglomeration's soils is observed. The median values of Σ17PAHs in loamy, sandy and silty soils are 252 µg/kg, 369 µg/kg, and 214 µg/kg, respectively. The highest concentrations of Σ17PAHs were recorded in industrial soils (median 1644 µg/kg) and anthropogenic soils (median 1310 µg/kg). Significantly elevated PAH concentrations were found in soils from urban areas with high-rise (median Σ17PAHs 1282 µg/kg) and low-rise (median Σ17PAHs 799 µg/kg) housing, compared to rural areas (median Σ17PAHs 345 µg/kg). The lowest amounts of PAHs were measured in forest soils (median Σ17PAHs 137 µg/kg), as well as in soils from undeveloped (median Σ17PAHs 161 µg/kg) and cultivated (median Σ17PAHs 178 µg/kg) areas. None of the compounds exceeded 200 µg/kg in soil samples from forest areas. To assess the degree of contamination of topsoil (from a depth of 0.00–0.25 m) with PAH compounds, the results were compared with the permissible values specified in the Regulation of the Minister of the Environment on the method of assessing soil contamination (Rozporządzenie..., 2024). The maximum concentration of Σ17PAHs (64,823 µg/kg) was measured in a loamy soil sample taken from fallow land and wasteland. The sampling site is located in a rural area near provincial road No. 835 and a company that rents out tow trucks and trailers (in the Abramowice quarter). Two soil samples collected in 2023 from parks in the Lublin agglomeration showed concentrations of Σ17PAHs several times higher (4673 µg/kg and 6458 µg/kg) than the value measured for the soil from Saski Park in Lublin city centre, obtained over 20 years ago (the Σ13PAHs concentration was 888.8 µg/kg at that time; Baran, Oleszczuk, 2001). The likely cause of the increase in the amount of PAHs is the more intense car traffic in recent years compared to the period when the earlier studies were conducted. In the entire set of analyzed soil samples, individual PAH content above 1000 µg/kg or 500 µg/kg (for benzo(a)pyrene and dibenzo(a,h)anthracene) was recorded in more than a dozen locations. Benzo(a)anthracene content above 1000 µg/kg was measured in nine soil samples, and benzo(a)pyrene concentrations above 500 µg/kg was detected in 25 soil samples. Only one of these samples was collected from agricultural fields, and the measured benzo(a)pyrene content was 1113 µg/kg, more than twice the permissible value for soil group II (Rozporządzenie..., 2024). Higher amounts of individual PAH compounds were found in anthropogenic soil samples collected from lawns, wasteland and fallow land located within the city area.

Aquatic sediments: Plates 83-99, Table 6

The deposition of dust resulting from the combustion of fossil fuels and biomass is the primary source of PAH emissions in contemporary aquatic sediments (Bojakowska, Sokołowska, 2003). PAH concentrations in sediments are significantly higher than in water due to their low solubility and high affinity for organic matter. In uncontaminated river sediments in Poland, the mean concentration of Σ17PAHs did not exceed 1000 µg/kg, while in lake sediments, which are much richer in organic matter, the mean concentration of these compounds was 4800 µg/kg (Bojakowska, Sokołowska, 2003).

The levels of particular PAHs in aquatic sediments from the study area range from below 1 µg/kg to 1321 µg/kg. The percentage contribution of the individual PAHs is similar to that in soils. However, the median concentration of Σ17PAHs in sediments in Lublin (1118 µg/kg) is three times higher than the median value calculated for soils. This is also more than twice the value obtained in earlier studies of sediments from the Warsaw agglomeration – 476 µg/kg (Tomassi-Morawiec, 2016). The highest median concentration of Σ17PAHs was recorded for sediment samples collected from the SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth (2209 µg/kg). This is more than twice the median concentration of Σ17PAHs, calculated for all sediment samples (1118 µg/kg). The maximum Σ17PAHs concentration was also recorded in this SWB – 10,223 µg/kg. Sediment samples collected from the upper reach of the Bystrzyca River, in the SWB Bystrzyca to the Zemborzycki Reservoir, are characterized by significantly lower concentrations of PAHs (median Σ17PAHs 38 µg/kg). The variation in PAHs concentration in sediments of this river, which belongs to two different SWBs, is most likely influenced by factors such as the location of industrial and service facilities, road traffic intensity, residential housing density, and the amount of contaminants emitted by these sources. Similar conclusions can be drawn based on the results obtained for sediments from the SWBs Czechówka and Czerniejówka. Sediments from the former contain approximately 100% more PAHs (median Σ17PAHs 1744 µg/kg) than those from the SWB Czerniejówka (median Σ17 PAHs 750 µg/kg). In the survey area, the Czerniejówka River flows mainly through single-family housing areas. In contrast, the surroundings of the Czechówka River consist predominantly of multi-family and collective housing areas for most of its length. There is also a large zone with a population of over 100,000 inhabitants (the Downtown quarter). Therefore, atmospheric precipitation and surface runoff from heavily industrialized and urbanized areas may be significant sources of PAHs in sediments of the Czechówka River. Small amounts of the analysed hydrocarbons (median Σ17PAHs 16 µg/kg) were found in six sediment samples from the Zemborzycki Reservoir. Comparing the PAH results in sediments from watercourses and reservoirs in the study area with the TEC and PEC ecotoxicological risk risk thresholds (MacDonald et al., 2000; Contaminated Sediment Standing Team, 2003) indicates that a negative impact of the contaminants on benthic organisms is expected only in the case of three samples in which the PEC value has been exceeded. One sample contained over 89 µg/kg of acenaphthene, and two others revealed more than 135 µg/kg of dibenzo(a,h)anthracene. In addition, the PAH results for approximately 30% of the samples exceeded TEC ecotoxicological risk thresholds, pointing to their potential negative impact on benthic organisms.

OCPs – ORGANOCHLORINE PESTICIDES

Organochlorine pesticides (OCPs) are synthetic chlorinated hydrocarbons that were widely used as insecticides in agriculture between 1940 and 1960. Due to their very low susceptibility to environmental degradation, toxicity, and ability to accumulate in the food chains of humans and other living organisms (Rajan et al., 2023), their use has been banned in Poland and in many other countries since the 1970s. They have been classified by the Stockholm Convention as persistent organic pollutants. Despite their negative impact on living organisms, some developing countries still produce and use them to protect plants. Some of the pesticides are applied on farmland and plantations in tropical countries, particularly to soils with very low organic matter content, but exposed to strong solar radiation. These compounds subsequently enter the atmosphere and are transported by air masses over long distances towards the poles. With precipitation, they end up in soils of the temperate zone (Ramamoorthy, Ramamoorthy, 1997). The most problematic residues of organochlorine insecticides are p,p'-DDT and its degradation products (p,p'-DDE and p,p'-DDD), hexachlorocyclohexane isomers (α-HCH, β-HCH, γ-HCH, δ-HCH), hexachlorobenzene, heptachlor, aldrin and dieldrin. These are among the most persistent chemicals in soils and aquatic sediments, with half-lives of even more than ten years in these environmental components (Mackay et al., 1997). Another problem in Poland was posed by expired and unusable pesticides, which were placed in pesticide burial sites called *mogilniki*, in the 1960s and 1970s. Around 300 such facilities were created throughout the country at that time. In 1999, the process of closing the sites and disposing of thousands of tonnes of pesticides began. These sites were significant point sources of sediment and groundwater contamination, as confirmed by chemical analyses of water samples taken from the surrounding areas, which revealed exceedances of permissible pesticide concentrations (Wołkowicz, 2010). The organochlorine compounds currently detected in surface water, groundwater, and aquatic sediments should be considered historical pollutants originating from diffuse sources. Because these compounds degrade very slowly under anaerobic conditions, they will continue to be observed in aquatic sediments for many years to come. They can enter the aquatic environment through atmospheric deposition, municipal sewage, and runoff from agricultural fields and orchards (Bojakowska, Gliwicz, 2005). Due to the harmful nature and long half-life of organochlorine pesticides, they are included in the list of substances monitored within the State Environmental Monitoring (SEM). Analyses of residues of these compounds in soil samples taken from agricultural land in Poland in 2015 did not show any exceedances of the permissible levels (Rozporządzenie..., 2024) for α-HCH, β-HCH, γ-HCH, aldrin, dieldrin and endrin. However, 6% of the monitored soil samples demonstrated exceedances of the permissible levels of DDT and its metabolites (DDT/DDD/DDE). The concentrations of these compounds above the permissible level (120 µg/kg) varied between 130 and 480 µg/kg (https://www.gios.gov.pl/chemizm_gleb/index.php?mod=wyniki&cz=I). Research conducted in 2005 on pesticide content in arable soils (within the State Environmental Monitoring) showed that only 50% of the samples met Polish criteria for uncontaminated agricultural soils in the case of the sum of DDT, and 6.5% in the case of γ-HCH (in 2002 the permissible content for γ-HCH was 0.5 µg/kg and for Σ3DDT – 25 µg/kg). The calculated median concentrations were 24.39 µg/kg for Σ3DDT and 2.85 µg/kg for Σ3HCH, with γ-HCH accounting for the largest proportion within the HCH group. The average contents of Σ3DDT and γ-HCH in soil samples collected from 214 sites in various voivodeships varied greatly, and the districts (*powiats*) with the highest average amounts of Σ3DDT were characterized by the lowest average values of γ-HCH (Maliszewska-Kordybach et al., 2014).

DIELDRIN

Soils: Plate 100, Table 4

The concentrations of dieldrin in soils of the Lublin agglomeration are invariable and range from below 0.1 µg/kg to 8.4 µg/kg (median <0.1 µg/kg). Dieldrin was detected only in soils from 15 sites. Its highest concentration was found in a sample collected south of the Hajdów Wastewater Treatment Plant, near a tyre service. This is the only case in which the permissible concentration limit for soil group II is exceeded – 5 µg/kg (Rozporządzenie..., 2024). Slightly elevated concentrations of dieldrin were also observed in industrial areas near Trześniów and Wólka. The concentrations of this pesticide in Lublin soils are lower than in soils of Warsaw, where the maximum concentration was 41.0 µg/kg, and 3% of the results exceeded 3.3 µg/kg (Tomassi-Morawiec, 2016). The present study demonstrates that there are currently no sources of emissions of this compound into the environment in the survey area.

Aquatic sediments: Plate 100, Table 6

The concentration of dieldrin in sediments from the study area ranges from below 0.1 µg/kg to 1.4 µg/kg. This compound was detected in only nine sediment samples, five of which were collected from the SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth. No sample exceeded the TEC value – 1.9 µg/kg (MacDonald et al., 2000; Contaminated Sediment Standing Team, 2003). Comparable levels of dieldrin were obtained for sediments from the Warsaw agglomeration – median below 0.1 µg/kg (Tomassi-Morawiec, 2016).

HEXACHLOROBENZENE

Soils: Plate 101, Table 4

In the study area soils, the hexachlorobenzene concentrations range from below 0.1 µg/kg to 10.8 µg/kg (median below 0.1 µg/kg). Hexachlorobenzene levels do not exceed 1.0 µg/kg in approximately 96% of all soil samples. Elevated levels of this compound and its highest result were found in the Tatary quarter. The highest concentration of hexachlorobenzene was measured in a sample taken from a lawn in a high-rise urban area. Four other samples collected from lawns also show high levels of hexachlorobenzene (above 1.0 µg/kg). The highest median value was obtained in gardens (0.4 µg/kg). This is twice the median value calculated for anthropogenic, high-rise urban and industrial soils (0.2 µg/kg). The elevated levels of hexachlorobenzene in soil samples taken from gardens are probably due to its more intensive use in the past. Conversely, the low levels found in soil samples taken from agricultural areas in Lublin and environs indicate that this compound has been effectively removed through adsorption by crops (Schroll et al., 1994). This compound had many applications not only in agriculture but also in industry. Until the 1970s, hexachlorobenzene was used mainly in agriculture to treat the crop seeds, such as wheat, barley, oats and rye, in order to prevent fungal growth. In industry, it was utilized directly in the production of pyrotechnic materials and tracer bullets, as well as in aluminium production as a flux. In addition, the compound was used as a peptizing agent in the production of nitrocellulose and styrene rubber, which are the basic materials in tyre manufacturing (IARC, 2001).

Aquatic sediments: Plate 101, Table 6

Hexachlorobenzene levels above the limit of quantification (0.1 µg/kg) were found in approximately 57% of all surveyed sediments. The highest result (5.5 µg/kg) was recorded for aquatic sediments from the SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth. The surrounding areas are fallow fields. Aquatic sediments containing above 0.1 µg/kg of this pesticide were found mostly in close proximity to lawns, gardens, wasteland, and fallow land. These areas are predominantly undeveloped or rural. The potential sources of hexachlorobenzene contamination in the sediments include agricultural activities (past use of organochlorine pesticides) and municipal wastewater. As hexachlorobenzene is a persistent pesticide, its biodegradation in soil takes a relatively long time (its half-life is measured in decades). Therefore, it can be expected to remain present in sediments long after its use has been discontinued (IARC, 2001).

p,p'-DDT, p,p'-DDE, and p,p'-DDD

Soils: Plate 102, Table 4

The term "DDT and its metabolites" refers to the following compounds: DDT [1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane], DDD [1,1-dichloro-2,2-bis(chlorophenyl)ethylene], and DDE [1,1-dichloro-2,2-bis(p-chlorophenyl)ethane]. The total concentration of p,p'-DDT, p,p'-DDD, and p,p'-DDE (ΣDDT/DDE/DDD) in soils of Lublin and its environs range from 0.1 µg/kg to 391 µg/kg, and the calculated median value for this group of chemicals is 5.3 µg/kg. This is about twice as low as in soils of the Warsaw agglomeration – 10.2 µg/kg (Tomassi-Morawiec, 2016). Higher total concentrations of DDT and its metabolites were found in soil samples collected in the most urbanized central part of Lublin (the Old Town, Bronowice, Kośminek and Piaski areas), on the border between Wólka Abramowicka and Głusk by the Czerniejówka River, and in the environs of Dębówka and Barak in the north-western part of the study area. The highest total concentrations of DDT and its metabolites in the research area were found in soil samples collected from gardens (median 22 µg/kg) and industrial zones (median 13 µg/kg). Their lowest amounts were recorded in samples taken from forests (median 1.5 µg/kg) and meadows (median 2.5 µg/kg). Only three of the soil samples showed a total concentration of DDT and its metabolites that exceeded the permissible concentration of these pesticides for soil group IV, which is 250 µg/kg. In none sample of agricultural soil the content of ΣDDT/DDE/DDD exceeded the permissible level for soil group II – 120 µg/kg (Rozporządzenie..., 2024). The dominant metabolite in about 60% of the analysed samples is p,p'-DDE. In contrast, p,p'-DDT is the prevalent form in only around 10% of soils samples. The observed change in the ratios of p,p'-DDT to p,p'-DDD and p,p'-DDT to p,p'-DDE in soil and the increase in p,p'-DDD and p,p'-DDE content results from the degradation of p,p'-DDT by microorganisms, although DDT metabolism by organisms may occur at different rates in different soils. The low levels of p,p'-DDT in the tested soil samples indicate that there is currently no source of this compounds emission into the soil.

The p,p'-DDT content in soils of Lublin and its environs ranges from below 0.5 µg/kg to 200 µg/kg. The median p,p'-DDT value (1.8 µg/kg) is lower than that measured in the Warsaw agglomeration – 3.0 µg/kg (Tomassi-Morawiec, 2016). The highest median p,p'-DDT concentration was calculated for samples taken from gardens (7.8 µg/kg). High levels of this compound are also found in soils from industrial areas (median 4.1 µg/kg). In contrast, the lowest amounts of the pesticide were recorded in forest soils (below 0.5 µg/kg). Anthropogenic soils are characterized by elevated concentrations of p,p'-DDT (median 2.7 µg/kg), compared to sandy, loamy and silty soils (medians of 1.3 µg/kg, 1.4 µg/kg, and 1.5 µg/kg, respectively). The p,p'-DDE concentration ranges from 0.1 µg/kg to 130 µg/kg (median 2.7 µg/kg). The highest levels of p,p'-DDE were found in soil samples collected from gardens (median 11 µg/kg) and industrial areas (median 6.3 µg/kg). The lowest median values of this compound were calculated for meadows and forests (1.0 µg/kg). Rural soils exhibit higher levels of p,p'-DDE (median 3.9 µg/kg) than soils from areas with high-rise urban development (median 2.7 µg/kg). In the reseach area, the p,p'-DDD concentration in soils ranges from below 0.1 µg/kg to 81 µg/kg (median 0.8 µg/kg). The median p,p'-DDD value in soils of Lublin and its environs is more than twice that in Warsaw agglomeration soils – 1.7 µg/kg (Tomassi-Morawiec, 2016). As with DDT and DDE, the highest concentrations of p,p'-DDD were found in soil samples from gardens (median 2.8 µg/kg) and industrial areas (median 2.2 µg/kg). The lowest median values were calculated for soil samples taken from forests (0.3 µg/kg) and undeveloped areas (0.6 µg/kg).

Aquatic sediments: Plate 102, Table 6

The total concentration of p,p'-DDT, p,p'-DDD and p,p'-DDE in aquatic sediments in the Lublin agglomeration ranges from 0.1 µg/kg to 40 µg/kg, and the median value is 5.1 µg/kg. This figure is approximately twice the median obtained for sediments from the Warsaw area – 2.7 µg/kg (Tomassi-Morawiec, 2016). The highest median value of ΣDDT/DDE/DDD was calculated for sediments of the SWB Bystrzyca to the Zemborzycki Reservoir (median 6.2 µg/kg), while the lowest one was found in the SWB Bystrzyca upstream of the reservoir (median 0.3 µg/kg). The maximum ΣDDT/DDE/DDD concentration was determined in a sample taken from

the Czerniejówka River. The total concentration of DDT and its metabolites was the sum of p,p'-DDE, p,p'-DDD and p,p'-DDT, which were 22 µg/kg, 16 µg/kg, and 2.0 µg/kg, respectively. The TEC value of 5.3 µg/kg for ΣDDT/DDE/DDD was exceeded in 24 sediment samples. No sample exceeded the PEC value of 572 µg/kg (MacDonald et al., 2000; Contaminated Sediment Standing Team, 2003).

The concentration of p,p'-DDT ranges from below 0.5 µg/kg to 3.8 µg/kg (median below 0.5 µg/kg). A slightly higher median p,p'-DDT value was recorded for sediments from the SWB Bystrzyca to the Zemborzycki Reservoir (1.3 µg/kg). In the other SWBs, the median is below 0.5 µg/kg. No exceedances of the ecotoxicological risk indices (TEC and PEC) were recorded for p,p'-DDT. The p,p'-DDE concentrations are slightly higher than the p,p'-DDT concentrations, ranging from 0.1 µg/kg to 22 µg/kg. The median p,p'-DDE value (3.1 µg/kg) is almost three times higher than that recorded for sediments in Warsaw – 1.1 µg/kg (Tomassi-Morawiec, 2016). The lowest levels of p,p'-DDE were recorded in sediments from the SWB Bystrzyca to the Zemborzycki Reservoir (median 0.3 µg/kg), while the highest levels were found in the SWB Czechówka (median 3.8 µg/kg). Referring the obtained results to ecotoxicological risk indices revealed that p,p'-DDE levels exceeded the TEC value (3.2 µg/kg) in 24 sediment samples. The PEC value (31 µg/kg) has not been exceeded at any location (MacDonald et al., 2000; Contaminated Sediment Standing Team, 2003). The p,p'-DDD concentration (ranging from below 0.1 to 16 µg/kg) is similar to that of p,p'-DDE. The median p,p'-DDD value for all of the sediments is 1.1 µg/kg, which is comparable to the median value for sediments in Warsaw – 0.8 µg/kg (Tomassi-Morawiec, 2016). When considered by individual SWBs, the SWB Czechówka has the highest median value (1.8 µg/kg), while the SWB Bystrzyca to the Zemborzycki Reservoir shows the lowest value (0.1 µg/kg). The TEC index value of 4.9 µg/kg for p,p'-DDD was exceeded in 31 aquatic sediment samples. No exceedances of the PEC index value of 28 µg/kg were recorded, above which harmful effects on aquatic organisms are expected (MacDonald et al., 2000; Contaminated Sediment Standing Team, 2003).

HEXACHLOROCYCLOHEXANE

Soils: Plate 103, Table 4

Within the study area, only seven soil samples contained small amounts of hexachlorocyclohexane isomers. For 97% of all soil samples analysed, the concentrations of HCH isomers (α-HCH, β-HCH, γ-HCH, δ-HCH) were below the limit of determination of the analytical method used (0.5 µg/kg). It is likely that the compound was not widely used in the study area previously. Its sporadic presence in the soils may be due to past use of this insecticide in some households. The maximum ΣHCH value (5.8 µg/kg) was found in a sample taken near a building belonging to the former Ursus SA plant in the Tatary industrial quarter. This sample contained two isomers: α-HCH (2.5 µg/kg) and β-HCH (3.3 µg/kg). The measured level was three times higher than the maximum permissible concentration 1 µg/kg for soil group I only in the case of β-HCH (Rozporządzenie..., 2024). These results are comparable with the data obtained for Warsaw's soils (Tomassi-Morawiec, 2016).

Aquatic sediments: Plate 103, Table 6

Single HCH isomers were identified in only three sediment samples. Two of them were collected from the SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth, and one from the SWB Czerniejówka. The highest single result (1.9 µg/kg) was measured for γ-HCH in a sediment sample collected near the Hajdów Treatment Plant. The TEC index value for γ-HCH – 3 µg/kg has not been exceeded in any sample (MacDonald et al., 2000; Contaminated Sediment Standing Team, 2003). Based on these studies, it can be concluded that neither sediments nor soils are contaminated with HCH compounds in the Lublin region. The measured concentrations are at the same level as those recorded for sediments from the Warsaw agglomeration (Tomassi-Morawiec, 2016).

PCBs – POLYCHLORINATED BIPHENYLS

Polychlorinated biphenyls (PCBs) are a group of organic compounds that are classified as persistent organic pollutants (POPs). There are over 200 congeners, of which around 130 can be found in environmental samples. None of these occurs naturally in the environment (Pycia, Jaworska, 2017; Ficek, Czupioł, 2013). Due to their durability, non-flammability, lipophilicity, and very poor solubility in water, PCBs were used in the production of, among others, plastics, plasticizers, paints, varnishes, lubricants, transformers, and electrical system coolants. Their production and use was discontinued after their negative impact on human health (carcinogenicity and immunosuppression) was discovered, but they may still be found in some existing devices and products (Migaszewski, Gałuszka, 2017; Bojakowska, Gliwicz, 2005). PCBs can be released into the environment as a result of fires and leaks, for instance from transformers and capacitors, or from landfills. The improper storage of used industrial oils or the use of inappropriate disposal processes can also contribute to the accumulation of these compounds in ecosystems. PCBs can spread throughout the environment via precipitation and water runoff from contaminated areas, or through industrial and municipal wastewater (Pycia, Jaworska, 2017).

Soils: Plate 104, Table 4

Soil samples collected from the study area were tested for the content of seven PCB congeners: 28, 52, 101, 118, 138, 153, and 180. The concentrations of individual polychlorinated biphenyls ranged from below 0.1 µg/kg to 28 µg/kg. The highest level was found for PCB28 in an anthropogenic soil sample taken from a garden in an urban area near the village of Trześniów. This is the only site where the amount of PCB28 congeners is higher than the permissible concentration for soil groups I, II and III – 20 µg/kg (Rozporządzenie..., 2024). Considering the median values of the individual PCB compounds, it can be seen that more than half of the tested soil samples contained less amounts of these xenobiotics than the limit of determination of the analytical method used (0.1 µg/kg). A similar situation was observed in soils from the Warsaw region (Tomassi-Morawiec, 2016). The total concentration of the seven PCB congeners in soils from the Lublin area and its environs ranges from below 0.1 µg/kg to 46 µg/kg, and the median ΣPCB for the entire set of samples is 0.2 µg/kg. The highest concentration (46 µg/kg) was found in urban soils (Trześniów region). Samples from industrial areas of north-eastern Lublin (Bronowice and Tatary quarters) showed ΣPCB concentrations above the 98th percentile (6.5 µg/kg). Median values of ΣPCB for silty, loamy and sandy soils are similar and low (0.1 µg/kg or below 0.1 µg/kg), while the median value for anthropogenic soils is significantly higher (0.8 µg/kg). The highest concentrations of polychlorinated biphenyls are found in soil samples taken from gardens (median ΣPCB 1.3 µg/kg), while the lowest levels are recorded in cultivated fields (median ΣPCB below 0.1 µg/kg). Considering the type of land development in Lublin and its surroundings, it is clear that soils in high-rise urban areas (median ΣPCB 0.9 µg/kg) and industrial areas (median ΣPCB 0.8 µg/kg) contains several times more PCBs than soils in rural areas (median ΣPCB below 0.1 µg/kg) and low-rise urban areas (median ΣPCB 0.2 µg/kg). The relationships observed in the survey area are consistent with the findings of other studies. Deposition of solid aerosols, a process that is more intense in urban than rural areas, is a significant source of polychlorinated biphenyls in the soils. Small amounts of these compounds may also originate from wastewater and the leaching of landfilled sewage sludge and industrial waste (Starek, 2001).

Aquatic sediments: Plate 104, Table 6

The concentration of individual PCBs in aquatic sediments from the study area ranges from 0.1 to 15 µg/kg. The median values for the individual compounds range from below 0.1 µg/kg to 0.4 µg/kg. These levels are similar to those obtained for aquatic sediments in the Warsaw agglomeration, from below 0.1 µg/kg to 1 µg/kg (Tomassi-Morawiec, 2016). The median ΣPCB for the entire population of the tested sediment samples is 2.1 µg/kg. The highest median ΣPCB value (4.6 µg/kg) was recorded in sediments from the SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth. The maximum total PCB concentration (50 µg/kg) was also recorded in this SWB. The sampling site is located near allotment gardens and reed beds. The lowest median ΣPCB value was found in sediment samples collected from the SWB Bystrzyca to the Zemborzycki Reservoir (0.4 µg/kg). Small amounts of analysed polychlorinated biphenyls (at levels ranging from below 0.1 µg/kg to 0.2 µg/kg) were detected also in six samples of aquatic sediments collected from the Zemborzycki Reservoir. Comparing the PCB results for sediments from watercourses and reservoirs in the study area with the ecotoxicological risk index TEC (MacDonald et al., 2000; Contaminated Sediment Standing Team, 2003) shows that none of the analysed samples exceeded the threshold value for ΣPCB (60 µg/kg). Therefore, no harmful impact on benthic organisms from the tested compounds is expected. The low PCB content indicates that there is currently no source of emission of these compounds into the environment in the survey area.

TOTAL MINERAL OILS

Mineral oils are mixtures of aliphatic (n-alkanes and isoalkanes), alicyclic and aromatic hydrocarbons. They are produced during the distillation of crude oil. Mineral oils are widely used in industry, including as lubricants, hydraulic fluids, dielectrics, heat transfer fluids, coolants, grinding fluids, steel hardening agents, anti-corrosion preparations, textile industry liquids, printing ink components, and softeners. Highly refined varieties of oils are also used as ingredients in cosmetics and pharmaceutical preparations, as well as in food processing (Starek, 2013). These substances enter the environment mainly as a result of human activity.

Soils: Plate 105, Table 4

The total mineral oil content in soil samples taken from Lublin and its environs ranges from below 10.0 mg/kg to 950 mg/kg. The median value is 12.6 mg/kg, which is lower than that obtained for Warsaw's soils – 18 mg/kg (Tomassi-Morawiec, 2016). Mineral oil contents above 148 mg/kg (i.e. higher than the 95th percentile) are primarily found in anthropogenic soils of Lublin's urban areas (in the Sławin, Szerokie and Konstantynów quarters), near Biskupia, and in the villages of Długie and Głuszczyzna. The maximum concentration of these substances (950 mg/kg) was recorded in a lawn soil on Wojciechowska Street in Lublin (east of the Polfa Lublin SA plant). Taking the type of land use into account, the highest concentrations of mineral oils were found in soils from industrial areas (median 50.9 mg/kg). Higher levels of these substances were measured in soils from both high-rise (median 30.1 mg/kg) and low-rise (median 15.0 mg/kg) urban areas than from rural and undeveloped areas (medians below 10.0 mg/kg). It was also found that soil samples taken from gardens and lawns are characterized by higher total mineral oil concentrations (medians of 34.8 mg/kg and 28.0 mg/kg, respectively). In contrast, soils from forests, fallow land and cultivated fields exhibit lower concentrations of these substances (medians of 18.1 mg/kg, 12.9 mg/kg, and below 10.0 mg/kg, respectively).

Aquatic sediments: Plate 105, Table 6

The total mineral oil content in aquatic sediments from the study area varies from below 10.0 mg/kg to 2000 mg/kg. The median value is 149 mg/kg, that is approximately five times higher than that obtained for aquatic sediments in the Warsaw agglomeration – 33 mg/kg (Tomassi-Morawiec, 2016). The highest median total mineral oil concentration (284 mg/kg) was recorded in sediments from the SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth. Significant levels of these substances (660–1700 mg/kg) were measured in samples taken from the Bystrzyca River. Aquatic sediment samples taken from the SWB Czechówka also stand out for their relatively high total mineral oil concentration (median 190 mg/kg). Moreover, in the same SWB, the maximum concentration of mineral oils (2000 mg/kg) was determined in sediments from an unnamed ditch located near Solidarności Avenue in the north-western part of Lublin. The lowest median concentration of the substances (below 10.0 mg/kg) was found in sediment samples collected from the SWB Bystrzyca to the Zemborzycki Reservoir. In six samples of aquatic sediments from the Zemborzycki Reservoir, their levels were below the limit of determination of the analytical method used (10.0 mg/kg). Mineral oils can enter the environment as a result of leaks from equipment and machinery (used both in households and for industrial purposes). Improper waste management can also result in the release of the substances into the environment. This includes waste generated from equipment and installation failures, oil changes in vehicles, and the operation of machines. These oils can then migrate directly into the soil and groundwater or spread with rainwater runoff from contaminated areas.

SUMMARY

The present study is a significant contribution to our knowledge of the current chemical status of the Earth's surface environments in the Lublin agglomeration. The geochemical data show that the presence and variability of elements in the area's environmental components result from natural (i.e. geological structure, surface relief, climate, and hydrological conditions) and anthropogenic factors. However, in many places, the relationship between the chemistry of the parent rock and the geochemistry of the soil is not clearly visible due to progressive urbanization and land use.

As in many other cities, Lublin's historical development relied on the usage of large quantities of various building materials, mineral deposits, metallic raw materials, and liquid fuels. These materials were dispersed into the environment as a result of human activity and various cataclysms (wildfires, floods, wars). In some cases, this has led to the contamination of surface environments. These processes occurred at different times and at various stages of urban development; therefore, it is often impossible to determine their extent or impact on the ecosystem chemistry. Consequently, most studies assessing the chemical status of the Earth's surface environments focus on identifying contemporary or recent sources of contamination, typically within the last 200 years. The most important sources of contamination emissions in the investigated area include industrial activity (food, automotive, metallurgical, pharmaceutical, energy and aviation industries), ongoing urbanization and the associated development of transport, services, construction, expansion of road and rail infrastructure, and agriculture.

Of all the natural factors that determine the content and spatial distribution of elements in the soils, the geological structure plays the most important role, particularly with regard to the chemical composition of the rocks that are exposed on the surface or lie at a shallow depth. The geological structure, terrain relief and associated erosion and deposition processes have a significant impact on the soil's grain framework. Within the study area, a higher proportion of sand fraction (0.063< d ≤2.0 mm) was observed in river valleys, primarily of the Bystrzyca and Czerniejówka rivers. In addition, a trend indicating an increasing proportion of the sand fraction in soils of urban areas can be seen. In contrast, soils that have developed on loess (Nałęczów Plateau), and sandy muds (silts) and loess-like silty sands (Świdnik Plateau and Bełżyce Plain) – which occur mostly on hills and slopes – exhibit significantly higher proportions of fine fractions (0.02< d ≤0.063 mm and d ≤0.02 mm).

The dependence of the soil chemistry on bedrock lithology is particularly evident for elements such as Al, Fe, Co, K, Li, Mg, P, Ti and V. Higher concentrations of these elements are found in soils of the loess-covered northern and north-western parts of the study area (Nałęczów Plateau). Additionally, these soils are enriched in other elements, including As, Be, Cr, Cu, Ni and Na. However, their spatial distributions are less pronounced due to anthropogenic contamination. The soil enrichment in elements is favoured by the high proportion of the silt fraction in loess, as well as their lower mobility under hypergenic conditions. As a consequence of the widespread occurrence of calcium carbonate-containing rocks (such as limestones, marls, gaizes, and opokas) in the region's bedrock, the contents of calcium, strontium and magnesium in the soils are more than twice the average concentrations of these elements in soils of Poland. An important property of soils containing significant amounts of carbonates is their higher resistance to the effects of acid rain that forms when water reacts with sulfur, nitrogen and carbon oxides generated during the combustion of coal and other fuels. In the study area, lower amounts of calcium, strotium and magnesium are present in soils formed from sandy muds and loess-like silty sands lying on Upper Cretaceous carbonates. These soils are found in the south-eastern, south-western and north-eastern parts of the survey area. The spatial distribution of these elements shows an inverse relationship with the manganese content in soils. In addition to natural factors, agricultural practices probably significantly affect the variation in manganese concentration in the soils.

Peaty soils, which occur in the marshy valleys of the Bystrzyca and Czerniejówka rivers and the Dopływ spod Świdnika stream, are characterized by naturally high levels of many elements, including Ca, Cd, Co, Cr, Cu, Hg, Mo, Na, Ni, P, Pb, S, Sb, Se, Sr and U, as well as organic carbon. This is because these elements have a high capacity to bond with humic and fulvic acids that occur in soils. Unlike peaty soils, which are enriched in various elements, forest soils are poor in all metals and non-metals tested. When considering the type of soil use, forest soils typically show the lowest median contents of elements (except for manganese). These soils are also characterized by the most acidic value (median pH 4.18).

Human activity in the study area manifests itself through both landscape transformation and the introduction of many chemicals into the natural environment. These chemical substances can accumulate in various environmental components and have a negative impact on ecosystems, as well as on the health of humans and animals. The pH values of the analysed soils ranges from 3.27 to 8.51 (median 7.11). Soil alkalization is observed in the urban areas of Lublin and Świdnik, particularly where dense housing development occurs. This process is probably linked to the deposition of alkaline dust emitted by industrial plants, primarily by combined heat and power plants, as well as to the significant proportion of anthropogenic soils contaminated with construction materials (e.g. concrete, rubble, bricks) containing high levels of calcium. The spatial distributions of chemical substances indicate that urban soils are characterized by higher content of Ag, Ba, Be, TOC, Ca, Cd, Cr, Cu, Hg, Mo, Na, Ni, P, Pb, S, Sb, Sn, Sr, Tl, U and Zn, as well as PAHs, PCBs and OCPs, than the surrounding rural soils. These elements accumulate primarily in anthropogenic soils of industrial and tower-block urban areas. Elevated levels of chemical compounds representing the group of persistent organic pollutants (PAHs, PCBs and OCPs) were found mainly in Lublin city centre. Soils from gardens (including allotments) are also enriched in certain elements and chemical compounds (e.g. Ag, Be, P, Sn, Zn, OCPs, DDT/DDE/DDD, and mineral oils).

The geochemical profile of soils from the city of Świdnik is characterized primarily by elevated concentrations of chromium and nickel, and to a lesser extent, barium, cadmium and copper. This is likely related to the activity of the PZL-Świdnik Communication Equipment Factory, which has been operating since 1951. Despite over 70 years of its operation, the median values of chromium and nickel calculated for soils in Świdnik are only about 5% higher than that obtained for the entire set of soil samples. High levels of these metals (above 150 mg/kg for chromium and above 100 mg/kg for nickel) were recorded only at point locations. Such levels may be caused not only by industrial activity, but also by the improper storage of scrap metal, electronic devices, and batteries, and by the use of metal structures, from which metals are released into the environment as a result of corrosion.

The elevated levels of risk-posing substances (including potentially toxic elements and persistent organic pollutants) in soils and aquatic sediments generally do not exceed the values indicating potentially harmful effects on human and animal health or aquatic organisms. The impact of soil contaminants on human health and the environment was assessed by comparing the results with the permissible levels of risk-causing substances, specified in Polish legal acts regarding land contamination assessment (Rozporządzenie..., 2024). Exceedances of the permissible levels were found only for barium, cadmium, nickel and zinc in soil groups III and/or IV. No exceedances of the permissible levels of arsenic and mercury were found in any soil sample, even for soil group I. In the case of POPs, exceedances of the permissible levels for soil groups I–IV were found for eight PAH compounds. The hydrocarbons for which elevated levels were most frequently observed are: pyrene, fluoranthene, benzo(a)pyrene, and benzo(a)anthracene. In one soil sample, the amount of benzo(a)pyrene exceeded the permissible level for soil group IV. In three soil samples, the results obtained for the sum of DDT and its metabolites were higher than the permissible level for soil group IV. Among the seven polychlorinated biphenyls measured, only the PCB28 congener (in the garden sample) stood out with the amounts above the permissible level for soil group III. All detected exceedances concern only single spot cases.

The chemical status of aquatic sediments from Lublin and environs was assessed by comparing the research results with the thresholds of ecotoxicological risk indices PEC (*Probable Effect Concentration*; MacDonald et al., 2000; Contaminated Sediment Standing Team, 2003), above which harmful effects of chemicals on benthic organisms are observed. Based on this, exceedances of PEC values were found only for silver, arsenic, cadmium, iron, mercury, manganese, nickel and zinc. The highest median concentrations of these elements are found in the SWB Dopływ spod Świdnika and SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth. Higher concentrations of some elements in sediments of the SWB Bystrzyca from the Zemborzycki Reservoir to river's mouth than those of the SWB Bystrzyca to the Zemborzycki Reservoir indicate the presence of human impact due to urbanization and industrial activity, affecting the chemical status of the sediments in the Bystrzyca River downstream of the city of Lublin. The study demonstrates that aquatic sediments from the Lublin region are not heavily contaminated by organic compounds. The PEC threshold values are exceeded for acenaphthene or dibenzo(a,h) anthracene in only three sediment samples. Consequently, these contaminants are expected to have a negative impact on aquatic organisms.

The surface waters are characterized by regional variability in terms of the concentration of chemical elements, water pH, and mineralization levels. Approximately 96% of all water samples showed a slightly alkaline values (pH 7–9). The specific electrical conductivity did not exceed 1 mS/cm, except for one sample taken from a ditch in Sobianowice (in the Wólka municipality), where the EC value was 1.092 mS/cm. The concentration of elements and other physicochemical parameters determined in surface waters of the study area do not exceed the limit values for water quality indices from the group of specific synthetic and non-synthetic contaminants, nor do they exceed the environmental quality standards relating to indices of the chemical status of surface water bodies (Rozporządzenie..., 2021). The exception is antimony, whose concentration in one water sample was 2.45 µg/dm^3, and was slightly higher than the limit value (≤2 µg/dm^3) specified in Rozporządzenie..., 2021. Of all the surface water bodies in this area, the SWB Dopływ spod Świdnika stands out with elevated median values for most of analysed parameters.

Geochemical studies conducted by the PGI-NRI in urban and industrial areas provide information on the chemical status of soils, aquatic sediments, and surface waters. When interpreting the results, various factors that may affect the variability of the physical and chemical properties in these environmental components are taken into account. The impact of different types of land use and development on soil contamination is also assessed. Therefore, the geochemical data obtained in this study may be useful for analysing solutions for introducing a new monitoring system and for assessing soil health in Poland, in accordance with the requirements of the *Directive of the European Parliament and of the Council on Soil Monitoring and Resilience (Soil Monitoring Law).* Additionally, the collected data can be used to determine geochemical baseline reference values (geochemical background levels of elements) for the study area and to identify environmental risks associated with soil, aquatic sediment and surface water contamination.

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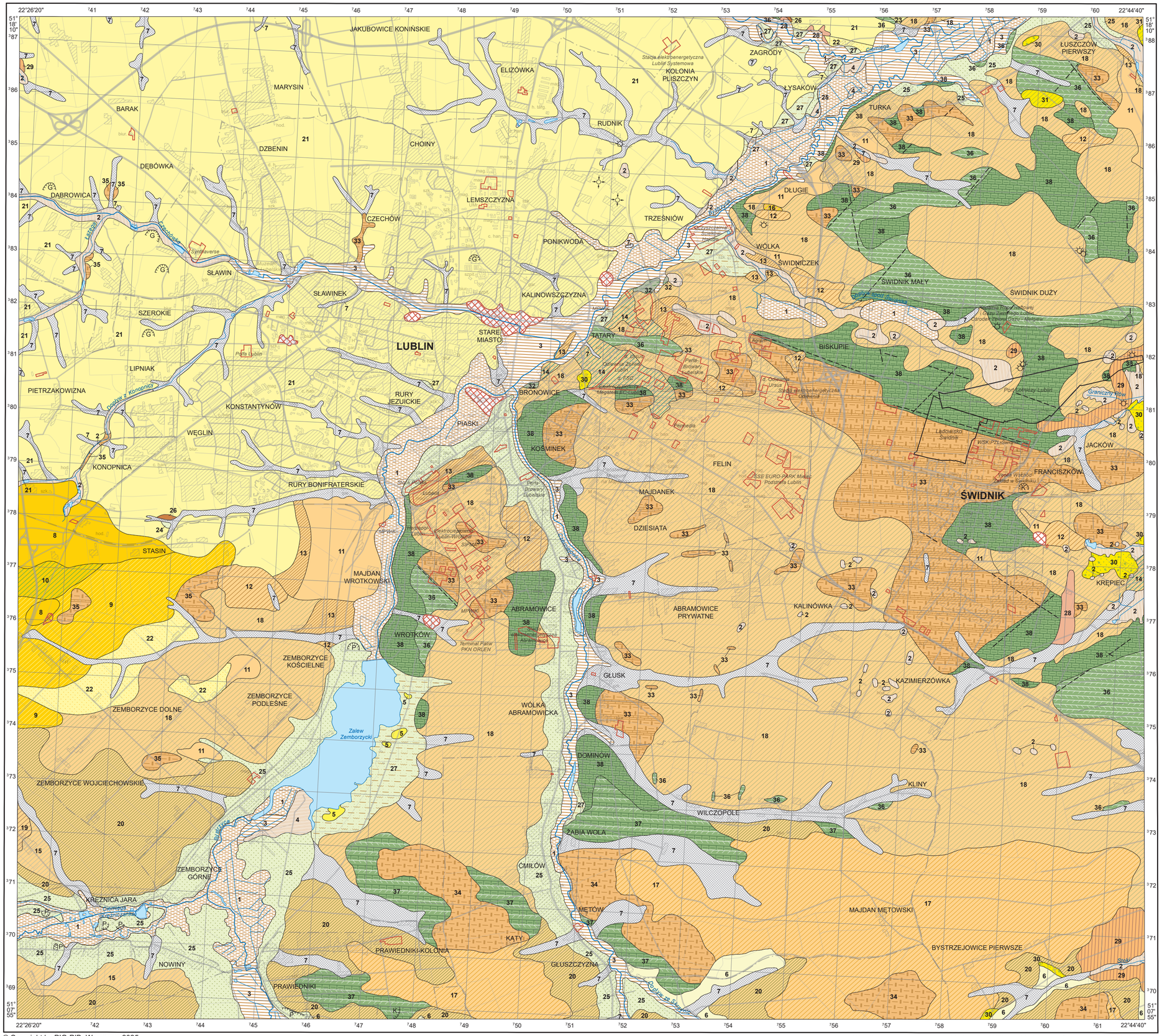
https://www.gov.pl/web/wody-polskie-lublin/historia-zalewu (accessed 08.04.2024)
https://www.mpwik.lublin.pl/o-spolce/infrastruktura/obiekty/ (accessed 03.09.2025)
https://www.mpwik.lublin.pl/wp-content/uploads/2023/02/Deklaracja-Srodowiskowa-2021.pdf (accessed 03.09.2025)
https://www.pgi.gov.pl/psh/zadania-psh/8913-zadania-psh-jcwpd.html (accessed 29.10.2025)
https://www.powiatswidnik.pl/gmina-swidnik (accessed 06.11.2025)
https://www.pzlswidnik.pl/pl/o-nas/nasza-firma/historia (accessed 29.10.2025)
https://www.sipma.pl/o-firmie/grupa-sipma/ (accessed 28.10.2025)

Tablica
Plate **1**

Mapa geologiczna

Geological map



CZWARTORZĘD QUATERNARY

HOLOCEN HOLOCENE

1 Torfy
Peat

2 Namuły
Mud

3 Piaski i gliny facji powodziowej dolin rzecznych (mady)
Fluvial sand and mud (flood facies)

4 Piaski rzeczne tarasów zalewowych
Fluvial sand (flood terrace)

PLEJSTOCEN + HOLOCEN PLEISTOCENE + HOLOCENE

5 Piaski eoliczne w wydmach
Aeolian sand in dunes

6 Piaski i piaski pylowate rzeczne i rzeczno-deluwialne
Fluvial-deluvial silty sand

7 Piaski, pyły, mułki, mułki piaszczyste i piaski pylowate, deluwialne
Deluvial sand, silt, sandy silt and silty sand

8 Mułki, piaski i gliny zwietrzelinowe:
Weathering silt, sand and clay:

9 na gezach, piaskowcach oraz iłach, mułkach i piaskach
on gaize, sandstone, clay, silt and sand

10 na marglach, opokach, wapieniach i gezach z glaukonitem
on marl, calcareous gaize, limestone and gaize with glauconite

PLEJSTOCEN PLEISTOCENE

11 Mułki (pyły) piaszczyste i piaski pylowate lessopodobne:
Sandy silt and silty loess-like sand:

12 na glinach lodowcowych
on till

13 na piaskach ze żwirami wodnolodowcowych
on glaciofluvial sand with gravel

14 na mułkach i iłach jeziornych
on lacustrine silt and clay

15 na piaskach wodnolodowcowych zlodowacenia Sanu 2
on Sanian 2 glaciofluvial sand

16 na piaskach i mułkach oligocenu
on Oligocene sand and silt

17 na gezach paleocenu
on Palaeocene gaize

18 na marglach, opokach i gezach kredy górnej oraz gezach paleocenu
on Upper Cretaceous marl and calcareous gaize, and Palaeocene gaize

19 na gezach kredy górnej i paleocenu dolnego
on Upper Cretaceous and Palaeocene gaize

20 na opokach kredy górnej
on Upper Cretaceous calcareous gaize

21 Lessy
Loess

22 Lessy piaszczyste:
Sandy loess:

23 na marglach, opokach i gezach kredy górnej oraz gezach paleocenu
on Upper Cretaceous marl and calcareous gaize, and Palaeocene gaize

24 Piaski pylowate rzeczno-peryglacjalne
Fluvial silty sand

25 Piaski i mułki (pyły) rzeczne i rzeczno-peryglacjalne tarasów nadzalewowych
Fluvial sand and silt (suprainanundation terrace)

ZLODOWACENIE WISŁY VISTULIAN

26 Gleby kopalne
Paleosoil

INTERGLACJAŁ EEMSKI EEMIAN INTERGLACIAL

27 Piaski ze żwirami kredowymi rzeczno-peryglacjalne
Fluvial sand with gravel of Cretaceous rocks

28 Piaski ze żwirami lodowcowe
Glacial sand and gravel

29 Gliny lodowcowe
Till

30 Piaski ze żwirami wodnolodowcowe:
Glaciofluvial sand with gravel:

31 na marglach, opokach i gezach kredy górnej oraz gezach paleocenu
on Upper Cretaceous calcareous gaize and Palaeocene gaize

ZLODOWACENIE ODRY ODRANIAN

INTERGLACJAŁ MAZOWIECKI MAZOVIAN INTERGLACIAL

32 Mułki i iły jeziorne
Lacustrine silt and clay

PALEOGEN PALEOGENE

PALEOCEN PALEOCENE

33 Gezy z przewarstwieniami i soczewkami wapieni
Gaize with limestone intercalations and lens

34 Gezy z przewarstwieniami wapieni i gezy margliste
Gaize with limestone intercalations and marly gaize

35 Gezy, piaskowce oraz iły, mułki i piaski
Gaize, sandstone, clay, silt and sand

KREDA CRETACEOUS

KREDA GÓRNA UPPER CRETACEOUS

36 Opoki
Calcareous gaize

37 Opoki i margle
Calcareous gaize and marl

38 Margle
Marl

Uskoki przypuszczalne
Probable faults

Glinianki
Clay pits

Kamieniołomy
Quarries

Piaskownie
Sand pits

Obszary przemysłowe
Industrial areas

Lotniska
Airports

Hałdy i nasypy
Dumps and embankments

Odwierty eksploatacyjne
Production boreholes

Odwierty zatłaczające
Injection boreholes

Mapa geologiczna opracowana na podstawie:
Geological map prepared on the basis of the:

Szczegółowej mapy geologicznej Polski 1:50 000:
Detailed geological map of Poland 1:50,000:
ark. Bełżyce (A. Henkiel, W. Danel, 2008)
ark. Niedrzwica (S. Marszałek, A. Albrycht, S. Buła, 1989)
ark. Bychawa (S. Marszałek, A. Albrycht, S. Buła, 1988)
ark. Lublin (J. Butrym, M. Harasimiuk, A. Henkiel, 1980)
Mapy geologicznej Polski 1:500 000 (L. Marks, J. Grabowski, U. Stępień, 2022)
Geological map of Poland 1:500,000

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1:50 000

0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Tablica
Plate **2**

Miejsca opróbowania gleb i zabudowa terenu

Soil sampling locations and land development

- Punkty opróbowania
  Sampling points
- Punkty opróbowania (związki organiczne)
  Sampling points (organic compounds)
- Tereny bez zabudowy
  Non-built-up areas
- Tereny z zabudową wiejską
  Village areas
- Tereny z zabudową miejską niską
  Low-block urban areas
- Tereny z zabudową miejską wysoką
  Tower-block urban areas
- Tereny z zabudową przemysłową
  Industrial areas

Objaśnienia wybranych znaków topograficznych

Explanation of selected topographic signs

- Lasy
  Forests
- Obszary przemysłowe
  Industrial areas
- Lotniska
  Airports
- Hałdy i nasypy
  Dumps and embankments
- Miejsca zrzutu ścieków
  Sewage discharge points
- Odwierty eksploatacyjne
  Production boreholes
- Odwierty zatłaczające
  Injection boreholes

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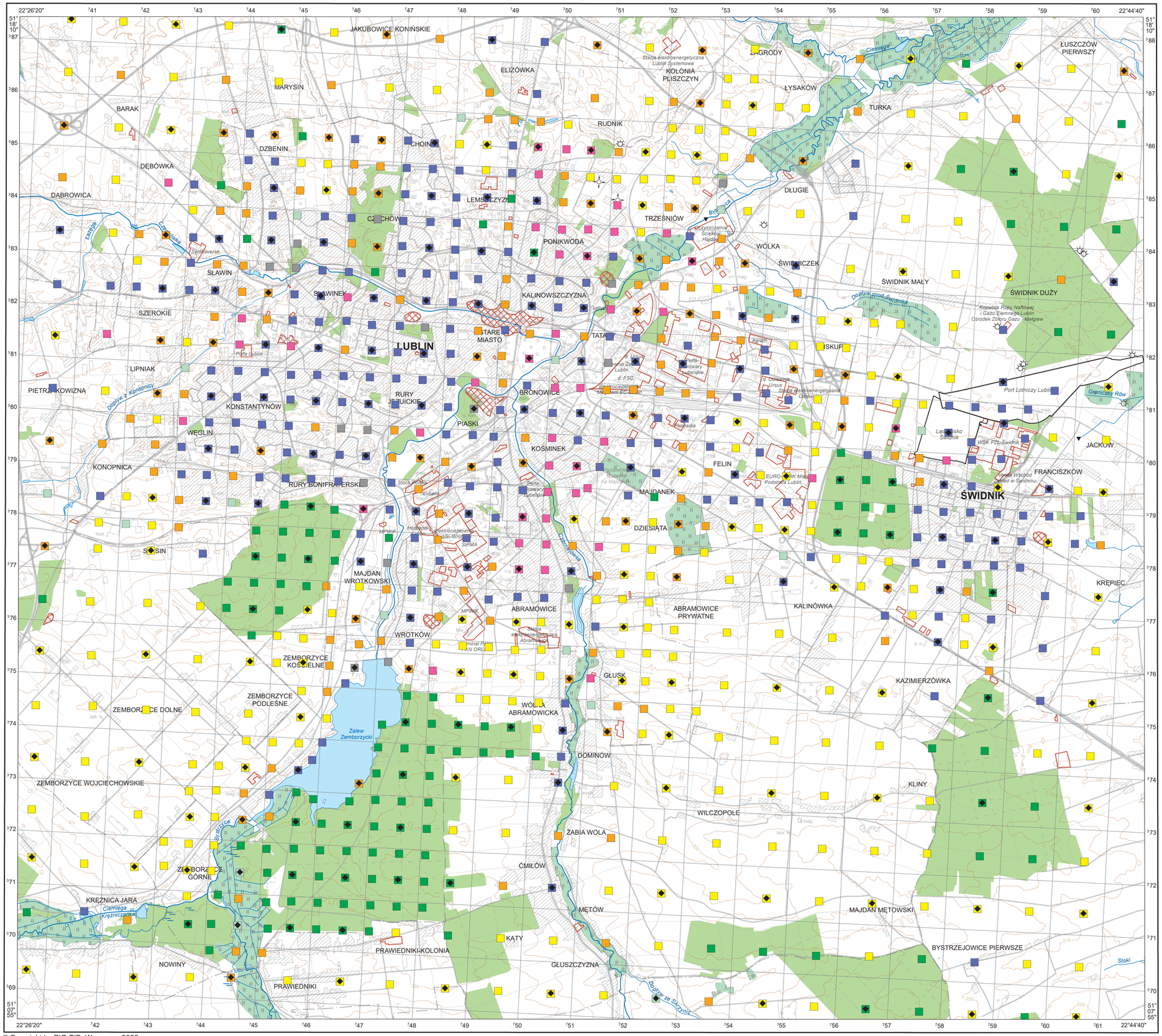
1:50 000

0 1 2 3 4 5 km

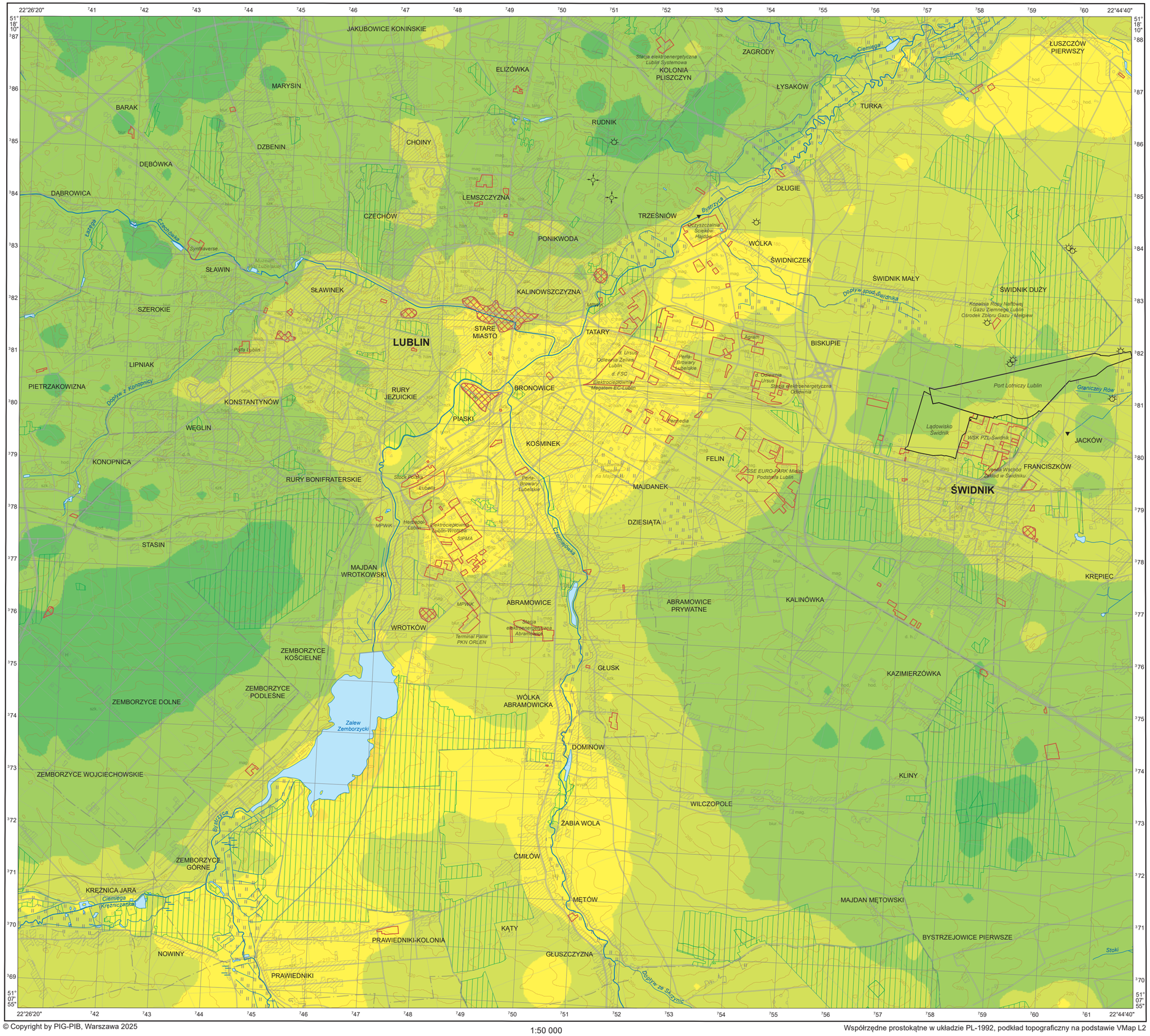
Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Miejsca opróbowania gleb i użytkowanie terenu

Soil sampling locations and land use


JAKUBOWICE KONIŃSKIE
ELIZÓWKA
MARYSIN
BARAK
DZIEBNIN
DĘBÓWKA
DĄBROWICA
CHOINY
RUDNIK
LEMSZCZYZNA
CZECHÓW
PONIKWODA
TRZEŚNIÓW
ŁAGRODY
KOLONIA PLISZCZYN
ŁYSAKÓW
TURKA
ŁUSZCZÓW PIERWSZY
DŁUGIE
WÓLKA
ŚWIDNICZEK
ŚWIDNIK MAŁY
ŚWIDNIK DUŻY
SŁAWIN
SŁAWINEK
SZEROKIE
KALINOWSZCZYZNA
STARE MIASTO
LUBLIN
TATARY
LIPNIAK
PIETRZKOWIZNA
RURY JEZUICKIE
BRONOWICE
KONSTANTYNÓW
PIASKI
WĘGLIN
KOŚMINEK
KONOPNICA
RURY BONIFRATERSKI
FELIN
MAŁDANEK
DZIESIĄTA
ŚWIDNIK
FRANCISZKÓW
JAKÓW
SOSIN
MAJDAN WRÓTKOWSKI
WRÓTKÓW
ABRAMOWICE
ABRAMOWICE PRYWATNE
KALINÓWKA
KRĘPIEC
ZEMBORZYCE KOŚCIELNE
ZEMBORZYCE PODLEŚNE
ZEMBORZYCE DOLNE
GŁUSK
KAZIMIERZÓWKA
WÓLKA ABRAMOWICKA
Zalew Zemborzycki
DOMINÓW
ZEMBORZYCE WOJCIECHOWSKIE
KLINY
WILCZOPOLE
ŻABIA WOLA
ĆMIŁÓW
ZEMBORZYCE GÓRNE
KRĘŻNICA JARA
METÓW
MAJDAN METOWSKI
KĄTY
PRAWIEDNIKI-KOLONIA
BYSTRZEJOWICE PIERWSZE
NOWINY
GŁUSZCZYZNA
PRAWIEDNIKI
Ciemięga
Bystrzyca
Czerniejówka
Dopływ ze Skrzynic
Stoki
Graniczny Rów
Dopływ spod Świdnika
Dopływ z Konopnicy
Krężniczanka
Zalew Zemborzycki
Stacja elektroenergetyczna Lublin Systemowa
Oczyszczalnia Ścieków Hajdów
Symtaverse
Agram
Port Lotniczy Lublin
Lotnisko Świdnik
WSK PZL-Świdnik
Kopalnia Ropy Naftowej i Gazu Ziemnego Lublin Ośrodek Zbioru Gazu - Mełgiew
Elektrociepłownia Lublin-Wrotków
SIPMA
Stacja elektroenergetyczna Abramowice
Elektrociepłownia Lublin-Wrotków
Stacja elektroenergetyczna Ostrów
Fabryka Lubelskie
Fabryka Lubelskie
Fabryka Lubelskie

Frakcja 0,063 < d ≤ 2,0 mm w glebach
Fraction 0.063 < d ≤ 2.0 mm in soil



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Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Gleby – parametry statystyczne
Soil – statistical parameters

	%	
Średnia arytmetyczna	32,42	Arithmetic mean
Średnia geometryczna	22,65	Geometric mean
Mediana	27,04	Median

Percentyl Percentile	%
100	96,48 max.
90	68,27
75	49,58
50	27,04
25	10,84
0	min. 2,00

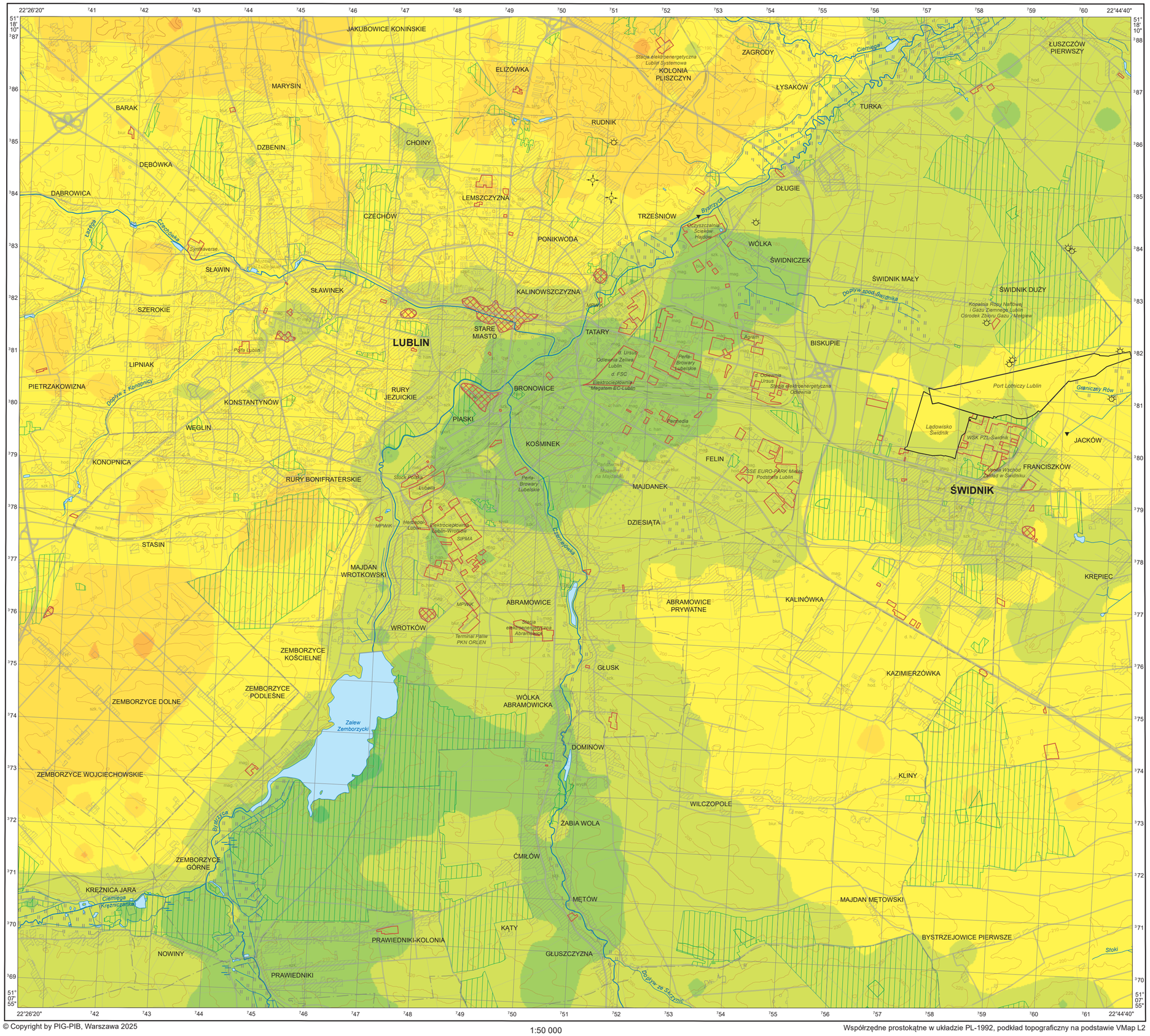
n = 909

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

Frakcja 0,02 < d ≤ 0,063 mm w glebach

Fraction 0.02 < d ≤ 0.063 mm in soil



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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Gleby – parametry statystyczne
Soil – statistical parameters

%

Średnia arytmetyczna	37,55	Arithmetic mean
Średnia geometryczna	33,13	Geometric mean
Mediana	40,58	Median

Percentyl Percentile	%
100	67,98 max.
90	54,81
75	49,50
50	40,58
25	26,42
10	15,30
0	min. 1,09

n = 909

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

Frakcja d ≤ 0,02 mm w glebach
Fraction d ≤ 0.02 mm in soil

Gleby – parametry statystyczne
Soil – statistical parameters

%

Średnia arytmetyczna	30,03	Arithmetic mean
Średnia geometryczna	27,38	Geometric mean
Mediana	30,71	Median

Percentyl Percentile	%
100	71,75 max.
90	43,26
75	39,07
50	30,71
25	21,90
10	14,58
0	min. 2,29

n = 909

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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1:50 000

0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Odczyn gleb i wód powierzchniowych
Acidity of soil and surface water

pH

Gleby – parametry statystyczne
Soil – statistical parameters

Średnia arytmetyczna	6,49	Arithmetic mean
Średnia geometryczna	6,35	Geometric mean
Mediana	7,11	Median

8,51 max.
7,20
6,50
5,50
4,50
min. 3,27

n = 909

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

Średnia arytmetyczna	8,02	Arithmetic mean
Średnia geometryczna	8,01	Geometric mean
Mediana	7,97	Median

Percentyl Percentile	
98 – 100	9,15 – 10,76 max.
95 – 98	8,98 – 9,15
90 – 95	8,71 – 8,98
75 – 90	8,15 – 8,71
50 – 75	7,97 – 8,15
25 – 50	7,75 – 7,97
10 – 25	7,51 – 7,75
0 – 10	min. 6,92 – 7,51

n = 182

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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1:50 000

0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Tablica
Plate **8**

Przewodność elektrolityczna właściwa wód powierzchniowych

Electrolytic conductivity of surface water

EC

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

	mS/cm	
Średnia arytmetyczna	0,573	Arithmetic mean
Średnia geometryczna	0,545	Geometric mean
Mediana	0,567	Median

Percentyl Percentile	mS/cm
98 – 100	0,883 – 1,092 max.
95 – 98	0,849 – 0,883
90 – 95	0,784 – 0,849
75 – 90	0,689 – 0,784
50 – 75	0,567 – 0,689
25 – 50	0,440 – 0,567
10 – 25	0,386 – 0,440
0 – 10	min. 0,138 – 0,386

n = 182

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy — Forests
- Obszary przemysłowe — Industrial areas
- Lotniska — Airports
- Hałdy i nasypy — Dumps and embankments
- Miejsca zrzutu ścieków — Sewage discharge points
- Odwierty eksploatacyjne — Production boreholes
- Odwierty zatłaczające — Injection boreholes

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1:50 000

0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Srebro w glebach i osadach wodnych
Silver in soil and aquatic sediment

Ag

Gleby – parametry statystyczne
Soil – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	n.o.	Arithmetic mean
Średnia geometryczna	n.o.	Geometric mean
Mediana	<0,05	Median
Granica oznaczalności	0,05	Determination limit

Percentyl Percentile	mg/kg
100	1,48 max.
98	0,32
95	0,19
90	0,12
75	0,06
0	min. <0,05

n = 909

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	0,16	Arithmetic mean
Średnia geometryczna	0,07	Geometric mean
Mediana	0,06	Median
Granica oznaczalności	0,05	Determination limit

Percentyl Percentile	mg/kg
98 – 100	0,89 – 5,22 max.
95 – 98	0,60 – 0,89
90 – 95	0,37 – 0,60
75 – 90	0,11 – 0,37
50 – 75	0,06 – 0,11
0 – 50	min.<0,05 – 0,06

n = 169

„n.o." nie obliczono, gdy odsetek wyników poniżej granicy oznaczalności przekraczał 50%
not calculated when the percentage of the results below determination limit exceeded 50%

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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1:50 000

0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Srebro w wodach powierzchniowych
Silver in surface water

Ag

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

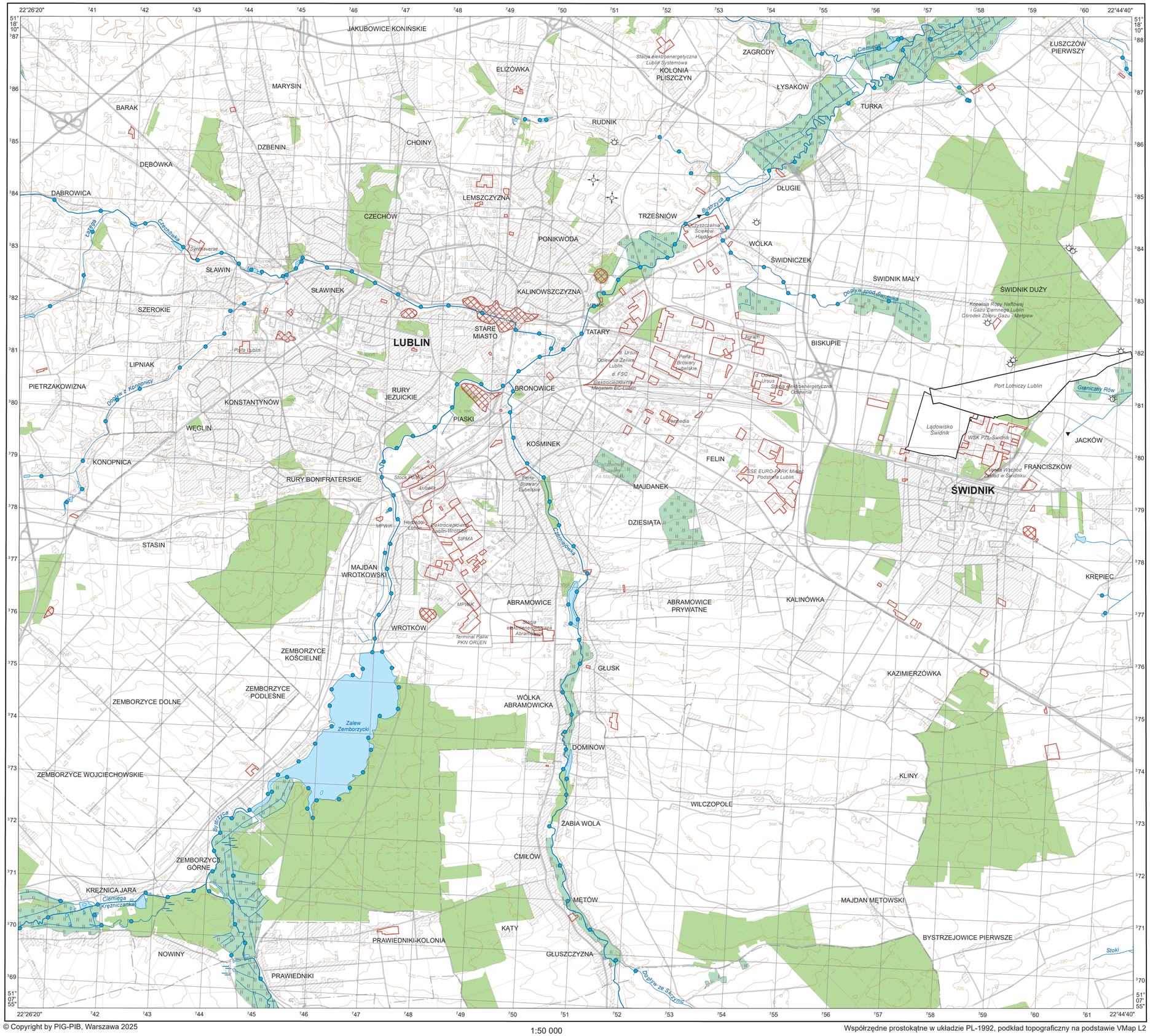
ppb = µg/dm^3

Średnia arytmetyczna	n.o.	Arithmetic mean
Średnia geometryczna	n.o.	Geometric mean
Mediana	<0,05	Median
Granica oznaczalności	0,05	Determination limit

Percentyl Percentile		µg/dm^3
0 – 100	●	<0,05

n = 182

„n.o." nie obliczono, gdy odsetek wyników poniżej granicy oznaczalności przekraczał 50%
not calculated when the percentage of the results below determination limit exceeded 50%



Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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1:50 000

0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Glin w glebach i osadach wodnych
Aluminium in soil and aquatic sediment

Al

Gleby – parametry statystyczne
Soil – statistical parameters

	%	
Średnia arytmetyczna	0,67	Arithmetic mean
Średnia geometryczna	0,63	Geometric mean
Mediana	0,68	Median
Granica oznaczalności	0,01	Determination limit

Percentyl Percentile	%	
100		1,66 max.
95		0,97
90		0,90
75		0,80
50		0,68
25		0,54
10		0,38
0		min. 0,08

n = 909

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

	%	
Średnia arytmetyczna	0,50	Arithmetic mean
Średnia geometryczna	0,42	Geometric mean
Mediana	0,49	Median
Granica oznaczalności	0,01	Determination limit

Percentyl Percentile	%
98 – 100	0,99 – 1,65 max.
95 – 98	0,89 – 0,99
90 – 95	0,80 – 0,89
75 – 90	0,62 – 0,80
50 – 75	0,49 – 0,62
25 – 50	0,36 – 0,49
10 – 25	0,15 – 0,36
0 – 10	min. 0,04 – 0,15

n = 169

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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1:50 000

0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Glin w wodach powierzchniowych
Aluminium in surface water

Al

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppb = µg/dm^3

Średnia arytmetyczna	5,7	Arithmetic mean
Średnia geometryczna	2,3	Geometric mean
Mediana	2,2	Median
Granica oznaczalności	0,5	Determination limit

Percentyl Percentile	µg/dm^3
98 – 100	80,9 – 133,5 max.
95 – 98	13,2 – 80,9
90 – 95	5,6 – 13,2
75 – 90	3,5 – 5,6
50 – 75	2,2 – 3,5
25 – 50	1,2 – 2,2
10 – 25	0,8 – 1,2
0 – 10	min.<0,5 – 0,8

n = 182

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Arsen w glebach i osadach wodnych
Arsenic in soil and aquatic sediment

As

Gleby – parametry statystyczne
Soil – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	<3	Arithmetic mean
Średnia geometryczna	<3	Geometric mean
Mediana	3	Median
Granica oznaczalności	3	Determination limit

Percentyl Percentile	mg/kg
100	18 max.
98	5
90	4
50	3
0	min. <3

n = 909

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	n.o	Arithmetic mean
Średnia geometryczna	n.o	Geometric mean
Mediana	<3	Median
Granica oznaczalności	3	Determination limit

Percentyl Percentile	mg/kg
98 – 100	12 – 47 max.
95 – 98	7 – 12
90 – 95	5 – 7
75 – 90	3 – 5
0 – 75	min. <3 – 3

n = 169

„n.o." nie obliczono, gdy odsetek wyników poniżej granicy oznaczalności przekraczał 50%
not calculated when the percentage of the results below determination limit exceeded 50%

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Tablica
Plate **14**

Arsen w wodach powierzchniowych
Arsenic in surface water

As

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppb = µg/dm^3

Średnia arytmetyczna	n.o.	Arithmetic mean
Średnia geometryczna	n.o.	Geometric mean
Mediana	<2	Median
Granica oznaczalności	2	Determination limit

Percentyl Percentile	µg/dm^3
98 – 100	5 – 11 max.
95 – 98	3 – 5
0 – 95	min.<2 – 3

n = 182

„n.o." nie obliczono, gdy odsetek wyników poniżej granicy oznaczalności przekraczał 50%
not calculated when the percentage of the results below determination limit exceeded 50%

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Bor w wodach powierzchniowych
Boron in surface water

B

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppm = mg/dm^3

Średnia arytmetyczna	0,03	Arithmetic mean
Średnia geometryczna	0,03	Geometric mean
Mediana	0,03	Median
Granica oznaczalności	0,01	Determination limit

Percentyl Percentile		mg/dm^3
98 – 100	●	0,06 – 0,09 max.
95 – 98	●	0,05 – 0,06
90 – 95	●	0,04 – 0,05
50 – 90	●	0,03 – 0,04
25 – 50	●	0,02 – 0,03
0 – 25	•	min.<0,01 – 0,02

n = 182

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- ▼ Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Bar w glebach i osadach wodnych
Barium in soil and aquatic sediment

Ba

Gleby – parametry statystyczne
Soil – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	58	Arithmetic mean
Średnia geometryczna	49	Geometric mean
Mediana	49	Median
Granica oznaczalności	1	Determination limit

Percentyl Percentile	mg/kg
100	1327 max.
98	177
95	106
90	75
75	57
50	49
25	41
10	27
0	min. 8

n = 909

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	47	Arithmetic mean
Średnia geometryczna	38	Geometric mean
Mediana	40	Median
Granica oznaczalności	1	Determination limit

Percentyl Percentile	mg/kg
98 – 100	157 – 309 max.
95 – 98	86 – 157
90 – 95	75 – 86
75 – 90	58 – 75
50 – 75	40 – 58
25 – 50	28 – 40
10 – 25	14 – 28
0 – 10	min. 6 – 14

n = 169

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy – Forests
- Obszary przemysłowe – Industrial areas
- Lotniska – Airports
- Hałdy i nasypy – Dumps and embankments
- Miejsca zrzutu ścieków – Sewage discharge points
- Odwierty eksploatacyjne – Production boreholes
- Odwierty zatłaczające – Injection boreholes

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Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Bar w wodach powierzchniowych
Barium in surface water

Ba

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppm = mg/dm^3

Średnia arytmetyczna	0,041	Arithmetic mean
Średnia geometryczna	0,032	Geometric mean
Mediana	0,035	Median
Granica oznaczalności	0,001	Determination limit

Percentyl Percentile	mg/dm^3
98 – 100	0,121 – 0,161 max.
95 – 98	0,103 – 0,121
90 – 95	0,075 – 0,103
75 – 90	0,054 – 0,075
50 – 75	0,035 – 0,054
25 – 50	0,022 – 0,035
10 – 25	0,010 – 0,022
0 – 10	min. 0,002 – 0,010

n = 182

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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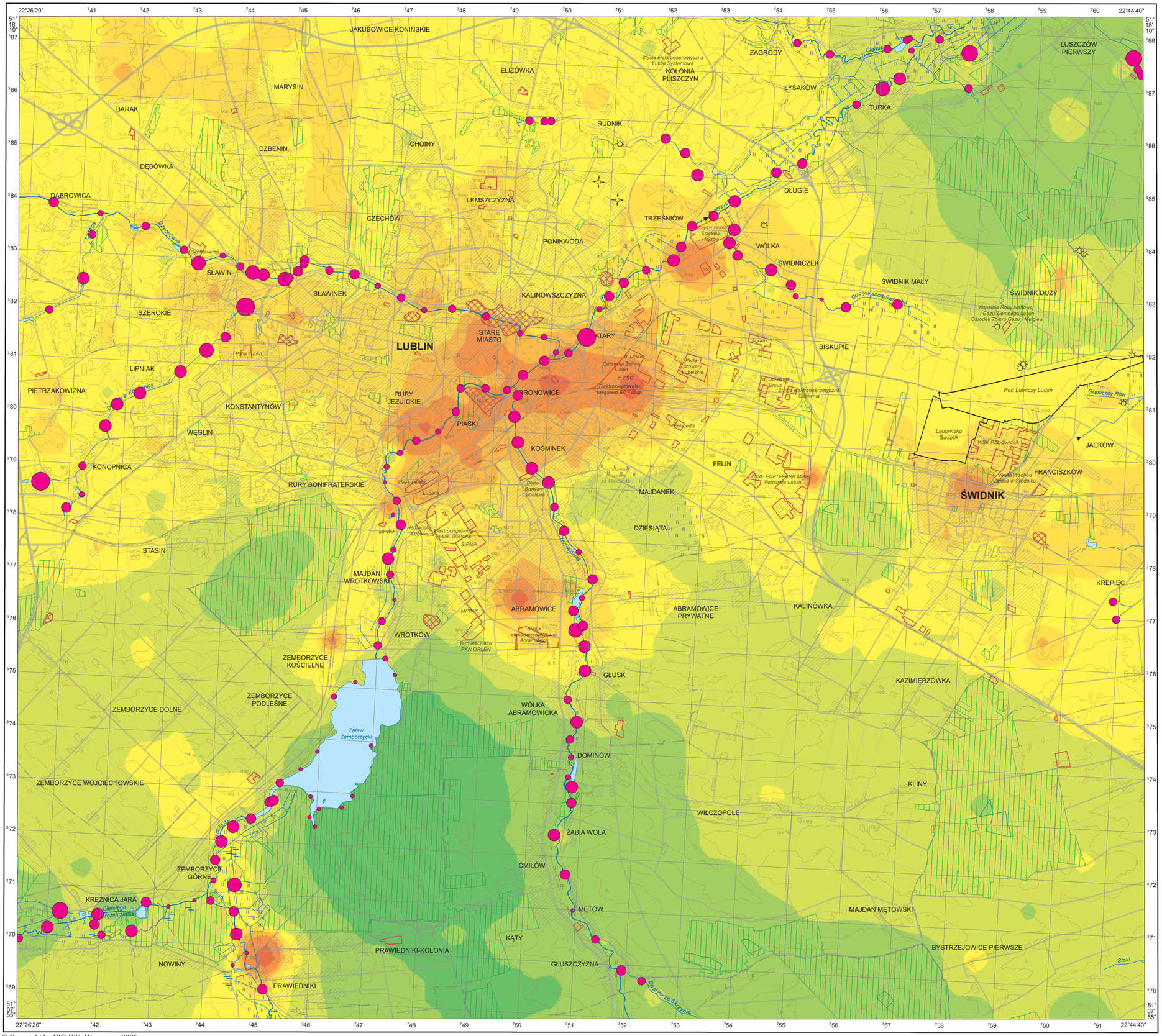
0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Beryl w glebach i osadach wodnych
Beryllium in soil and aquatic sediment

Be



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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Gleby – parametry statystyczne
Soil – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	0,46	Arithmetic mean
Średnia geometryczna	0,39	Geometric mean
Mediana	0,43	Median
Granica oznaczalności	0,05	Determination limit

Percentyl Percentile	mg/kg
100	4,71 max.
98	1,09
95	0,74
90	0,62
75	0,52
50	0,43
25	0,34
10	0,20
0	min. <0,05

n = 909

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	0,36	Arithmetic mean
Średnia geometryczna	0,30	Geometric mean
Mediana	0,36	Median
Granica oznaczalności	0,05	Determination limit

Percentyl Percentile	mg/kg
98 – 100	0,76 – 1,03 max.
95 – 98	0,64 – 0,76
90 – 95	0,59 – 0,64
75 – 90	0,46 – 0,59
50 – 75	0,36 – 0,46
25 – 50	0,26 – 0,36
10 – 25	0,13 – 0,26
0 – 10	min. <0,05 – 0,13

n = 169

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

Beryl w wodach powierzchniowych
Beryllium in surface water

Be

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

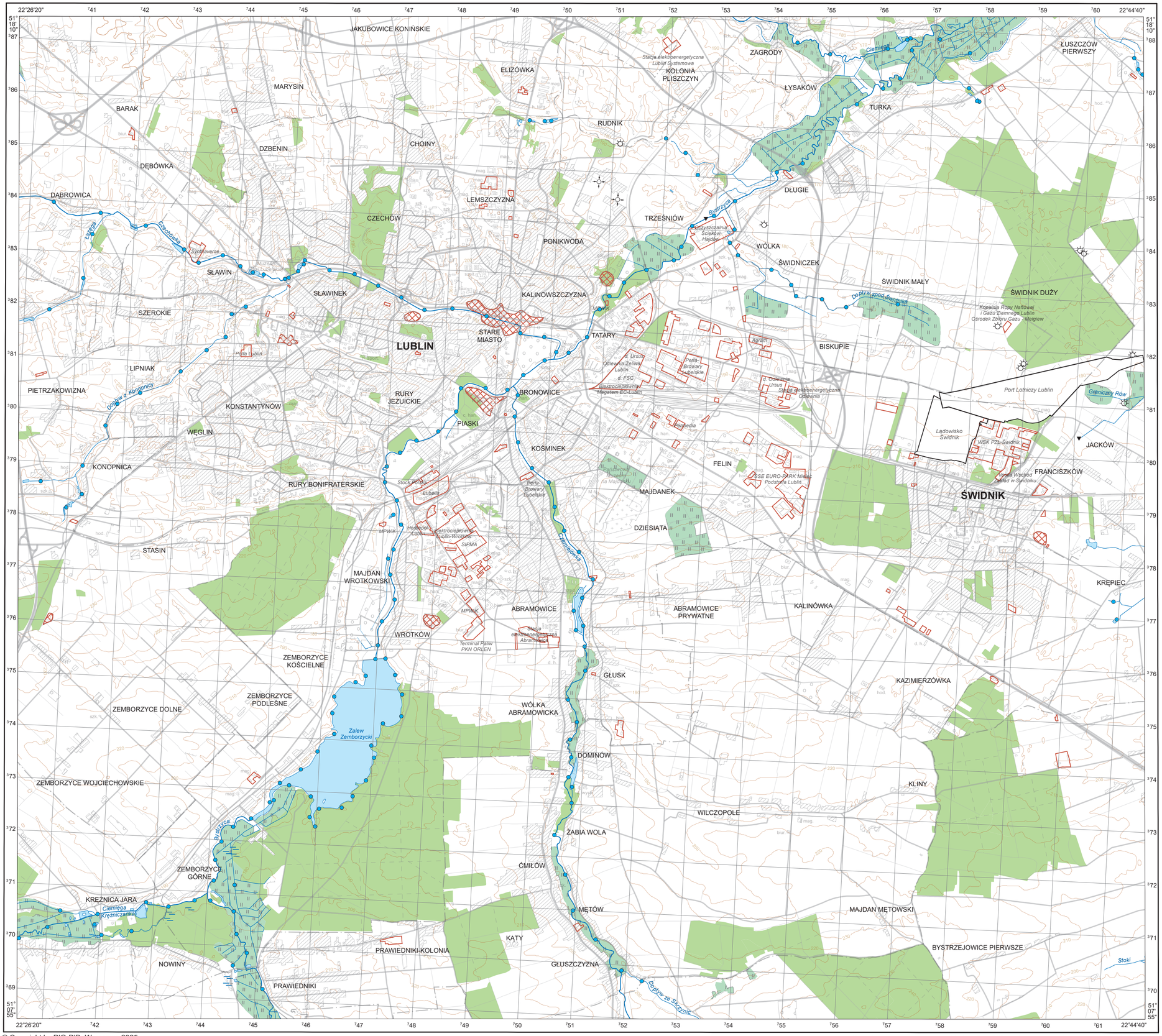
ppb = µg/dm^3

Średnia arytmetyczna	n.o.	Arithmetic mean
Średnia geometryczna	n.o.	Geometric mean
Mediana	<0,05	Median
Granica oznaczalności	0,05	Determination limit

Percentyl Percentile	µg/dm^3
0 – 100	<0,05

n = 182

„n.o." nie obliczono, gdy odsetek wyników poniżej granicy oznaczalności przekraczał 50%
not calculated when the percentage of the results below determination limit exceeded 50%



Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Bromki w wodach powierzchniowych
Bromides in surface water

Br^-

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppm = mg/dm^3

Średnia arytmetyczna	n.o.	Arithmetic mean
Średnia geometryczna	n.o.	Geometric mean
Mediana	<0,1	Median
Granica oznaczalności	0,1	Determination limit

Percentyl Percentile		mg/dm^3
0 – 100	●	<0,1

n = 182

„n.o." nie obliczono, gdy odsetek wyników poniżej granicy oznaczalności przekraczał 50%
not calculated when the percentage of the results below determination limit exceeded 50%

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Ogólny węgiel organiczny w glebach i osadach wodnych

Total organic carbon in soil and aquatic sediment

OWO
TOC

Gleby – parametry statystyczne
Soil – statistical parameters

	%	
Średnia arytmetyczna	1,94	Arithmetic mean
Średnia geometryczna	1,49	Geometric mean
Mediana	1,36	Median
Granica oznaczalności	0,02	Determination limit

Percentyl Percentile	%
100	34,66 max.
98	7,55
95	4,74
90	3,43
75	2,04
50	1,36
25	1,00
10	0,78
0	min. 0,13

n = 909

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

	%	
Średnia arytmetyczna	3,86	Arithmetic mean
Średnia geometryczna	2,51	Geometric mean
Mediana	3,05	Median
Granica oznaczalności	0,02	Determination limit

Percentyl Percentile	%
98 – 100	12,36 – 25,32 max.
95 – 98	10,57 – 12,36
90 – 95	8,06 – 10,57
75 – 90	5,31 – 8,06
50 – 75	3,05 – 5,31
25 – 50	1,35 – 3,05
10 – 25	0,55 – 1,35
0 – 10	min.0,11 – 0,55

n = 169

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Ogólny węgiel organiczny w wodach powierzchniowych
Total organic carbon in surface water

OWO
TOC

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppm = mg/dm^3

Średnia arytmetyczna	2,5	Arithmetic mean
Średnia geometryczna	1,6	Geometric mean
Mediana	1,5	Median
Granica oznaczalności	1,0	Determination limit

Percentyl Percentile	mg/dm^3
98 – 100	15,0 – 34,0 max.
95 – 98	9,5 – 15,0
90 – 95	3,8 – 9,5
75 – 90	2,0 – 3,8
50 – 75	1,5 – 2,0
25 – 50	1,1 – 1,5
0 – 25	min.<1,0 – 1,1

n = 182

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Wapń w glebach i osadach wodnych

Calcium in soil and aquatic sediment

Ca

Gleby – parametry statystyczne
Soil – statistical parameters

%

Średnia arytmetyczna	0,97	Arithmetic mean
Średnia geometryczna	0,39	Geometric mean
Mediana	0,35	Median
Granica oznaczalności	0,01	Determination limit

Percentyl Percentile	%
100	12,89 max.
98	4,78
95	3,40
90	2,47
75	1,38
50	0,35
25	0,14
10	0,05
0	min. <0,01

n = 909

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

%

Średnia arytmetyczna	3,07	Arithmetic mean
Średnia geometryczna	2,19	Geometric mean
Mediana	2,65	Median
Granica oznaczalności	0,01	Determination limit

Percentyl Percentile	%
98 – 100	8,11 – 9,74 max.
95 – 98	7,05 – 8,11
90 – 95	6,26 – 7,05
75 – 90	4,31 – 6,26
50 – 75	2,65 – 4,31
25 – 50	1,43 – 2,65
10 – 25	0,76 – 1,43
0 – 10	min. 0,03 – 0,76

n = 169

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy — Forests
- Obszary przemysłowe — Industrial areas
- Lotniska — Airports
- Hałdy i nasypy — Dumps and embankments
- Miejsca zrzutu ścieków — Sewage discharge points
- Odwierty eksploatacyjne — Production boreholes
- Odwierty zatłaczające — Injection boreholes

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Wapń w wodach powierzchniowych
Calcium in surface water

Ca

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppm = mg/dm^3

Średnia arytmetyczna	91,9	Arithmetic mean
Średnia geometryczna	84,4	Geometric mean
Mediana	98,7	Median
Granica oznaczalności	0,1	Determination limit

Percentyl Percentile	mg/dm^3
98 – 100	163,6 – 195,2 max.
95 – 98	152,0 – 163,6
90 – 95	130,0 – 152,0
75 – 90	108,0 – 130,0
50 – 75	98,7 – 108,0
25 – 50	63,4 – 98,7
10 – 25	52,8 – 63,4
0 – 10	min.12,7 – 52,8

n = 182

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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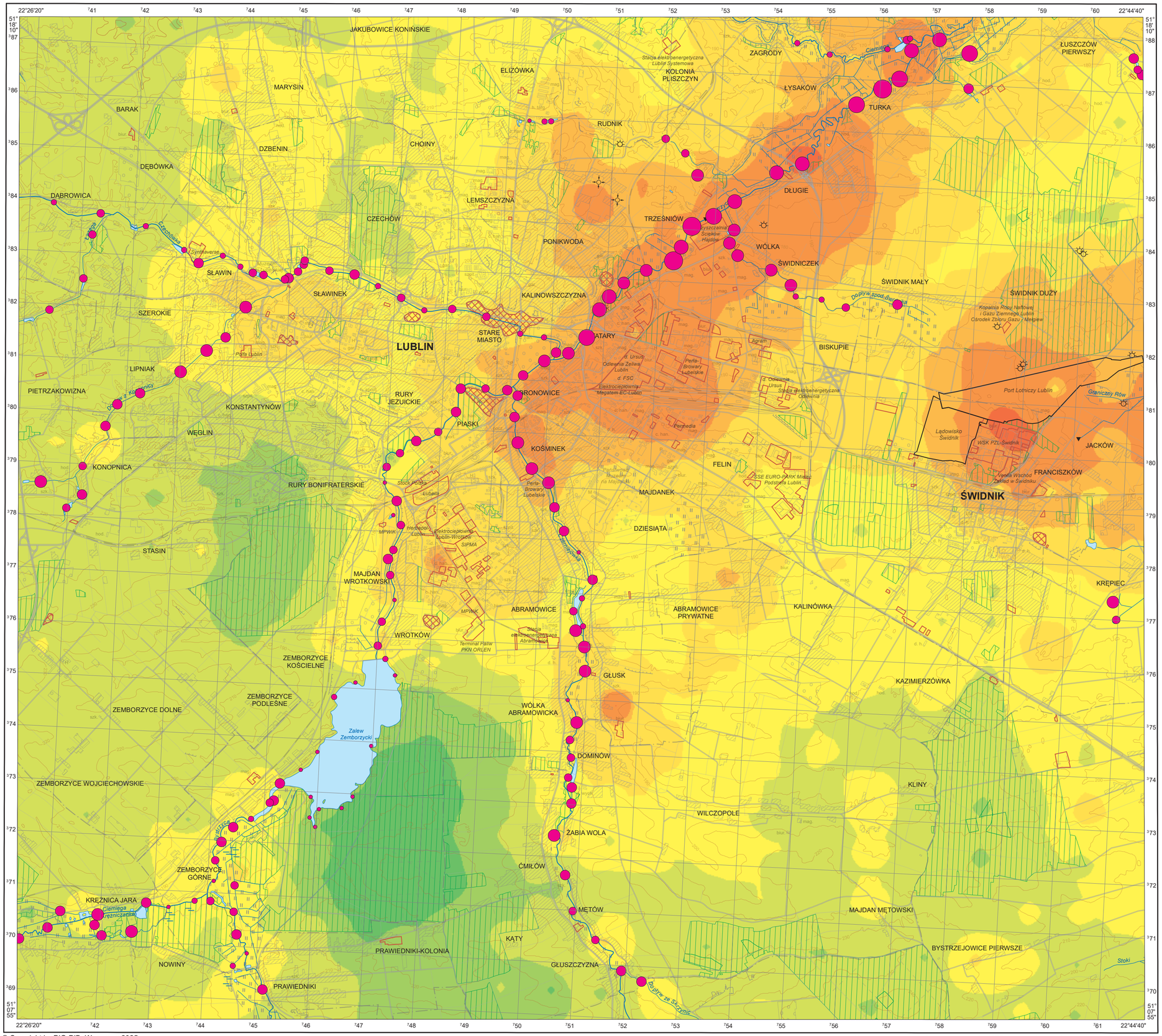
0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Kadm w glebach i osadach wodnych
Cadmium in soil and aquatic sediment

Cd



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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Gleby – parametry statystyczne
Soil – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	0,38	Arithmetic mean
Średnia geometryczna	0,20	Geometric mean
Mediana	0,19	Median
Granica oznaczalności	0,05	Determination limit

Percentyl Percentile	mg/kg
100	15,57 max.
98	2,93
95	0,93
90	0,62
75	0,30
50	0,19
25	0,13
10	0,08
0	min. <0,05

n = 909

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	1,43	Arithmetic mean
Średnia geometryczna	0,34	Geometric mean
Mediana	0,32	Median
Granica oznaczalności	0,05	Determination limit

Percentyl Percentile	mg/kg
98 – 100	14,38 – 85,79 max.
95 – 98	4,71 – 14,38
90 – 95	1,62 – 4,71
75 – 90	0,53 – 1,62
50 – 75	0,32 – 0,53
25 – 50	0,17 – 0,32
10 – 25	0,11 – 0,17
0 – 10	min.<0,05 – 0,11

n = 169

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

Kadm w wodach powierzchniowych
Cadmium in surface water

Cd

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppb = µg/dm^3

Średnia arytmetyczna	n.o.	Arithmetic mean
Średnia geometryczna	n.o.	Geometric mean
Mediana	<0,05	Median
Granica oznaczalności	0,05	Determination limit

Percentyl Percentile	µg/dm^3
98 – 100	0,07 – 0,22 max.
95 – 98	0,05 – 0,07
0 – 95	min.<0,05 – 0,05

n = 182

„n.o." nie obliczono, gdy odsetek wyników poniżej granicy oznaczalności przekraczał 50%
not calculated when the percentage of the results below determination limit exceeded 50%

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Chemiczne zapotrzebowanie tlenu w wodach powierzchniowych

Chemical oxygen demand in surface water

ChZT
COD

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppm = mg/dm^3

Średnia arytmetyczna	5,5	Arithmetic mean
Średnia geometryczna	3,7	Geometric mean
Mediana	3,4	Median
Granica oznaczalności	2,0	Determination limit

Percentyl Percentile	mg/dm^3
98 – 100	31,5 – 77,0 max.
95 – 98	19,2 – 31,5
90 – 95	7,5 – 19,2
75 – 90	4,6 – 7,5
50 – 75	3,4 – 4,6
25 – 50	2,5 – 3,4
10 – 25	2,0 – 2,5
0 – 10	min.<2,0 – 2,0

n = 182

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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1:50 000

0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Chlorki w wodach powierzchniowych
Chlorides in surface water

Cl^-

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppm = mg/dm^3

Średnia arytmetyczna	28,6	Arithmetic mean
Średnia geometryczna	25,4	Geometric mean
Mediana	23,5	Median
Granica oznaczalności	0,5	Determination limit

Percentyl Percentile		mg/dm^3
98 – 100	●	78,0 – 240,0 max.
95 – 98	●	58,3 – 78,0
90 – 95	●	39,2 – 58,3
75 – 90	●	31,5 – 39,2
50 – 75	●	23,5 – 31,5
25 – 50	●	20,8 – 23,5
10 – 25	●	16,2 – 20,8
0 – 10	•	min.5,2 – 16,2

n = 182

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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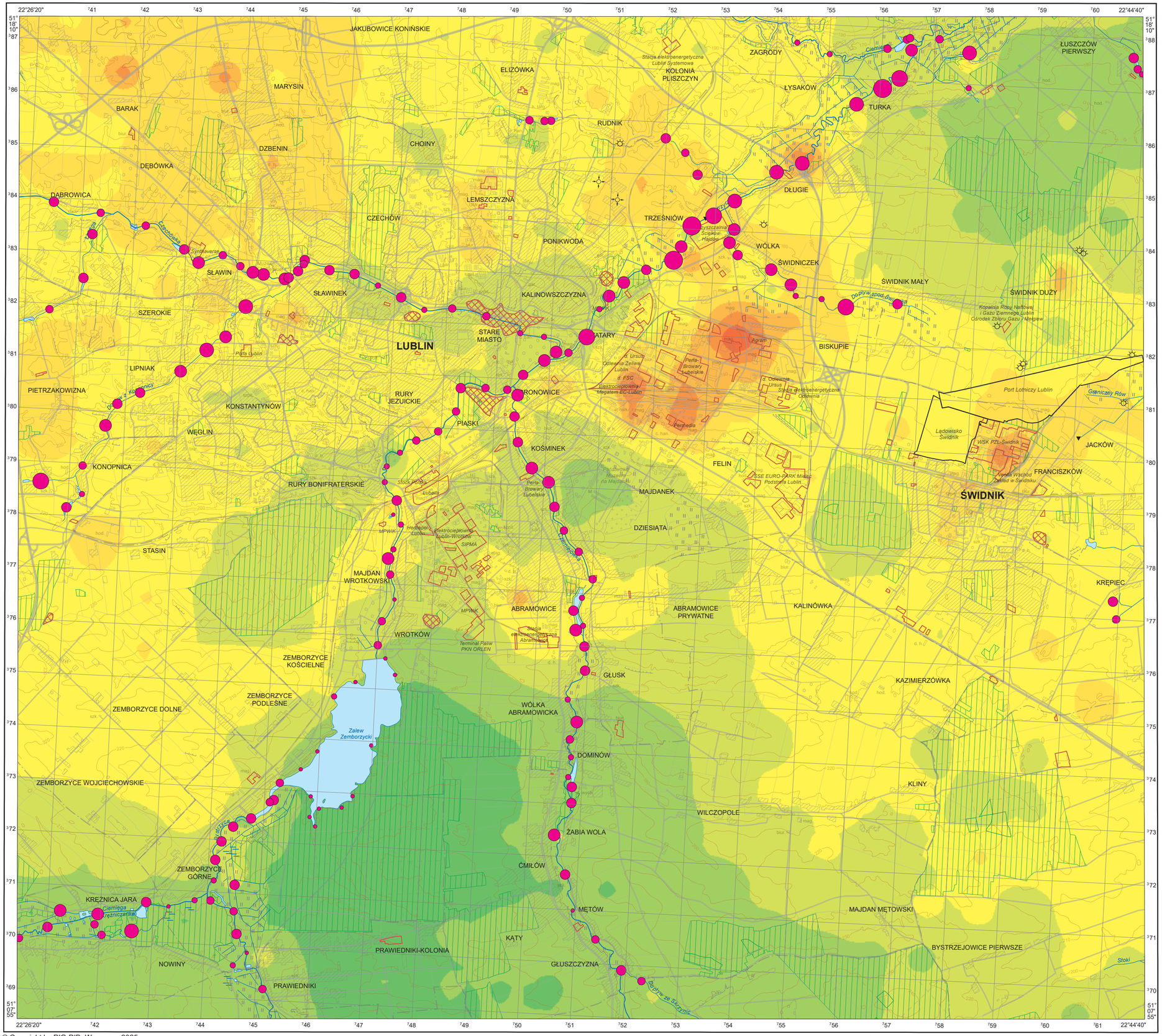
1:50 000

0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Kobalt w glebach i osadach wodnych
Cobalt in soil and aquatic sediment

Co



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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Gleby – parametry statystyczne
Soil – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	3,91	Arithmetic mean
Średnia geometryczna	3,62	Geometric mean
Mediana	4,04	Median
Granica oznaczalności	0,05	Determination limit

Percentyl Percentile	mg/kg	
100		20,54 max.
98		6,74
95		5,59
90		5,05
75		4,55
50		4,04
25		3,35
10		2,14
0		min. 0,32

n = 909

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	3,81	Arithmetic mean
Średnia geometryczna	2,97	Geometric mean
Mediana	3,38	Median
Granica oznaczalności	0,05	Determination limit

Percentyl Percentile	mg/kg
98 – 100	9,63 – 40,81 max.
95 – 98	7,28 – 9,63
90 – 95	5,88 – 7,28
75 – 90	4,68 – 5,88
50 – 75	3,38 – 4,68
25 – 50	2,41 – 3,38
10 – 25	1,30 – 2,41
0 – 10	min. 0,09 – 1,30

n = 169

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

Kobalt w wodach powierzchniowych
Cobalt in surface water

Co

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppb = µg/dm^3

Średnia arytmetyczna	n.o.	Arithmetic mean
Średnia geometryczna	n.o.	Geometric mean
Mediana	<0,05	Median
Granica oznaczalności	0,05	Determination limit

Percentyl Percentile	µg/dm^3
98 – 100	0,78 – 3,84 max.
95 – 98	0,37 – 0,78
90 – 95	0,17 – 0,37
75 – 90	0,08 – 0,17
0 – 75	min.<0,05 – 0,08

n = 182

„n.o." nie obliczono, gdy odsetek wyników poniżej granicy oznaczalności przekraczał 50%
not calculated when the percentage of the results below determination limit exceeded 50%

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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1:50 000

0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Chrom w glebach i osadach wodnych
Chromium in soil and aquatic sediment

Cr

Gleby – parametry statystyczne
Soil – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	13	Arithmetic mean
Średnia geometryczna	11	Geometric mean
Mediana	12	Median
Granica oznaczalności	1	Determination limit

Percentyl Percentile	mg/kg
100	348 max.
98	25
95	19
90	17
75	14
50	12
25	9
10	6
0	min. 2

n = 909

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	14	Arithmetic mean
Średnia geometryczna	11	Geometric mean
Mediana	13	Median
Granica oznaczalności	1	Determination limit

Percentyl Percentile	mg/kg
98 – 100	42 – 79 max.
95 – 98	29 – 42
90 – 95	26 – 29
75 – 90	18 – 26
50 – 75	13 – 18
25 – 50	9 – 13
10 – 25	4 – 9
0 – 10	min.<1 – 4

n = 169

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy – Forests
- Obszary przemysłowe – Industrial areas
- Lotniska – Airports
- Hałdy i nasypy – Dumps and embankments
- Miejsca zrzutu ścieków – Sewage discharge points
- Odwierty eksploatacyjne – Production boreholes
- Odwierty zatłaczające – Injection boreholes

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1:50 000

0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Chrom w wodach powierzchniowych
Chromium in surface water

Cr

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

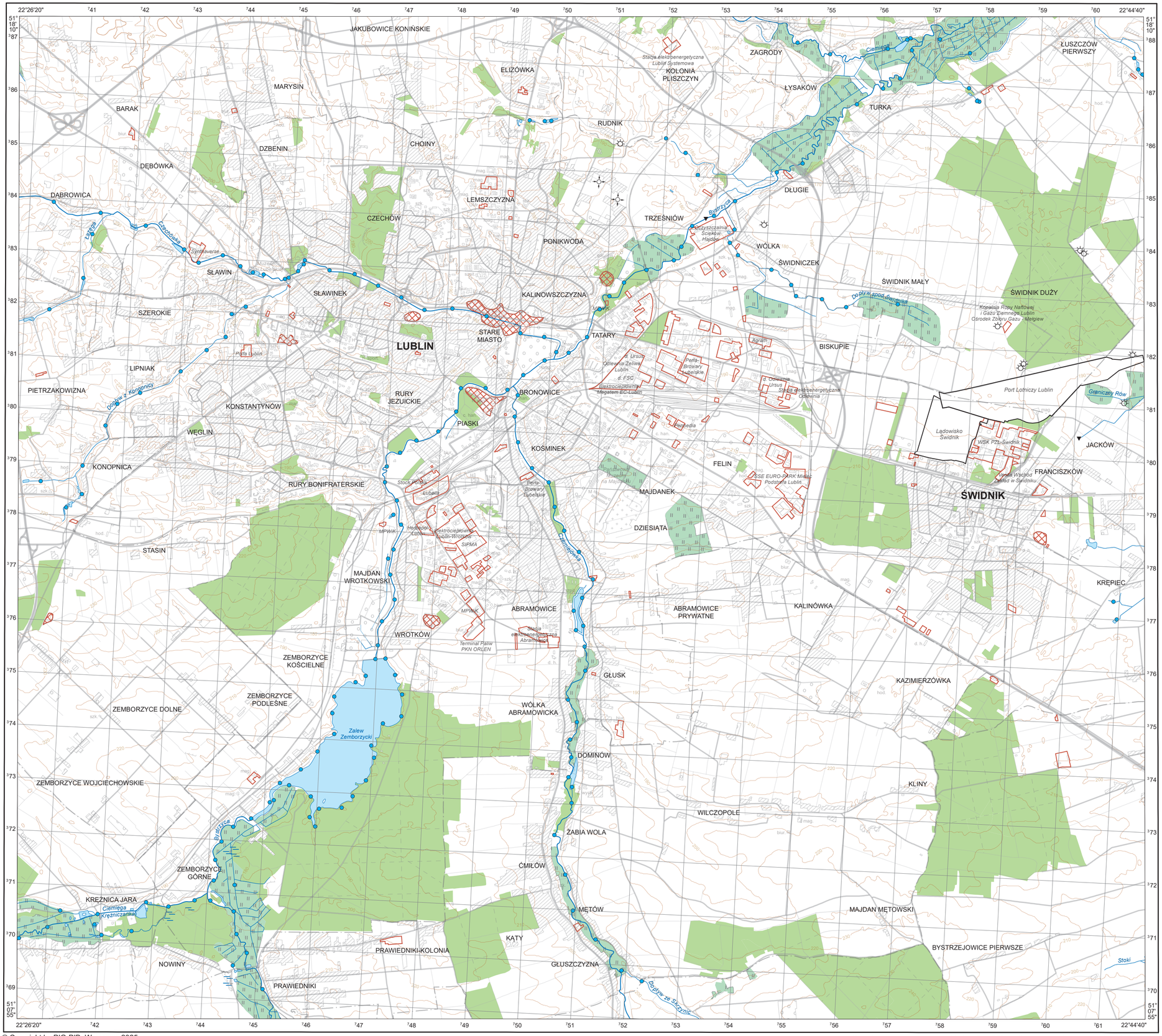
ppm = mg/dm^3

Średnia arytmetyczna	n.o.	Arithmetic mean
Średnia geometryczna	n.o.	Geometric mean
Mediana	<0,003	Median
Granica oznaczalności	0,003	Determination limit

Percentyl Percentile		mg/dm^3
0 – 100	●	<0,003

n = 182

„n.o." nie obliczono, gdy odsetek wyników poniżej granicy oznaczalności przekraczał 50%
not calculated when the percentage of the results below determination limit exceeded 50%



Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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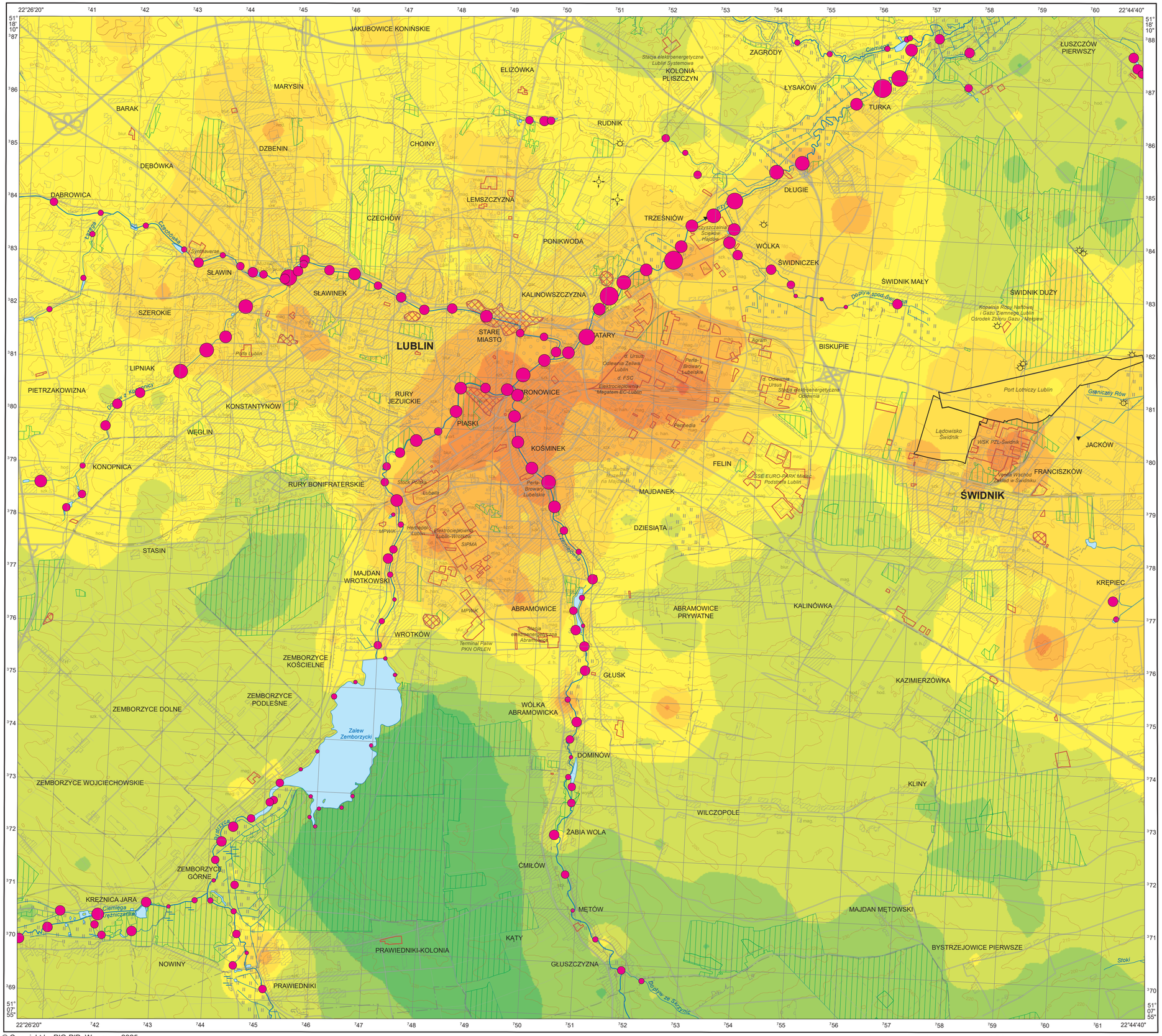
0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Miedź w glebach i osadach wodnych
Copper in soil and aquatic sediment

Cu


JAKUBOWICE KONIŃSKIE
ELIZÓWKA
MARYSIN
BARAK
DZBENIN
DĘBÓWKA
DĄBROWICA
CHOINY
RUDNIK
KOLONIA PLISZCZYN
ZAGRODY
ŁYSAKÓW
TURKA
ŁUSZCZÓW PIERWSZY
DŁUGIE
LEMSZCZYZNA
CZECHÓW
TRZEŚNIÓW
PONIKWODA
WÓLKA
ŚWIDNICZEK
ŚWIDNIK MAŁY
ŚWIDNIK DUŻY
SŁAWIN
SŁAWINEK
KALINOWSZCZYZNA
SZEROKIE
STARE MIASTO
LUBLIN
TATARY
BISKUPIE
LIPNIAK
PIETRZAKOWIZNA
RURY JEZUICKIE
RONOWICE
KONSTANTYNÓW
PIASKI
WĘGLIN
KOŚMINEK
KONOPNICA
FELIN
RURY BONIFRATERSKIE
MAJDANEK
ŚWIDNIK
JACKÓW
FRANCISZKÓW
DZIESIĄTA
STASIN
MAJDAN WROTKOWSKI
KRĘPIEC
ABRAMOWICE
ABRAMOWICE PRYWATNE
KALINÓWKA
WROTKÓW
ZEMBORZYCE KOŚCIELNE
GŁUSK
KAZIMIERZÓWKA
ZEMBORZYCE PODLEŚNE
ZEMBORZYCE DOLNE
WÓLKA ABRAMOWICKA
Zalew Zemborzycki
DOMINÓW
ZEMBORZYCE WOJCIECHOWSKIE
KLINY
WILCZOPOLE
ŻABIA WOLA
ZEMBORZYCE GÓRNE
ĆMIŁÓW
KRĘŻNICA JARA
MĘTÓW
MAJDAN MĘTOWSKI
KĄTY
PRAWIEDNIKI-KOLONIA
BYSTRZEJOWICE PIERWSZE
NOWINY
GŁUSZCZYZNA
PRAWIEDNIKI
Stoki
Bystrzyca
Czerniejowska
Czechowska
Symfonia
Muzeum
Kapela
Pasieka
Lubelska
Kościuszki
Ciemięga
Krężniczanka
Stacja elektroenergetyczna Lublin Systemowa
Oczyszczalnia Ścieków Hajdów
Dopływ spod Świdnika
Kopalnia Ropy Naftowej i Gazu Ziemnego Lublin Ośrodek Zbioru Gazu - Mełgiew
Port Lotniczy Lublin
Graniczny Rów
Lądowisko Świdnik
WSK PZL-Świdnik
Wytwórnia Wkładów Zaworowych w Świdniku
SSE EURO-PARK Mielec Podstrefa Lublin
Stacja elektroenergetyczna Czerwonka
Elektrociepłownia Megaterm EC-Lublin
Perfa-Browary Lubelskie
Perfa Lublin
Perfa-Browary Lubelskie
Perfa-Browary Lubelskie
Perfa-Browary Lubelskie

Miedź w wodach powierzchniowych
Copper in surface water

Cu

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppb = µg/dm³

Średnia arytmetyczna	1,08	Arithmetic mean
Średnia geometryczna	0,67	Geometric mean
Mediana	0,61	Median
Granica oznaczalności	0,05	Determination limit

Percentyl Percentile	
98 – 100	4,99 – 33,87 max.
95 – 98	2,34 – 4,99
90 – 95	1,16 – 2,34
75 – 90	0,82 – 1,16
50 – 75	0,61 – 0,82
25 – 50	0,45 – 0,61
10 – 25	0,37 – 0,45
0 – 10	min. 0,22 – 0,37

n = 182

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Fluorki w wodach powierzchniowych
Fluorides in surface water

F^-

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

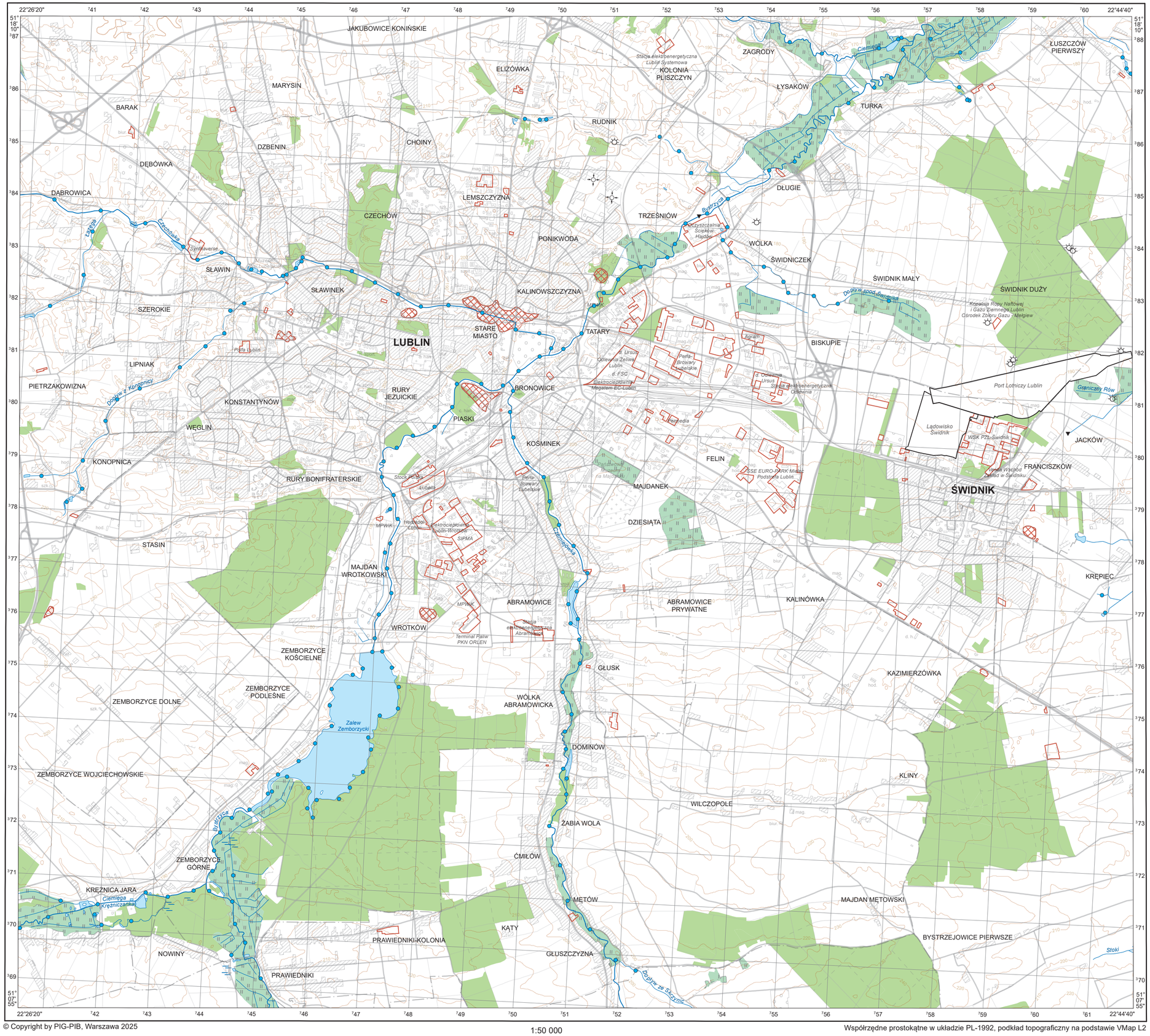
ppm = mg/dm^3

Średnia arytmetyczna	n.o.	Arithmetic mean
Średnia geometryczna	n.o.	Geometric mean
Mediana	<0,10	Median
Granica oznaczalności	0,10	Determination limit

Percentyl Percentile		mg/dm^3
0 – 100	●	<0,10

n = 182

„n.o." nie obliczono, gdy odsetek wyników poniżej granicy oznaczalności przekraczał 50%
not calculated when the percentage of the results below determination limit exceeded 50%



Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Żelazo w glebach i osadach wodnych
Iron in soil and aquatic sediment

Fe

Gleby – parametry statystyczne
Soil – statistical parameters

	%	
Średnia arytmetyczna	0,89	Arithmetic mean
Średnia geometryczna	0,82	Geometric mean
Mediana	0,90	Median
Granica oznaczalności	0,01	Determination limit

Percentyl Percentile	%
100	5,37 max.
98	1,76
95	1,37
90	1,22
75	1,06
50	0,90
25	0,71
10	0,43
0	min. 0,13

n = 909

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

	%	
Średnia arytmetyczna	0,89	Arithmetic mean
Średnia geometryczna	0,73	Geometric mean
Mediana	0,84	Median
Granica oznaczalności	0,01	Determination limit

Percentyl Percentile	%
98 – 100	1,97 – 4,21 max.
95 – 98	1,62 – 1,97
90 – 95	1,42 – 1,62
75 – 90	1,11 – 1,42
50 – 75	0,84 – 1,11
25 – 50	0,59 – 0,84
10 – 25	0,30 – 0,59
0 – 10	min. 0,02 – 0,30

n = 169

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Żelazo w wodach powierzchniowych
Iron in surface water

Fe

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppm = mg/dm^3

Średnia arytmetyczna	0,13	Arithmetic mean
Średnia geometryczna	0,02	Geometric mean
Mediana	0,02	Median
Granica oznaczalności	0,01	Determination limit

Percentyl Percentile	mg/dm^3
98 – 100	0,45 – 13,70 max.
95 – 98	0,19 –0,45
90 – 95	0,08 – 0,19
75 – 90	0,03 – 0,08
50 – 75	0,02 – 0,03
25 – 50	0,01 – 0,02
0 – 25	min.<0,01 – 0,01

n = 182

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy
  Forests
- Obszary przemysłowe
  Industrial areas
- Lotniska
  Airports
- Hałdy i nasypy
  Dumps and embankments
- Miejsca zrzutu ścieków
  Sewage discharge points
- Odwierty eksploatacyjne
  Production boreholes
- Odwierty zatłaczające
  Injection boreholes

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Wodorowęglany w wodach powierzchniowych
Hydrocarbonates in surface water

HCO_3^-

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppm = mg/dm³

Średnia arytmetyczna	255	Arithmetic mean
Średnia geometryczna	238	Geometric mean
Mediana	267	Median
Granica oznaczalności	24	Determination limit

Percentyl Percentile	mg/dm³
98 – 100	411 – 590 max.
95 – 98	397 – 411
90 – 95	360 – 397
75 – 90	317 – 360
50 – 75	267 – 317
25 – 50	181 – 267
10 – 25	149 – 181
0 – 10	min. 43 – 149

n = 182

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Rtęć w glebach i osadach wodnych
Mercury in soil and aquatic sediment

Hg

Gleby – parametry statystyczne
Soil – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	0,05	Arithmetic mean
Średnia geometryczna	0,03	Geometric mean
Mediana	0,03	Median
Granica oznaczalności	0,02	Determination limit

Percentyl Percentile	mg/kg
100	1,94 max.
98	0,19
95	0,11
90	0,08
75	0,05
50	0,03
25	0,02
0	min. <0,02

n = 909

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	0,10	Arithmetic mean
Średnia geometryczna	0,03	Geometric mean
Mediana	0,03	Median
Granica oznaczalności	0,02	Determination limit

Percentyl Percentile	mg/kg
98 – 100	0,63 – 2,46 max.
95 – 98	0,23 – 0,63
90 – 95	0,15 – 0,23
75 – 90	0,06 – 0,15
50 – 75	0,03 – 0,06
0 – 50	min.<0,02 – 0,03

n = 169

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Potas w glebach i osadach wodnych

Potassium in soil and aquatic sediment

K

Gleby – parametry statystyczne
Soil – statistical parameters

	%	
Średnia arytmetyczna	0,13	Arithmetic mean
Średnia geometryczna	0,12	Geometric mean
Mediana	0,13	Median
Granica oznaczalności	0,01	Determination limit

Percentyl Percentile	%
100	0,34 max.
95	0,19
90	0,18
75	0,16
50	0,13
25	0,10
10	0,06
0	min. 0,02

n = 909

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

	%	
Średnia arytmetyczna	0,08	Arithmetic mean
Średnia geometryczna	0,07	Geometric mean
Mediana	0,08	Median
Granica oznaczalności	0,01	Determination limit

Percentyl Percentile	%
98 – 100	0,17 – 0,23 max.
95 – 98	0,15 – 0,17
90 – 95	0,12 – 0,15
75 – 90	0,10 – 0,12
50 – 75	0,08 – 0,10
25 – 50	0,06 – 0,08
10 – 25	0,03 – 0,06
0 – 10	min. 0,01 – 0,03

n = 169

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy – Forests
- Obszary przemysłowe – Industrial areas
- Lotniska – Airports
- Hałdy i nasypy – Dumps and embankments
- Miejsca zrzutu ścieków – Sewage discharge points
- Odwierty eksploatacyjne – Production boreholes
- Odwierty zatłaczające – Injection boreholes

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Potas w wodach powierzchniowych
Potassium in surface water

K

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppm = mg/dm^3

Średnia arytmetyczna	3,3	Arithmetic mean
Średnia geometryczna	2,9	Geometric mean
Mediana	2,7	Median
Granica oznaczalności	0,5	Determination limit

Percentyl Percentile	mg/dm^3
98 – 100	7,5 – 19,1 max.
95 – 98	6,8 – 7,5
90 – 95	5,6 – 6,8
75 – 90	3,3 – 5,6
50 – 75	2,7 – 3,3
25 – 50	2,5 – 2,7
10 – 25	1,9 – 2,5
0 – 10	min.<0,5 – 1,9

n = 182

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Lit w glebach i osadach wodnych
Lithium in soil and aquatic sediment

Li

Gleby – parametry statystyczne
Soil – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	5,6	Arithmetic mean
Średnia geometryczna	5,3	Geometric mean
Mediana	5,7	Median
Granica oznaczalności	0,5	Determination limit

Percentyl Percentile	mg/kg
100	17,9 max.
98	8,8
95	8,1
90	7,5
75	6,7
50	5,7
25	4,5
10	3,2
0	min. 0,6

n = 909

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	5,0	Arithmetic mean
Średnia geometryczna	4,3	Geometric mean
Mediana	5,0	Median
Granica oznaczalności	0,5	Determination limit

Percentyl Percentile	mg/kg
98 – 100	9,9 – 16,5 max.
95 – 98	8,8 – 9,9
90 – 95	8,1 – 8,8
75 – 90	6,4 – 8,1
50 – 75	5,0 – 6,4
25 – 50	3,6 – 5,0
10 – 25	1,7 – 3,6
0 – 10	min. 0,5 – 1,7

n = 169

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy – Forests
- Obszary przemysłowe – Industrial areas
- Lotniska – Airports
- Hałdy i nasypy – Dumps and embankments
- Miejsca zrzutu ścieków – Sewage discharge points
- Odwierty eksploatacyjne – Production boreholes
- Odwierty zatłaczające – Injection boreholes

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Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Lit w wodach powierzchniowych
Lithium in surface water

Li

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppb = µg/dm^3

Średnia arytmetyczna	4,7	Arithmetic mean
Średnia geometryczna	4,5	Geometric mean
Mediana	4,8	Median
Granica oznaczalności	0,3	Determination limit

Percentyl Percentile	µg/dm^3
98 – 100	7,0 – 7,7 max.
95 – 98	6,3 – 7,0
90 – 95	5,9 – 6,3
75 – 90	5,2 – 5,9
50 – 75	4,8 – 5,2
25 – 50	4,4 – 4,8
10 – 25	3,9 – 4,4
0 – 10	min. 0,4 – 3,9

n = 182

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Magnez w glebach i osadach wodnych

Magnesium in soil and aquatic sediment

Mg

Gleby – parametry statystyczne
Soil – statistical parameters

	%	
Średnia arytmetyczna	0,17	Arithmetic mean
Średnia geometryczna	0,14	Geometric mean
Mediana	0,15	Median
Granica oznaczalności	0,01	Determination limit

Percentyl Percentile	%	
100		0,93 max.
98		0,48
95		0,38
90		0,30
75		0,21
50		0,15
25		0,11
10		0,06
0		min. 0,01

n = 909

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

	%	
Średnia arytmetyczna	0,22	Arithmetic mean
Średnia geometryczna	0,17	Geometric mean
Mediana	0,18	Median
Granica oznaczalności	0,01	Determination limit

Percentyl Percentile	%
98 – 100	0,78 – 0,93 max.
95 – 98	0,44 – 0,78
90 – 95	0,39 – 0,44
75 – 90	0,31 – 0,39
50 – 75	0,18 – 0,31
25 – 50	0,12 – 0,18
10 – 25	0,06 – 0,12
0 – 10	min. <0,01 – 0,06

n = 169

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy – Forests
- Obszary przemysłowe – Industrial areas
- Lotniska – Airports
- Hałdy i nasypy – Dumps and embankments
- Miejsca zrzutu ścieków – Sewage discharge points
- Odwierty eksploatacyjne – Production boreholes
- Odwierty zatłaczające – Injection boreholes

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Magnez w wodach powierzchniowych
Magnesium in surface water

Mg

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppm = mg/dm^3

Średnia arytmetyczna	9,7	Arithmetic mean
Średnia geometryczna	8,2	Geometric mean
Mediana	7,0	Median
Granica oznaczalności	0,1	Determination limit

Percentyl Percentile		µg/dm^3
98 – 100	●	21,9 – 31,4 max.
95 – 98	●	20,8 – 21,9
90 – 95	●	19,9 – 20,8
75 – 90	●	11,2 – 19,9
50 – 75	●	7,0 – 11,2
25 – 50	●	6,6 – 7,0
10 – 25	●	5,9 – 6,6
0 – 10	●	min. 0,8 – 5,9

n = 182

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- ▼ Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Mangan w glebach i osadach wodnych
Manganese in soil and aquatic sediment

Mn

Gleby – parametry statystyczne
Soil – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	317	Arithmetic mean
Średnia geometryczna	292	Geometric mean
Mediana	305	Median
Granica oznaczalności	2	Determination limit

Percentyl Percentile	mg/kg	
100	1142	max.
98	566	
95	513	
90	464	
75	384	
50	305	
25	246	
10	189	
0	min. 8	

n = 909

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	286	Arithmetic mean
Średnia geometryczna	184	Geometric mean
Mediana	215	Median
Granica oznaczalności	2	Determination limit

Percentyl Percentile	mg/kg	
98 – 100	925 – 3530	max.
95 – 98	644 – 925	
90 – 95	515 – 644	
75 – 90	332 – 515	
50 – 75	215 – 332	
25 – 50	118 – 215	
10 – 25	58 – 118	
0 – 10	min. 3 – 58	

n = 169

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy – Forests
- Obszary przemysłowe – Industrial areas
- Lotniska – Airports
- Hałdy i nasypy – Dumps and embankments
- Miejsca zrzutu ścieków – Sewage discharge points
- Odwierty eksploatacyjne – Production boreholes
- Odwierty zatłaczające – Injection boreholes

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Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Mangan w wodach powierzchniowych
Manganese in surface water

Mn

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppm = mg/dm^3

Średnia arytmetyczna	0,091	Arithmetic mean
Średnia geometryczna	0,029	Geometric mean
Mediana	0,033	Median
Granica oznaczalności	0,001	Determination limit

Percentyl Percentile	mg/dm^3
98 – 100	1,350 – 2,527 max.
95 – 98	0,222 – 1,350
90 – 95	0,148 – 0,222
75 – 90	0,057 – 0,148
50 – 75	0,033 – 0,057
25 – 50	0,021 – 0,033
10 – 25	0,003 – 0,021
0 – 10	min.<0,001 – 0,003

n = 182

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Molibden w glebach i osadach wodnych
Molybdenum in soil and aquatic sediment

Mo

Gleby – parametry statystyczne
Soil – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	0,38	Arithmetic mean
Średnia geometryczna	0,29	Geometric mean
Mediana	0,26	Median
Granica oznaczalności	0,05	Determination limit

Percentyl Percentile	mg/kg
100	18,41 max.
98	1,57
95	0,93
90	0,55
75	0,33
50	0,26
25	0,21
10	0,18
0	min. 0,12

n = 909

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	0,69	Arithmetic mean
Średnia geometryczna	0,42	Geometric mean
Mediana	0,41	Median
Granica oznaczalności	0,05	Determination limit

Percentyl Percentile	mg/kg
98 – 100	4,11 – 5,40 max.
95 – 98	2,05 – 4,11
90 – 95	1,71 – 2,05
75 – 90	0,84 – 1,71
50 – 75	0,41 – 0,84
25 – 50	0,21 – 0,41
10 – 25	0,12 – 0,21
0 – 10	min. <0,05 – 0,12

n = 169

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy — Forests
- Obszary przemysłowe — Industrial areas
- Lotniska — Airports
- Hałdy i nasypy — Dumps and embankments
- Miejsca zrzutu ścieków — Sewage discharge points
- Odwierty eksploatacyjne — Production boreholes
- Odwierty zatłaczające — Injection boreholes

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Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Molibden w wodach powierzchniowych
Molybdenum in surface water

Mo

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppb = µg/dm^3

Średnia arytmetyczna	1,82	Arithmetic mean
Średnia geometryczna	1,16	Geometric mean
Mediana	1,03	Median
Granica oznaczalności	0,05	Determination limit

Percentyl Percentile	µg/dm^3
98 – 100	14,11 – 26,57 max.
95 – 98	4,08 – 14,11
90 – 95	2,16 – 4,08
75 – 90	1,55 – 2,16
50 – 75	1,03 – 1,55
25 – 50	0,85 – 1,03
10 – 25	0,60 – 0,85
0 – 10	min. 0,10 – 0,60

n = 182

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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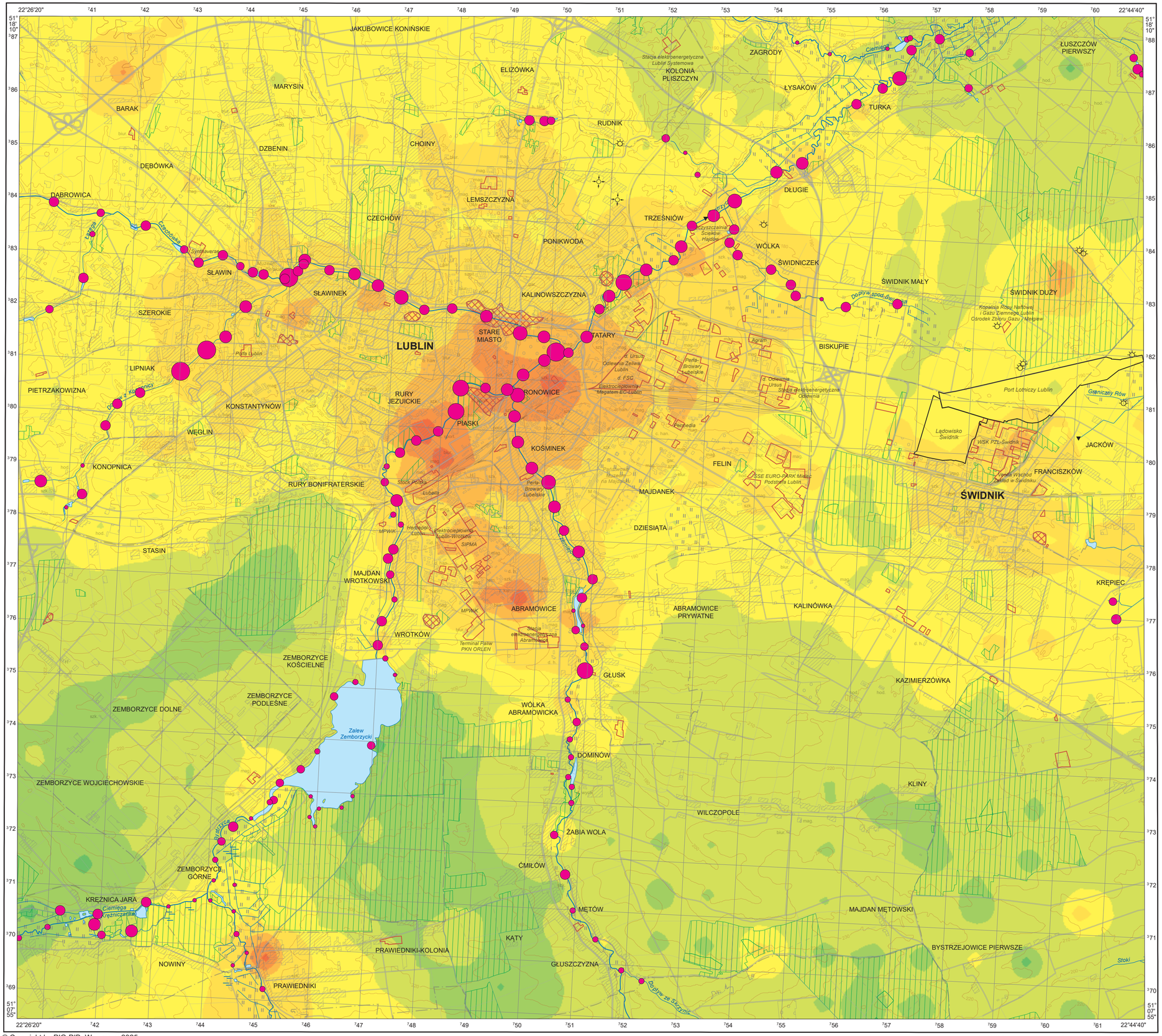
Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Sód w glebach i osadach wodnych
Sodium in soil and aquatic sediment

Na



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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Gleby – parametry statystyczne
Soil – statistical parameters

	%	
Średnia arytmetyczna	0,011	Arithmetic mean
Średnia geometryczna	0,009	Geometric mean
Mediana	0,008	Median
Granica oznaczalności	0,003	Determination limit

Percentyl / Percentile	%
100	0,172 max.
98	0,037
95	0,025
90	0,018
75	0,011
50	0,008
25	0,006
10	0,005
0	min. 0,004

n = 909

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

	%	
Średnia arytmetyczna	0,015	Arithmetic mean
Średnia geometryczna	0,012	Geometric mean
Mediana	0,011	Median
Granica oznaczalności	0,003	Determination limit

Percentyl / Percentile	%
98 – 100	0,052 – 0,077 max.
95 – 98	0,034 – 0,052
90 – 95	0,030 – 0,034
75 – 90	0,020 – 0,030
50 – 75	0,011 – 0,020
25 – 50	0,008 – 0,011
10 – 25	0,006 – 0,008
0 – 10	min. 0,003 – 0,006

n = 169

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

Sód w wodach powierzchniowych
Sodium in surface water

Na

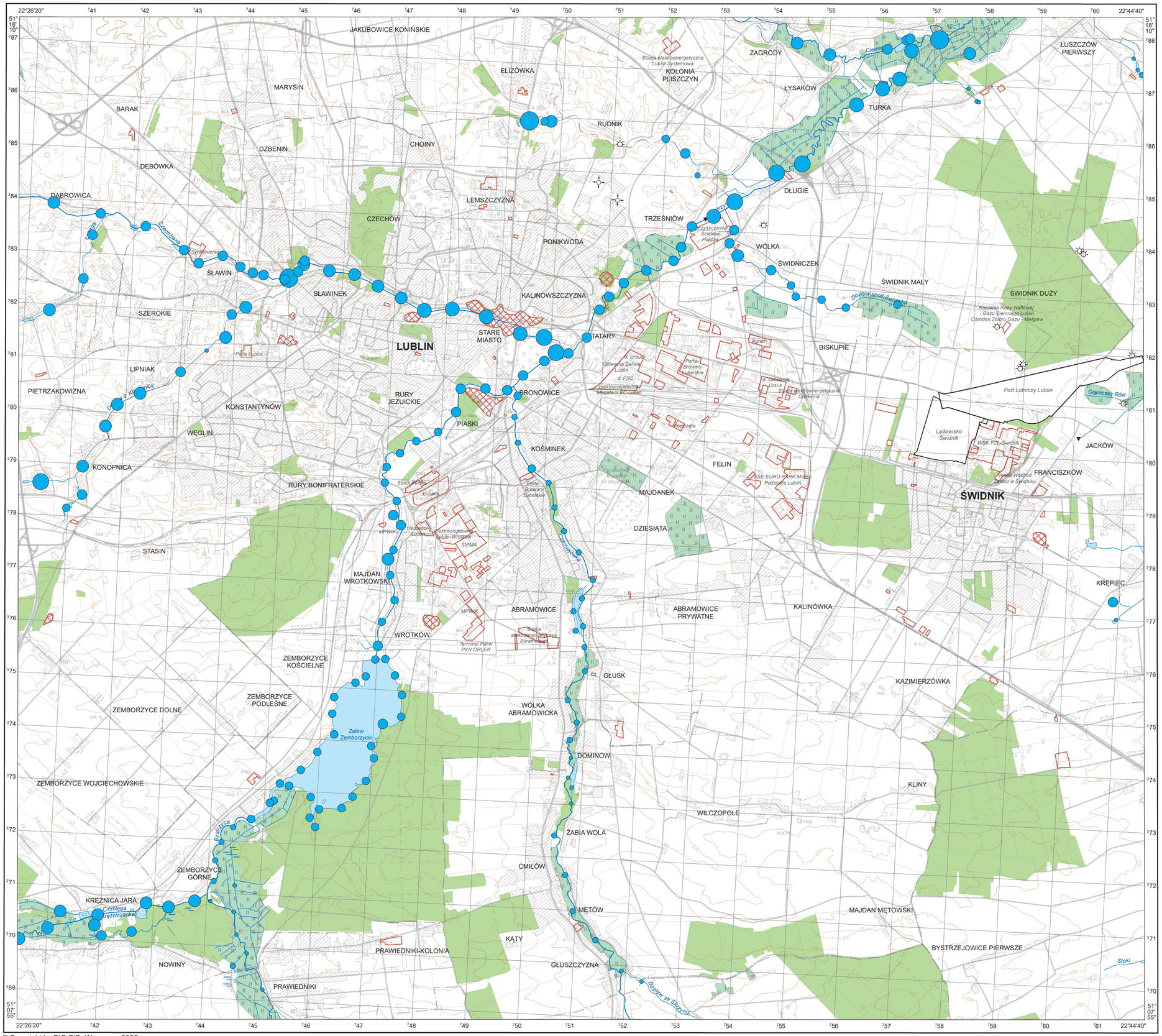
Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppm = mg/dm^3

Średnia arytmetyczna	10,2	Arithmetic mean
Średnia geometryczna	8,6	Geometric mean
Mediana	7,8	Median
Granica oznaczalności	0,5	Determination limit

Percentyl Percentile	mg/dm^3
98 – 100	27,1 – 148,1 max.
95 – 98	20,1 – 27,1
90 – 95	14,3 – 20,1
75 – 90	11,0 – 14,3
50 – 75	7,8 – 11,0
25 – 50	6,5 – 7,8
10 – 25	4,9 – 6,5
0 – 10	min. 2,4 – 4,9

n = 182



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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

Jon amonowy w wodach powierzchniowych
Ammonium ion in surface water

NH_4^+

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppm = mg/dm^3

Średnia arytmetyczna	0,20	Arithmetic mean
Średnia geometryczna	0,11	Geometric mean
Mediana	0,11	Median
Granica oznaczalności	0,05	Determination limit

Percentyl Percentile	mg/dm^3
98 – 100	0,76 – 2,23 max.
95 – 98	0,60 – 0,76
90 – 95	0,45 – 0,60
75 – 90	0,26 – 0,45
50 – 75	0,11 – 0,26
25 – 50	0,06 – 0,11
0 – 25	min.<0,05 – 0,06

n = 182

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Nikiel w glebach i osadach wodnych
Nickel in soil and aquatic sediment

Ni

Gleby – parametry statystyczne
Soil – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	11	Arithmetic mean
Średnia geometryczna	9	Geometric mean
Mediana	10	Median
Granica oznaczalności	1	Determination limit

Percentyl Percentile	mg/kg
100	649 max.
98	24
95	16
90	14
75	12
50	10
25	7
10	4
0	min. 1

n = 909

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	13	Arithmetic mean
Średnia geometryczna	9	Geometric mean
Mediana	11	Median
Granica oznaczalności	1	Determination limit

Percentyl Percentile	mg/kg
98 – 100	30 – 154 max.
95 – 98	25 – 30
90 – 95	21 – 25
75 – 90	15 – 21
50 – 75	11 – 15
25 – 50	7 – 11
10 – 25	4 – 7
0 – 10	min. <1 – 4

n = 169

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Nikiel w wodach powierzchniowych
Nickel in surface water

Ni

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppb = µg/dm^3

Średnia arytmetyczna	1,6	Arithmetic mean
Średnia geometryczna	1,3	Geometric mean
Mediana	1,4	Median
Granica oznaczalności	0,5	Determination limit

Percentyl Percentile	µg/dm^3
98 – 100	4,9 – 10,8 max.
95 – 98	3,0 – 4,9
90 – 95	2,6 – 3,0
75 – 90	2,0 – 2,6
50 – 75	1,4 – 2,0
25 – 50	0,9 – 1,4
10 – 25	0,7 – 0,9
0 – 10	min.<0,5 – 0,7

n = 182

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Azotany (III) w wodach powierzchniowych
Nitrites in surface water

NO_2^-

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppm = mg/dm^3

Średnia arytmetyczna	0,14	Arithmetic mean
Średnia geometryczna	0,08	Geometric mean
Mediana	0,11	Median
Granica oznaczalności	0,01	Determination limit

Percentyl Percentile	mg/dm^3
98 – 100	0,67 – 0,74 max.
95 – 98	0,41 – 0,67
90 – 95	0,26 – 0,41
75 – 90	0,18 – 0,26
50 – 75	0,11 – 0,18
0 – 50	min.<0,01 – 0,11

n = 182

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Azotany (V) w wodach powierzchniowych
Nitrates in surface water

NO_3^-

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppm = mg/dm³

Średnia arytmetyczna	7,32	Arithmetic mean
Średnia geometryczna	3,23	Geometric mean
Mediana	5,94	Median
Granica oznaczalności	0,01	Determination limit

Percentyl / Percentile	mg/dm³
98 – 100	22,80 – 34,20 max.
95 – 98	16,20 – 22,80
90 – 95	15,40 – 16,20
75 – 90	12,40 – 15,40
50 – 75	5,94 – 12,40
25 – 50	1,20 – 5,94
10 – 25	0,16 – 1,20
0 – 10	min. 0,07 – 0,16

n = 182

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Fosfor w glebach i osadach wodnych
Phosphorus in soil and aquatic sediment

P

Gleby – parametry statystyczne
Soil – statistical parameters

%

Średnia arytmetyczna	0,052	Arithmetic mean
Średnia geometryczna	0,043	Geometric mean
Mediana	0,044	Median
Granica oznaczalności	0,002	Determination limit

Percentyl Percentile	%
100	1,290 max.
98	0,135
95	0,096
90	0,075
75	0,056
50	0,044
25	0,034
10	0,023
0	min. 0,005

n = 909

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

%

Średnia arytmetyczna	0,074	Arithmetic mean
Średnia geometryczna	0,056	Geometric mean
Mediana	0,059	Median
Granica oznaczalności	0,002	Determination limit

Percentyl Percentile	%
98 – 100	0,198 – 0,688 max.
95 – 98	0,154 – 0,198
90 – 95	0,119 – 0,154
75 – 90	0,093 – 0,119
50 – 75	0,059 – 0,093
25 – 50	0,041 – 0,059
10 – 25	0,025 – 0,041
0 – 10	min. <0,002 – 0,025

n = 169

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy – Forests
- Obszary przemysłowe – Industrial areas
- Lotniska – Airports
- Hałdy i nasypy – Dumps and embankments
- Miejsca zrzutu ścieków – Sewage discharge points
- Odwierty eksploatacyjne – Production boreholes
- Odwierty zatłaczające – Injection boreholes

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Fosfor w wodach powierzchniowych
Phosphorus in surface water

P

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppm = mg/dm^3

Średnia arytmetyczna	0,13	Arithmetic mean
Średnia geometryczna	0,09	Geometric mean
Mediana	0,12	Median
Granica oznaczalności	0,05	Determination limit

Percentyl Percentile	mg/dm^3
98 – 100	0,37 – 0,90 max.
95 – 98	0,34 – 0,37
90 – 95	0,28 – 0,34
75 – 90	0,17 – 0,28
50 – 75	0,12 – 0,17
0 – 50	min.<0,05 – 0,12

n = 182

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Ołów w glebach i osadach wodnych
Lead in soil and aquatic sediment

Pb

Gleby – parametry statystyczne
Soil – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	19,91	Arithmetic mean
Średnia geometryczna	15,11	Geometric mean
Mediana	12,97	Median
Granica oznaczalności	0,05	Determination limit

Percentyl Percentile	mg/kg
100	340,79 max.
98	95,94
95	53,25
90	32,56
75	17,24
50	12,97
25	10,84
10	9,03
0	min. 3,35

n = 909

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	16,65	Arithmetic mean
Średnia geometryczna	12,38	Geometric mean
Mediana	13,31	Median
Granica oznaczalności	0,05	Determination limit

Percentyl Percentile	mg/kg
98 – 100	52,65 – 127,53 max.
95 – 98	36,04 – 52,65
90 – 95	32,25 – 36,04
75 – 90	18,78 – 32,25
50 – 75	13,31 – 18,78
25 – 50	8,15 – 13,31
10 – 25	3,89 – 8,15
0 – 10	min. 1,09 – 3,89

n = 169

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Ołów w wodach powierzchniowych
Lead in surface water

Pb

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppb = µg/dm^3

Średnia arytmetyczna	0,07	Arithmetic mean
Średnia geometryczna	<0,05	Geometric mean
Mediana	0,05	Median
Granica oznaczalności	0,05	Determination limit

Percentyl Percentile		µg/dm^3
98 – 100	●	0,34 – 0,73 max.
95 – 98	●	0,19 – 0,34
90 – 95	●	0,11 – 0,19
75 – 90	●	0,07 – 0,11
50 – 75	●	0,05 – 0,07
0 – 50	●	min. <0,05 – 0,05

n = 182

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Siarka w glebach i osadach wodnych
Sulphur in soil and aquatic sediment

S

Gleby – parametry statystyczne
Soil – statistical parameters

	%	
Średnia arytmetyczna	0,023	Arithmetic mean
Średnia geometryczna	0,018	Geometric mean
Mediana	0,016	Median
Granica oznaczalności	0,003	Determination limit

Percentyl Percentile	%	
100		0,726 max.
98		0,085
95		0,057
90		0,041
75		0,023
50		0,016
25		0,012
10		0,010
0		min. <0,003

n = 909

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

	%	
Średnia arytmetyczna	0,159	Arithmetic mean
Średnia geometryczna	0,092	Geometric mean
Mediana	0,100	Median
Granica oznaczalności	0,003	Determination limit

Percentyl Percentile	%	
98 – 100		0,716 – 1,135 max.
95 – 98		0,499 – 0,716
90 – 95		0,357 – 0,499
75 – 90		0,199 – 0,357
50 – 75		0,100 – 0,199
25 – 50		0,039 – 0,100
10 – 25		0,021 – 0,039
0 – 10		min. 0,006 – 0,021

n = 169

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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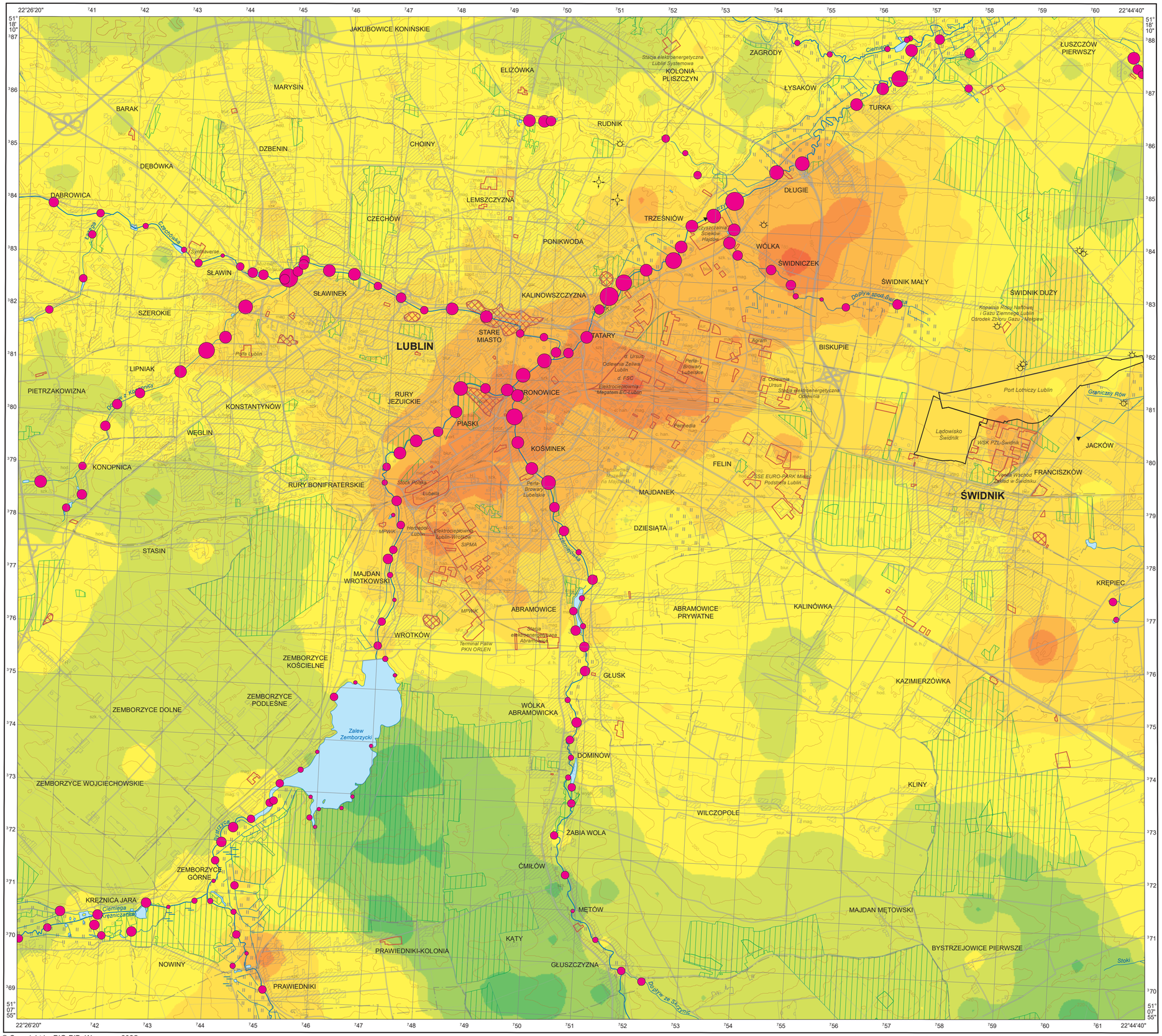
Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Antymon w glebach i osadach wodnych
Antimony in soil and aquatic sediment

Sb



Gleby – parametry statystyczne
Soil – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	0,43	Arithmetic mean
Średnia geometryczna	0,30	Geometric mean
Mediana	0,25	Median
Granica oznaczalności	0,05	Determination limit

Percentyl Percentile	mg/kg
100	10,70 max.
98	2,41
95	1,15
90	0,64
75	0,37
50	0,25
25	0,20
10	0,17
0	min. 0,06

n = 909

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	0,63	Arithmetic mean
Średnia geometryczna	0,34	Geometric mean
Mediana	0,34	Median
Granica oznaczalności	0,05	Determination limit

Percentyl Percentile	mg/kg
98 – 100	2,57 – 5,63 max.
95 – 98	2,27 – 2,57
90 – 95	1,69 – 2,27
75 – 90	0,66 – 1,69
50 – 75	0,34 – 0,66
25 – 50	0,16 – 0,34
10 – 25	0,10 – 0,16
0 – 10	min. <0,05 – 0,10

n = 169

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

Antymon w wodach powierzchniowych
Antimony in surface water

Sb

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppb = µg/dm^3

Średnia arytmetyczna	0,18	Arithmetic mean
Średnia geometryczna	0,14	Geometric mean
Mediana	0,12	Median
Granica oznaczalności	0,05	Determination limit

Percentyl Percentile	µg/dm^3
98 – 100	0,81 – 2,45 max.
95 – 98	0,39 – 0,81
90 – 95	0,26 – 0,39
75 – 90	0,16 – 0,26
50 – 75	0,12 – 0,16
25 – 50	0,11 – 0,12
10 – 25	0,08 – 0,11
0 – 10	min. <0,05 – 0,08

n = 182

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Selen w glebach i osadach wodnych
Selenium in soil and aquatic sediment

Se

Gleby – parametry statystyczne
Soil – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	n.o.	Arithmetic mean
Średnia geometryczna	n.o.	Geometric mean
Mediana	<2	Median
Granica oznaczalności	2	Determination limit

Percentyl / Percentile	mg/kg
100	10 max.
0	min. <2

n = 909

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	n.o.	Arithmetic mean
Średnia geometryczna	n.o.	Geometric mean
Mediana	<2	Median
Granica oznaczalności	2	Determination limit

Percentyl / Percentile	mg/kg
98 – 100	6 – 8 max.
95 – 98	5 – 6
90 – 95	4 – 5
75 – 90	3 – 4
0 – 75	min. <2 – 3

n = 169

„n.o." nie obliczono, gdy odsetek wyników poniżej granicy oznaczalności przekraczał 50%
not calculated when the percentage of the results below determination limit exceeded 50%

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Selen w wodach powierzchniowych
Selenium in surface water

Se

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

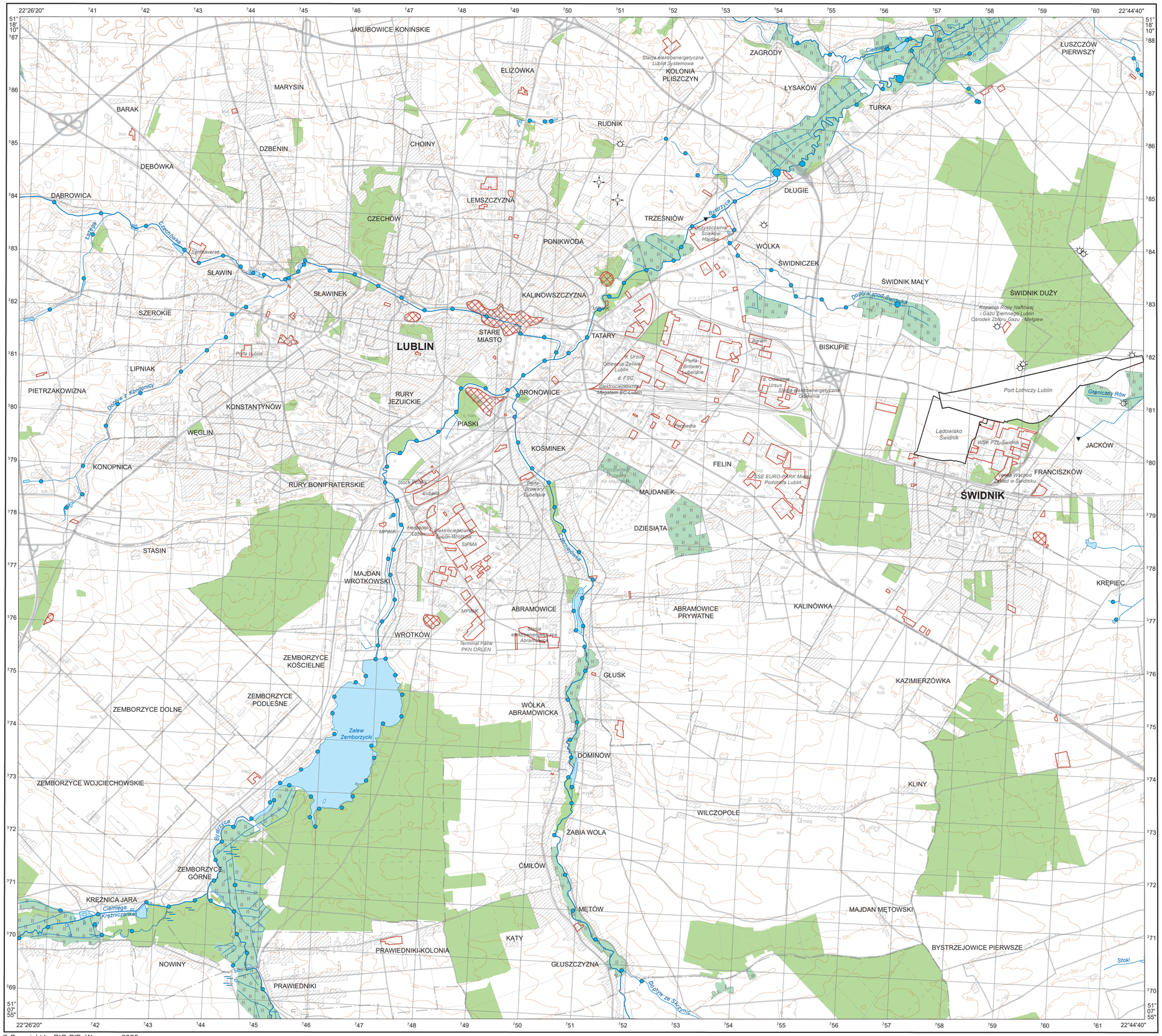
ppb = µg/dm^3

Średnia arytmetyczna	n.o.	Arithmetic mean
Średnia geometryczna	n.o.	Geometric mean
Mediana	<2	Median
Granica oznaczalności	2	Determination limit

Percentyl Percentile	µg/dm^3	
98 – 100	●	3 – 9 max.
95 – 98	●	2 – 3
0 – 95	•	min. <2 – 2

n = 182

„n.o." nie obliczono, gdy odsetek wyników poniżej granicy oznaczalności przekraczał 50%
not calculated when the percentage of the results below determination limit exceeded 50%



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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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Krzemionka w wodach powierzchniowych

Silica in surface water

SiO_2

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppm = mg/dm^3

Średnia arytmetyczna	20,9	Arithmetic mean
Średnia geometryczna	16,3	Geometric mean
Mediana	24,7	Median
Granica oznaczalności	0,1	Determination limit

Percentyl Percentile		mg/dm^3
98 – 100	●	33,8 – 38,0 max.
95 – 98	●	33,3 – 33,8
90 – 95	●	30,2 – 33,3
75 – 90	●	29,0 – 30,2
50 – 75	●	24,7 – 29,0
25 – 50	●	10,5 – 24,7
10 – 25	●	3,9 – 10,5
0 – 10	•	min. 0,5 – 3,9

n = 182

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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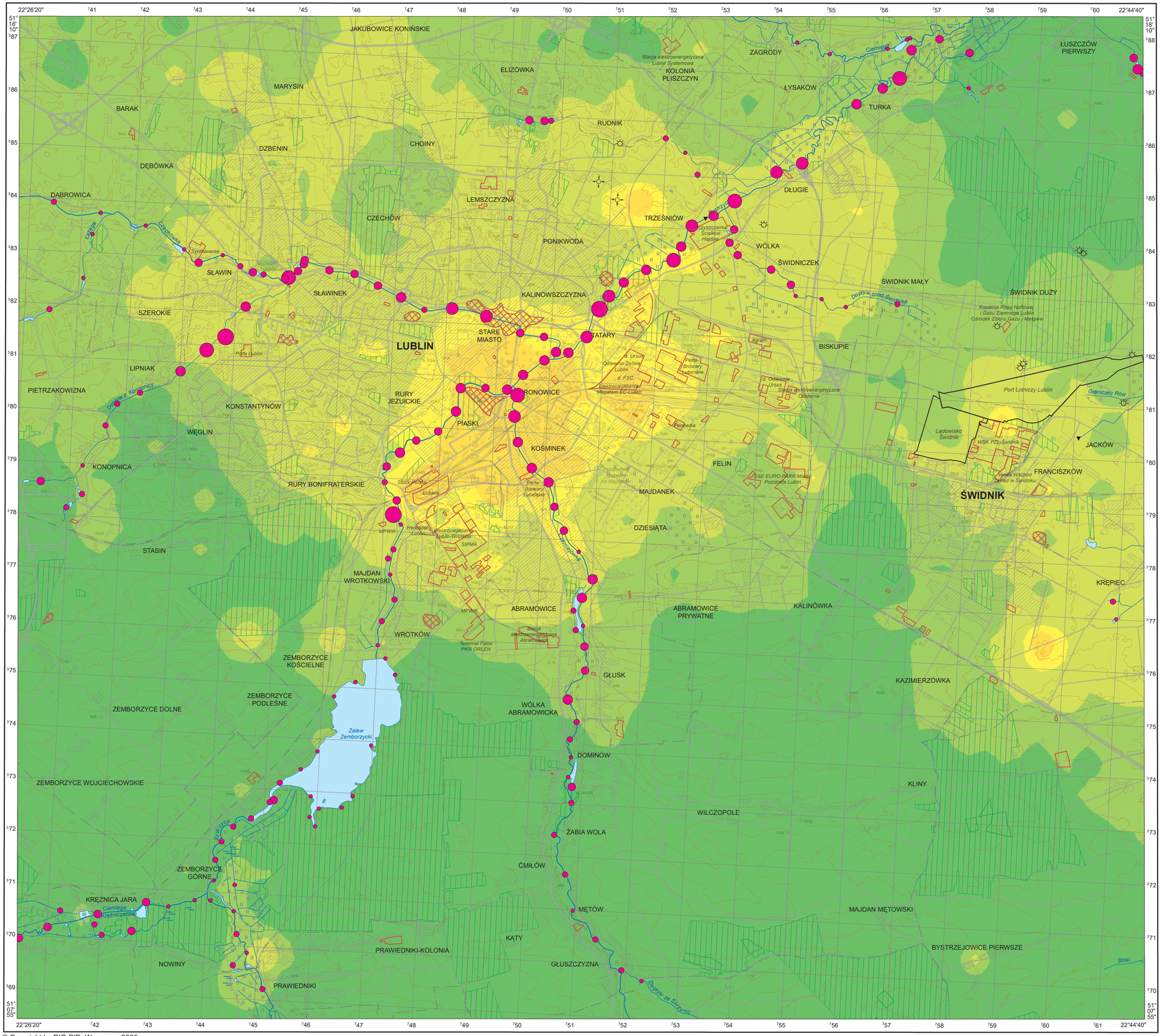
0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Cyna w glebach i osadach wodnych
Tin in soil and aquatic sediment

Sn



Gleby – parametry statystyczne
Soil – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	1,0	Arithmetic mean
Średnia geometryczna	0,7	Geometric mean
Mediana	0,6	Median
Granica oznaczalności	0,5	Determination limit

Percentyl Percentile	mg/kg
100	17,7 max.
95	2,9
90	1,9
75	0,9
50	0,6
0	min. <0,5

n = 909

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	1,8	Arithmetic mean
Średnia geometryczna	1,0	Geometric mean
Mediana	0,9	Median
Granica oznaczalności	0,5	Determination limit

Percentyl Percentile	mg/kg
98 – 100	8,2 – 10,9 max.
95 – 98	5,6 – 8,2
90 – 95	4,6 – 5,6
75 – 90	2,5 – 4,6
50 – 75	0,9 – 2,5
25 – 50	0,5 – 0,9
0 – 25	min. <0,5 – 0,5

n = 169

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Cyna w wodach powierzchniowych
Tin in surface water

Sn

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

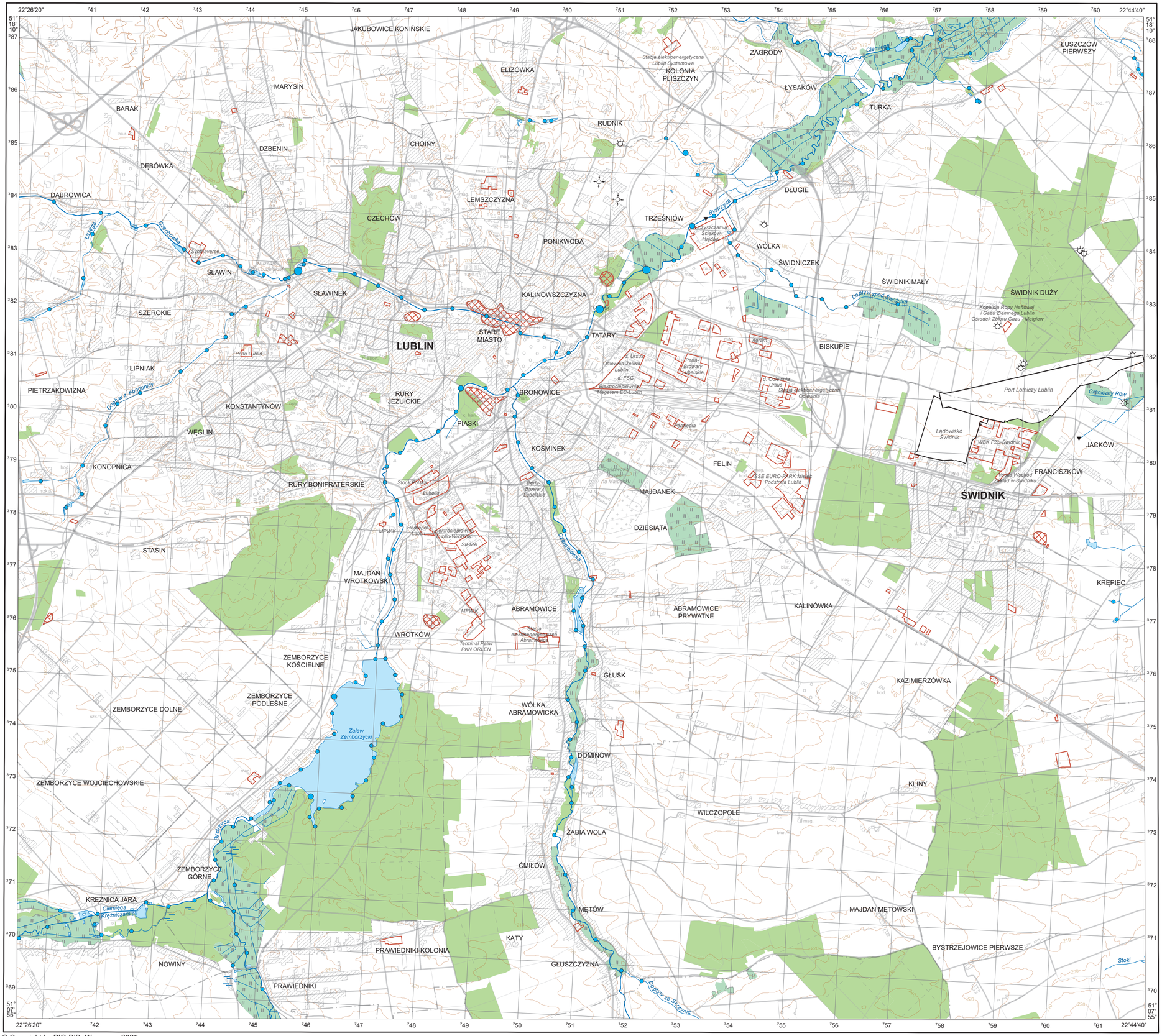
ppb = µg/dm^3

Średnia arytmetyczna	n.o.	Arithmetic mean
Średnia geometryczna	n.o.	Geometric mean
Mediana	<0,5	Median
Granica oznaczalności	0,5	Determination limit

Percentyl Percentile	µg/dm^3
98 – 100	3,7 – 3,9 max.
95 – 98	0,7 – 3,7
0 – 95	min. <0,5 – 0,7

n = 182

„n.o." nie obliczono, gdy odsetek wyników poniżej granicy oznaczalności przekraczał 50%
not calculated when the percentage of the results below determination limit exceeded 50%



Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Siarczany (VI) w wodach powierzchniowych
Sulphates in surface water

SO_4^{2-}

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppm = mg/dm³

Średnia arytmetyczna	29,6	Arithmetic mean
Średnia geometryczna	24,8	Geometric mean
Mediana	27,7	Median
Granica oznaczalności	0,5	Determination limit

Percentyl Percentile	mg/dm³
98 – 100	67,0 – 76,9 max.
95 – 98	63,4 – 67,0
90 – 95	49,7 – 63,4
75 – 90	32,3 – 49,7
50 – 75	27,7 – 32,3
25 – 50	22,8 – 27,7
10 – 25	16,7 – 22,8
0 – 10	min. <0,5 – 16,7

n = 182

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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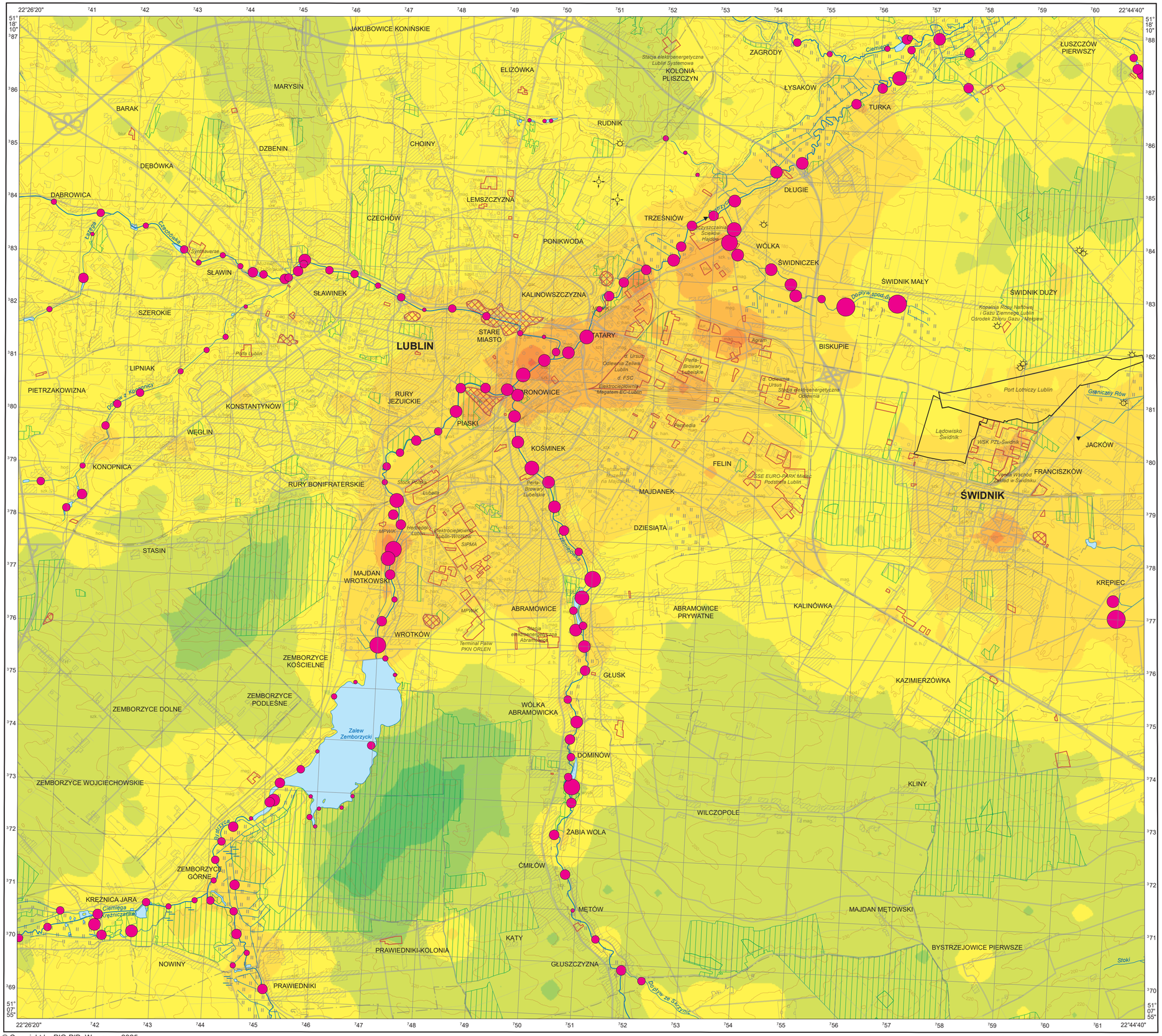
1:50 000

0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Stront w glebach i osadach wodnych
Strontium in soil and aquatic sediment

Sr



Gleby – parametry statystyczne
Soil – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	37	Arithmetic mean
Średnia geometryczna	19	Geometric mean
Mediana	18	Median
Granica oznaczalności	1	Determination limit

Percentyl Percentile	mg/kg
100	545 max.
98	207
95	141
90	95
75	41
50	18
25	9
10	5
0	min. 1

n = 909

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	109	Arithmetic mean
Średnia geometryczna	77	Geometric mean
Mediana	89	Median
Granica oznaczalności	1	Determination limit

Percentyl Percentile	mg/kg
98 – 100	305 – 445 max.
95 – 98	232 – 305
90 – 95	206 – 232
75 – 90	164 – 206
50 – 75	89 – 164
25 – 50	48 – 89
10 – 25	25 – 48
0 – 10	min. 2 – 25

n = 169

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Stront wodach powierzchniowych
Strontium in surface water

Sr

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppm = mg/dm^3

Średnia arytmetyczna	0,652	Arithmetic mean
Średnia geometryczna	0,575	Geometric mean
Mediana	0,664	Median
Granica oznaczalności	0,002	Determination limit

Percentyl Percentile	mg/dm^3
98 – 100	1,251 – 1,618 max.
95 – 98	1,187 – 1,251
90 – 95	0,948 – 1,187
75 – 90	0,782 – 0,948
50 – 75	0,664 – 0,782
25 – 50	0,525 – 0,664
10 – 25	0,376 – 0,525
0 – 10	min. 0,032 – 0,376

n = 182

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Tytan w glebach i osadach wodnych
Titanium in soil and aquatic sediment

Ti

Gleby – parametry statystyczne
Soil – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	113	Arithmetic mean
Średnia geometryczna	102	Geometric mean
Mediana	111	Median
Granica oznaczalności	5	Determination limit

Percentyl Percentile	mg/kg
100	530 max.
98	210
95	186
90	167
75	142
50	111
25	77
10	50
0	min. 19

n = 909

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	97	Arithmetic mean
Średnia geometryczna	82	Geometric mean
Mediana	87	Median
Granica oznaczalności	5	Determination limit

Percentyl Percentile	mg/kg
98 – 100	267 – 426 max.
95 – 98	174 – 267
90 – 95	153 – 174
75 – 90	125 – 153
50 – 75	87 – 125
25 – 50	62 – 87
10 – 25	33 – 62
0 – 10	min. 12 – 33

n = 169

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy – Forests
- Obszary przemysłowe – Industrial areas
- Lotniska – Airports
- Hałdy i nasypy – Dumps and embankments
- Miejsca zrzutu ścieków – Sewage discharge points
- Odwierty eksploatacyjne – Production boreholes
- Odwierty zatłaczające – Injection boreholes

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Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Tytan w wodach powierzchniowych
Titanium in surface water

Ti

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

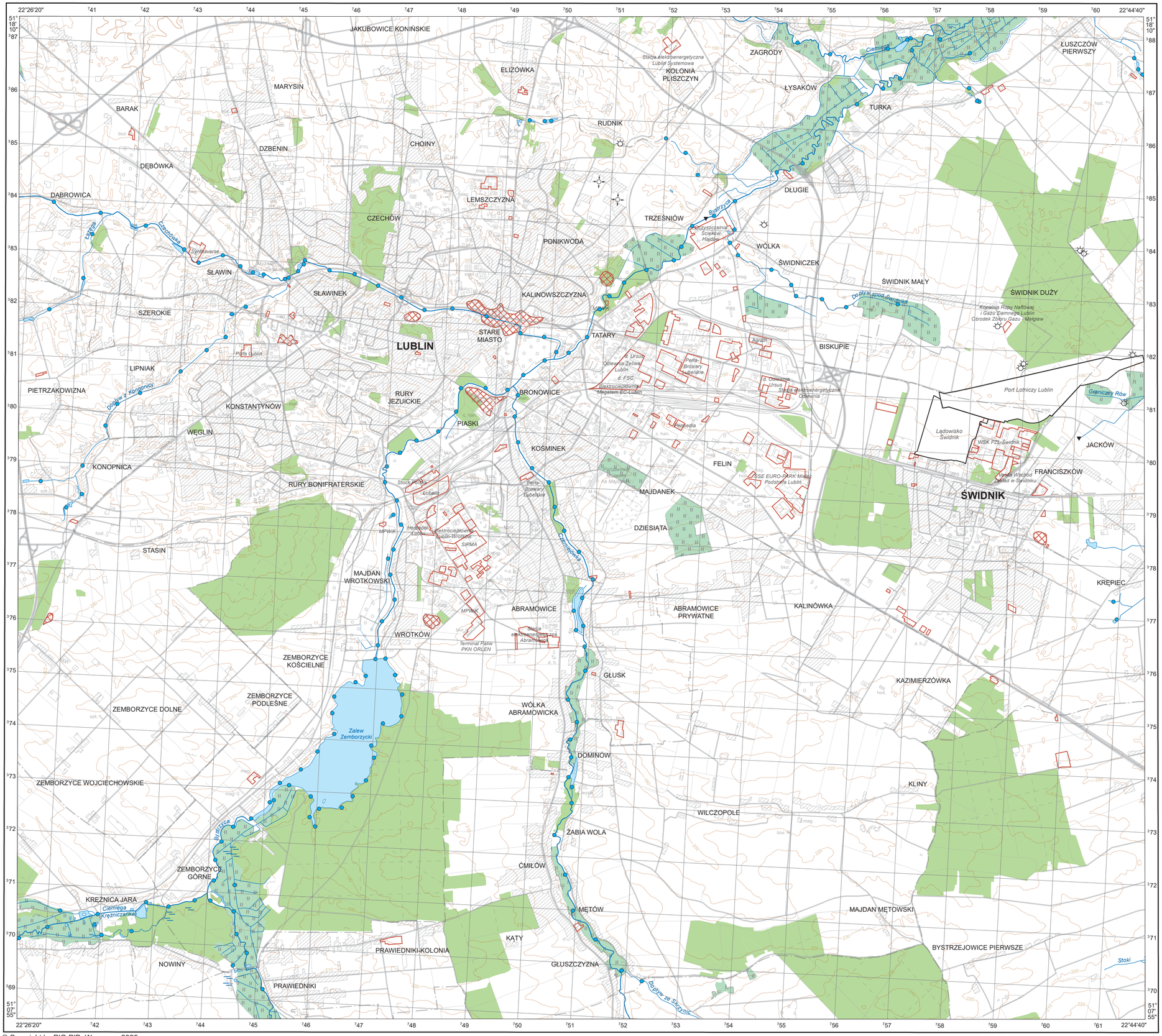
ppm = mg/dm^3

Średnia arytmetyczna	n.o.	Arithmetic mean
Średnia geometryczna	n.o.	Geometric mean
Mediana	<0,002	Median
Granica oznaczalności	0,002	Determination limit

Percentyl Percentile		mg/dm^3
0 – 100	●	<0,002 – 0,003

n = 182

„n.o." nie obliczono, gdy odsetek wyników poniżej granicy oznaczalności przekraczał 50%
not calculated when the percentage of the results below determination limit exceeded 50%



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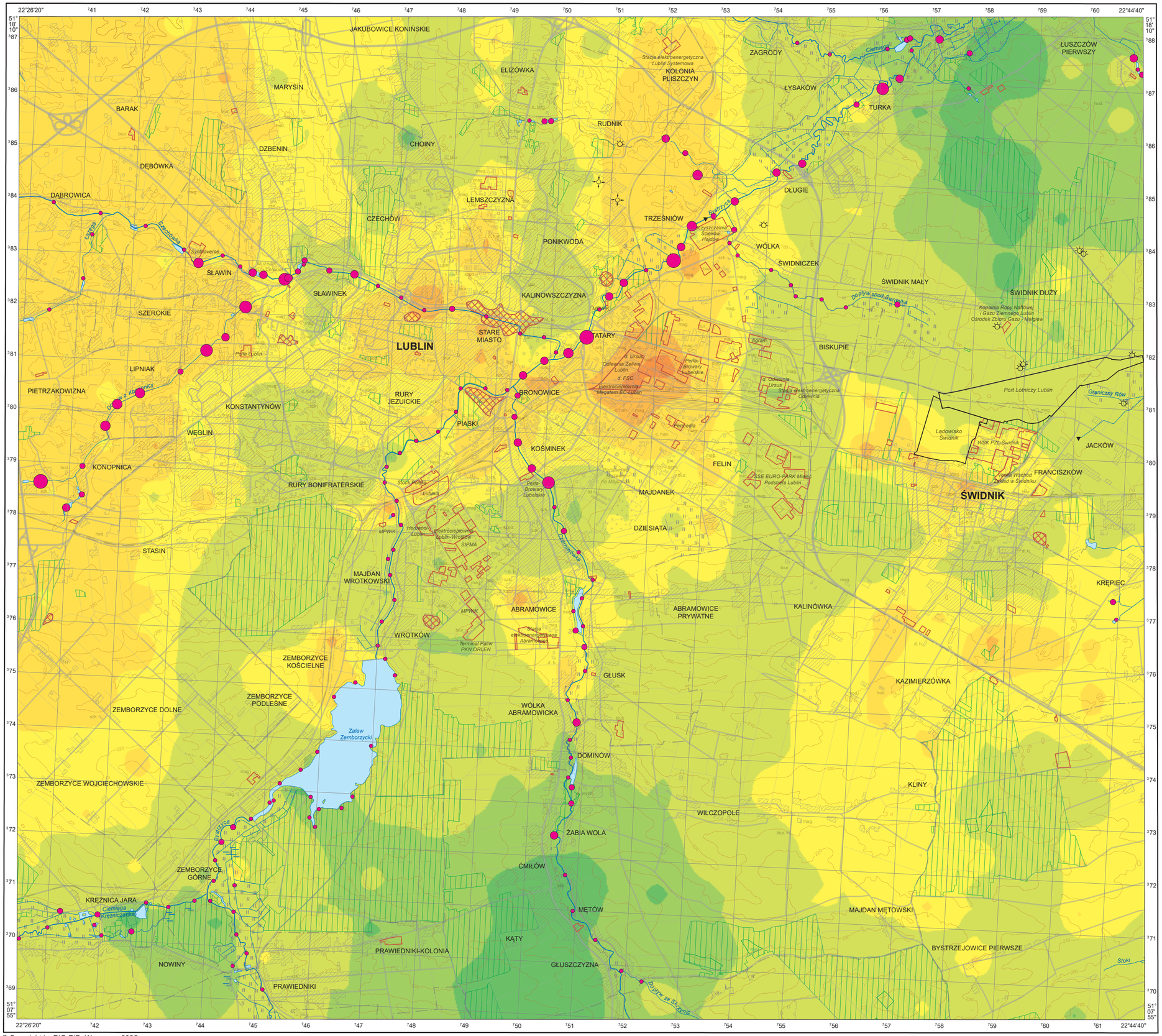
Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

Tal w glebach i osadach wodnych
Thallium in soil and aquatic sediment

Tl



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Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Gleby – parametry statystyczne
Soil – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	0,10	Arithmetic mean
Średnia geometryczna	0,09	Geometric mean
Mediana	0,10	Median
Granica oznaczalności	0,05	Determination limit

Percentyl Percentile	mg/kg	
100		0,34 max.
95		0,15
90		0,13
75		0,11
50		0,10
25		0,08
10		0,07
0		min. <0,05

n = 909

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	0,07	Arithmetic mean
Średnia geometryczna	0,06	Geometric mean
Mediana	0,07	Median
Granica oznaczalności	0,05	Determination limit

Percentyl Percentile	mg/kg
98 – 100	0,17 – 0,24 max.
95 – 98	0,14 – 0,17
90 – 95	0,12 – 0,14
75 – 90	0,09 – 0,12
50 – 75	0,07 – 0,09
0 – 50	min. <0,05 – 0,07

n = 169

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

Tal w wodach powierzchniowych
Thallium in surface water

Tl

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

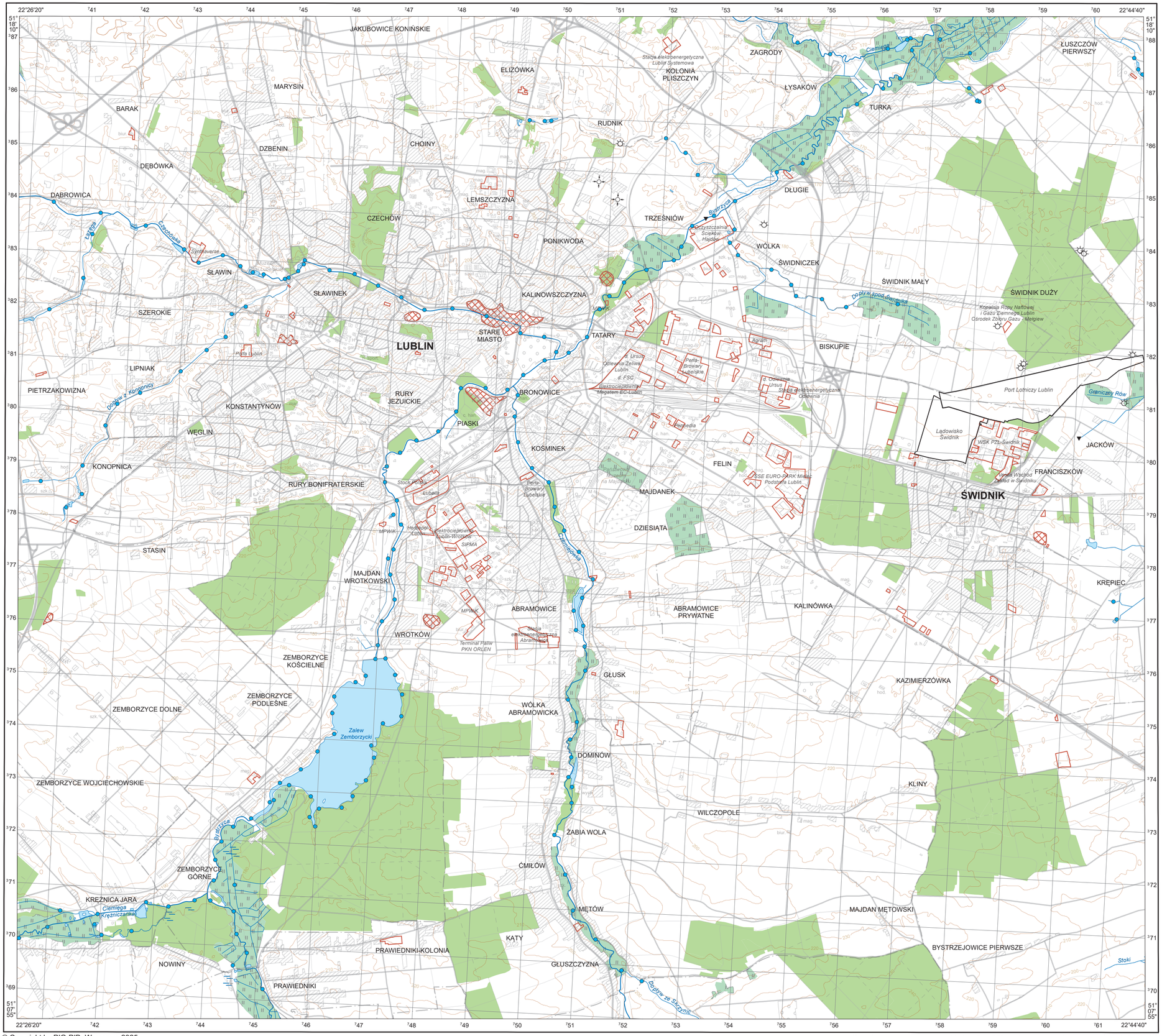
ppb = µg/dm^3

Średnia arytmetyczna	n.o.	Arithmetic mean
Średnia geometryczna	n.o.	Geometric mean
Mediana	<0,05	Median
Granica oznaczalności	0,05	Determination limit

Percentyl Percentile	µg/dm^3
0 – 100	<0,05 – 0,06

n = 182

„n.o." nie obliczono, gdy odsetek wyników poniżej granicy oznaczalności przekraczał 50%
not calculated when the percentage of the results below determination limit exceeded 50%



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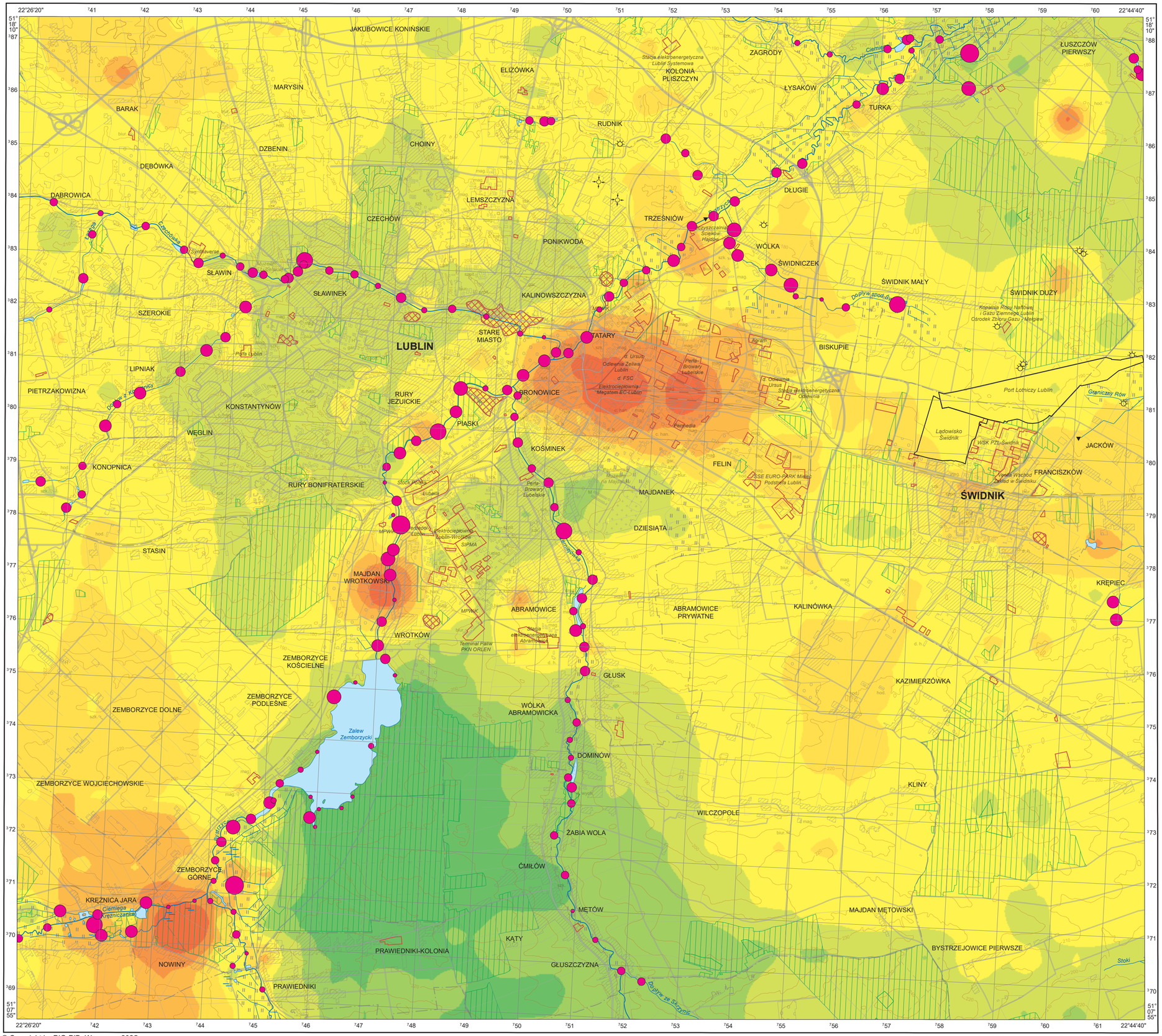
Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy — Forests
- Obszary przemysłowe — Industrial areas
- Lotniska — Airports
- Hałdy i nasypy — Dumps and embankments
- Miejsca zrzutu ścieków — Sewage discharge points
- Odwierty eksploatacyjne — Production boreholes
- Odwierty zatłaczające — Injection boreholes

Uran w glebach i osadach wodnych
Uranium in soil and aquatic sediment

U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Grzędzinka Zasilanie 906
Grzędzinka Zasilanie 907
Grzędzinka Zasilanie 908
Grzędzinka Zasilanie 909
Grzędzinka Zasilanie 910
Grzędzinka Zasilanie 911
Grzędzinka Zasilanie 912
Grzędzinka Zasilanie 913
Grzędzinka Zasilanie 914
Grzędzinka Zasilanie 915
Grzędzinka Zasilanie 916
Grzędzinka Zasilanie 917
Grzędzinka Zasilanie 918
Grzędzinka Zasilanie 919
Grzędzinka Zasilanie 920
Grzędzinka Zasilanie 921
Grzędzinka Zasilanie 922
Grzędzinka Zasilanie 923
Grzędzinka Zasilanie 924
Grzędzinka Zasilanie 925
Grzędzinka Zasilanie 926
Grzędzinka Zasilanie 927
Grzędzinka Zasilanie 928
Grzędzinka Zasilanie 929
Grzędzinka Zasilanie 930
Grzędzinka Zasilanie 931
Grzędzinka

Uran w wodach powierzchniowych
Uranium in surface water

U

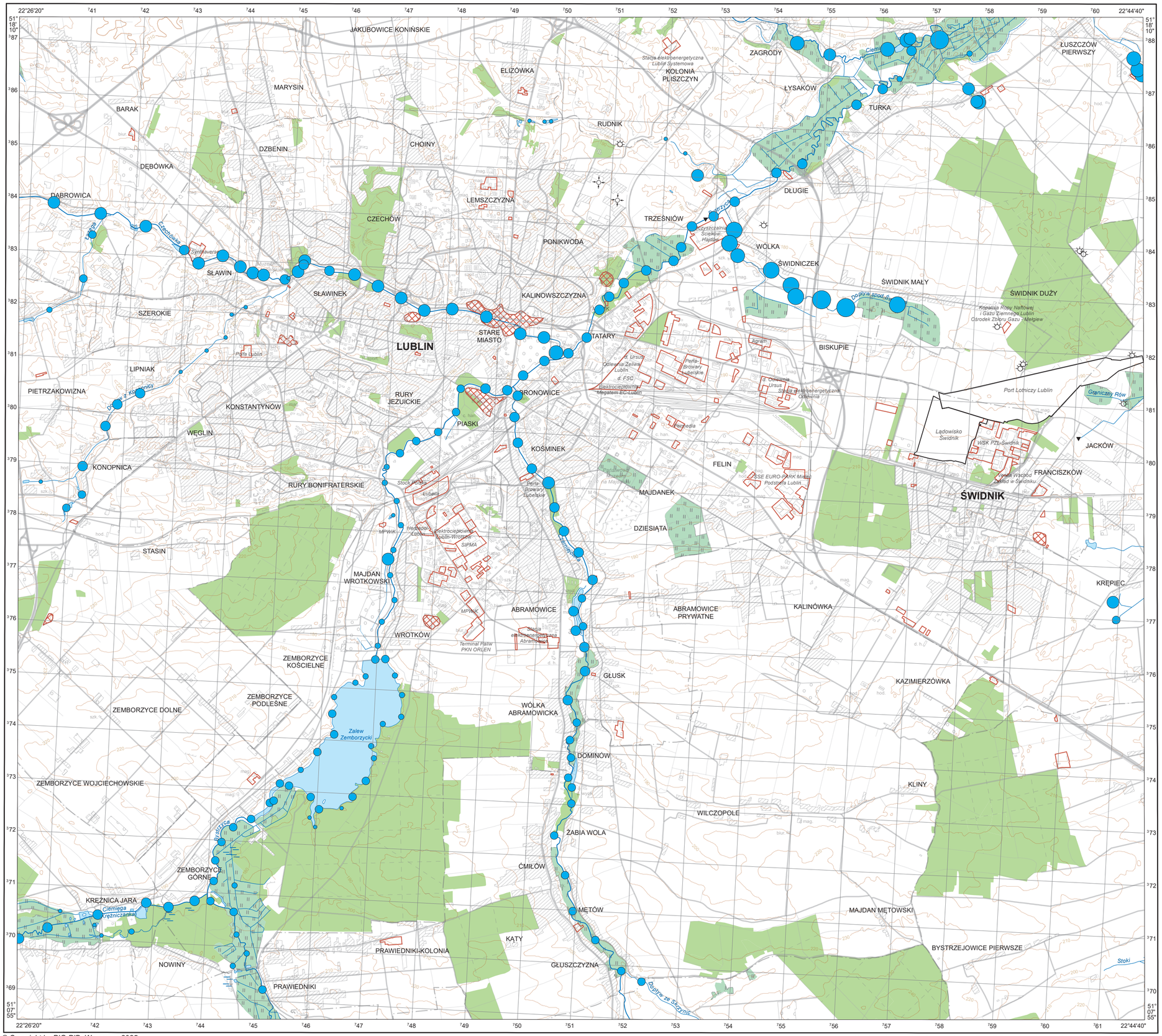
Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppb = µg/dm³

Średnia arytmetyczna	1,00	Arithmetic mean
Średnia geometryczna	0,79	Geometric mean
Mediana	0,83	Median
Granica oznaczalności	0,05	Determination limit

Percentyl Percentile	µg/dm³
98 – 100	3,73 – 4,11 max.
95 – 98	2,88 – 3,73
90 – 95	1,46 – 2,88
75 – 90	1,09 – 1,46
50 – 75	0,83 – 1,09
25 – 50	0,65 – 0,83
10 – 25	0,53 – 0,65
0 – 10	min. <0,05 – 0,53

n = 182



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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

Wanad w glebach i osadach wodnych
Vanadium in soil and aquatic sediment

V

Gleby – parametry statystyczne
Soil – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	14	Arithmetic mean
Średnia geometryczna	13	Geometric mean
Mediana	14	Median
Granica oznaczalności	1	Determination limit

Percentyl Percentile	mg/kg
100	36 max.
95	21
90	19
75	17
50	14
25	12
10	7
0	min. 2

n = 909

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	11	Arithmetic mean
Średnia geometryczna	9	Geometric mean
Mediana	11	Median
Granica oznaczalności	1	Determination limit

Percentyl Percentile	mg/kg
98 – 100	22 – 28 max.
95 – 98	19 – 22
90 – 95	17 – 19
75 – 90	14 – 17
50 – 75	11 – 14
25 – 50	7 – 11
10 – 25	4 – 7
0 – 10	min. <1 – 4

n = 169

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy – Forests
- Obszary przemysłowe – Industrial areas
- Lotniska – Airports
- Hałdy i nasypy – Dumps and embankments
- Miejsca zrzutu ścieków – Sewage discharge points
- Odwierty eksploatacyjne – Production boreholes
- Odwierty zatłaczające – Injection boreholes

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Wanad w wodach powierzchniowych
Vanadium in surface water

V

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppb = µg/dm^3

Średnia arytmetyczna	n.o.	Arithmetic mean
Średnia geometryczna	n.o.	Geometric mean
Mediana	<1	Median
Granica oznaczalności	1	Determination limit

Percentyl Percentile	µg/dm^3	
98 – 100	●	3 – 5 max.
95 – 98	●	2 – 3
75 – 95	●	1 – 2
0 – 75	•	min. <1 – 1

n = 182

„n.o." nie obliczono, gdy odsetek wyników poniżej granicy oznaczalności przekraczał 50%
not calculated when the percentage of the results below determination limit exceeded 50%



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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

Zawiesina ogólna w wodach powierzchniowych
Total suspended solids in surface water

Zawiesina ogólna
TSS

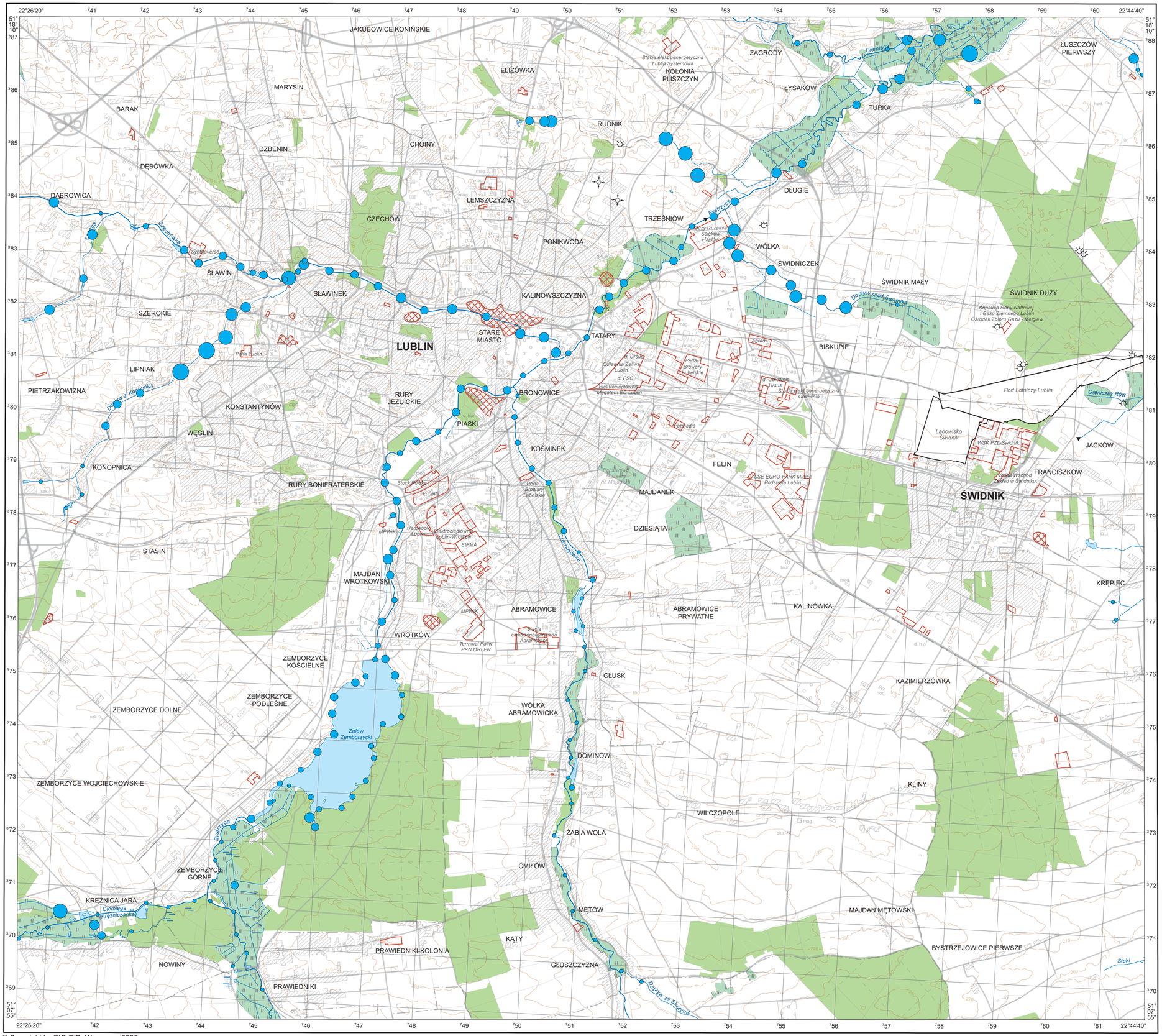
Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppm = mg/dm^3

Średnia arytmetyczna	21	Arithmetic mean
Średnia geometryczna	15	Geometric mean
Mediana	18	Median
Granica oznaczalności	5	Determination limit

Percentyl Percentile	mg/dm^3
98 – 100	91 – 156 max.
95 – 98	53 – 91
90 – 95	41 – 53
75 – 90	23 – 41
50 – 75	18 – 23
25 – 50	11 – 18
0 – 25	min. <5 – 11

n = 182



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Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
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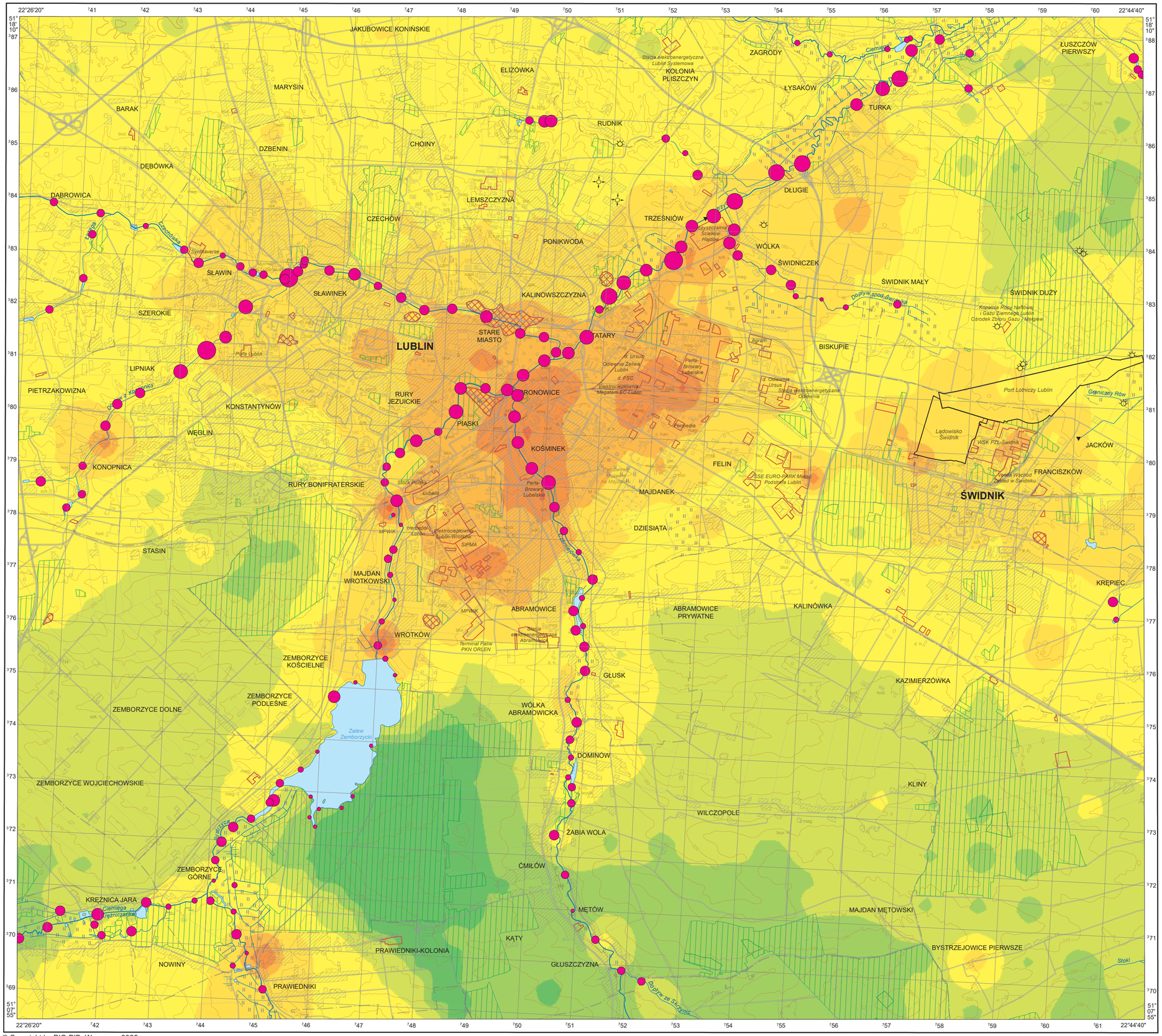
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

Cynk w glebach i osadach wodnych
Zinc in soil and aquatic sediment

Zn



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Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Gleby – parametry statystyczne
Soil – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	66	Arithmetic mean
Średnia geometryczna	41	Geometric mean
Mediana	35	Median
Granica oznaczalności	1	Determination limit

Percentyl / Percentile	mg/kg
100	1435 max.
98	369
95	204
90	121
75	61
50	35
25	25
10	17
0	min. 4

n = 909

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	95	Arithmetic mean
Średnia geometryczna	58	Geometric mean
Mediana	67	Median
Granica oznaczalności	1	Determination limit

Percentyl / Percentile	mg/kg
98 – 100	370 – 510 max.
95 – 98	288 – 370
90 – 95	231 – 288
75 – 90	120 – 231
50 – 75	67 – 120
25 – 50	32 – 67
10 – 25	13 – 32
0 – 10	min. 1 – 13

n = 169

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

Cynk w wodach powierzchniowych
Zinc in surface water

Zn

Wody powierzchniowe – parametry statystyczne
Surface water – statistical parameters

ppm = mg/dm^3

Średnia arytmetyczna	0,014	Arithmetic mean
Średnia geometryczna	0,007	Geometric mean
Mediana	0,008	Median
Granica oznaczalności	0,003	Determination limit

Percentyl Percentile	mg/dm^3
98 – 100	0,047 – 0,096 max.
95 – 98	0,036 – 0,047
90 – 95	0,030 – 0,036
75 – 90	0,025 – 0,030
50 – 75	0,008 – 0,025
0 – 50	min. <0,003 – 0,008

n = 182

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Acenaften w glebach i osadach wodnych
Acenaphthene in soil and aquatic sediment

Acenaften
Acenaphthene

Gleby – parametry statystyczne
Soil – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	9	Arithmetic mean
Średnia geometryczna	2	Geometric mean
Mediana	1	Median
Granica oznaczalności	1	Determination limit

Percentyl Percentile	µg/kg
100	216 max.
98	85
95	59
90	18
75	4
50	1
0	min. <1

n = 237

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	10	Arithmetic mean
Średnia geometryczna	4	Geometric mean
Mediana	4	Median
Granica oznaczalności	1	Determination limit

Percentyl Percentile	µg/kg
95 – 100	45 – 100 max.
90 – 95	30 – 45
75 – 90	9 – 30
50 – 75	4 – 9
25 – 50	2 – 4
0 – 25	min. <1 – 2

n = 49

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Acenaftylen w glebach i osadach wodnych
Acenaphthylene in soil and aquatic sediment

Acenaftylen
Acenaphthylene

Gleby – parametry statystyczne
Soil – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	4	Arithmetic mean
Średnia geometryczna	1	Geometric mean
Mediana	1	Median
Granica oznaczalności	1	Determination limit

Percentyl Percentile	µg/kg
100	103 max.
98	29
95	18
90	11
75	3
50	1
0	min. <1

n = 237

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	7	Arithmetic mean
Średnia geometryczna	3	Geometric mean
Mediana	3	Median
Granica oznaczalności	1	Determination limit

Percentyl Percentile	µg/kg
95 – 100	29 – 33 max.
90 – 95	24 – 29
75 – 90	6 – 24
50 – 75	3 – 6
25 – 50	2 – 3
0 – 25	min. <1 – 2

n = 49

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Antracen w glebach i osadach wodnych
Anthracene in soil and aquatic sediment

Antracen
Anthracene

Gleby – parametry statystyczne
Soil – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	33	Arithmetic mean
Średnia geometryczna	5	Geometric mean
Mediana	3	Median
Granica oznaczalności	1	Determination limit

Percentyl Percentile	µg/kg
100	976 max.
95	166
90	75
75	16
50	3
25	1
0	min. <1

n = 237

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	28	Arithmetic mean
Średnia geometryczna	10	Geometric mean
Mediana	13	Median
Granica oznaczalności	1	Determination limit

Percentyl Percentile	µg/kg
95 – 100	126 – 157 max.
90 – 95	92 – 126
75 – 90	30 – 92
50 – 75	13 – 30
25 – 50	6 – 13
0 – 25	min. <1 – 6

n = 49

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Benzo(a)antracen w glebach i osadach wodnych
Benzo(a)anthracene in soil and aquatic sediment

Benzo(a)antracen
Benzo(a)anthracene

Gleby – parametry statystyczne
Soil – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	169	Arithmetic mean
Średnia geometryczna	35	Geometric mean
Mediana	28	Median
Granica oznaczalności	2	Determination limit

Percentyl Percentile	µg/kg
100	5400 max.
98	1675
95	818
90	407
75	102
50	28
25	9
0	min. 2

n = 237

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	130	Arithmetic mean
Średnia geometryczna	50	Geometric mean
Mediana	78	Median
Granica oznaczalności	2	Determination limit

Percentyl Percentile	µg/kg
95 – 100	511 – 614 max.
90 – 95	390 – 511
75 – 90	141 – 390
50 – 75	78 – 141
25 – 50	35 – 78
0 – 25	min. <2 – 35

n = 49

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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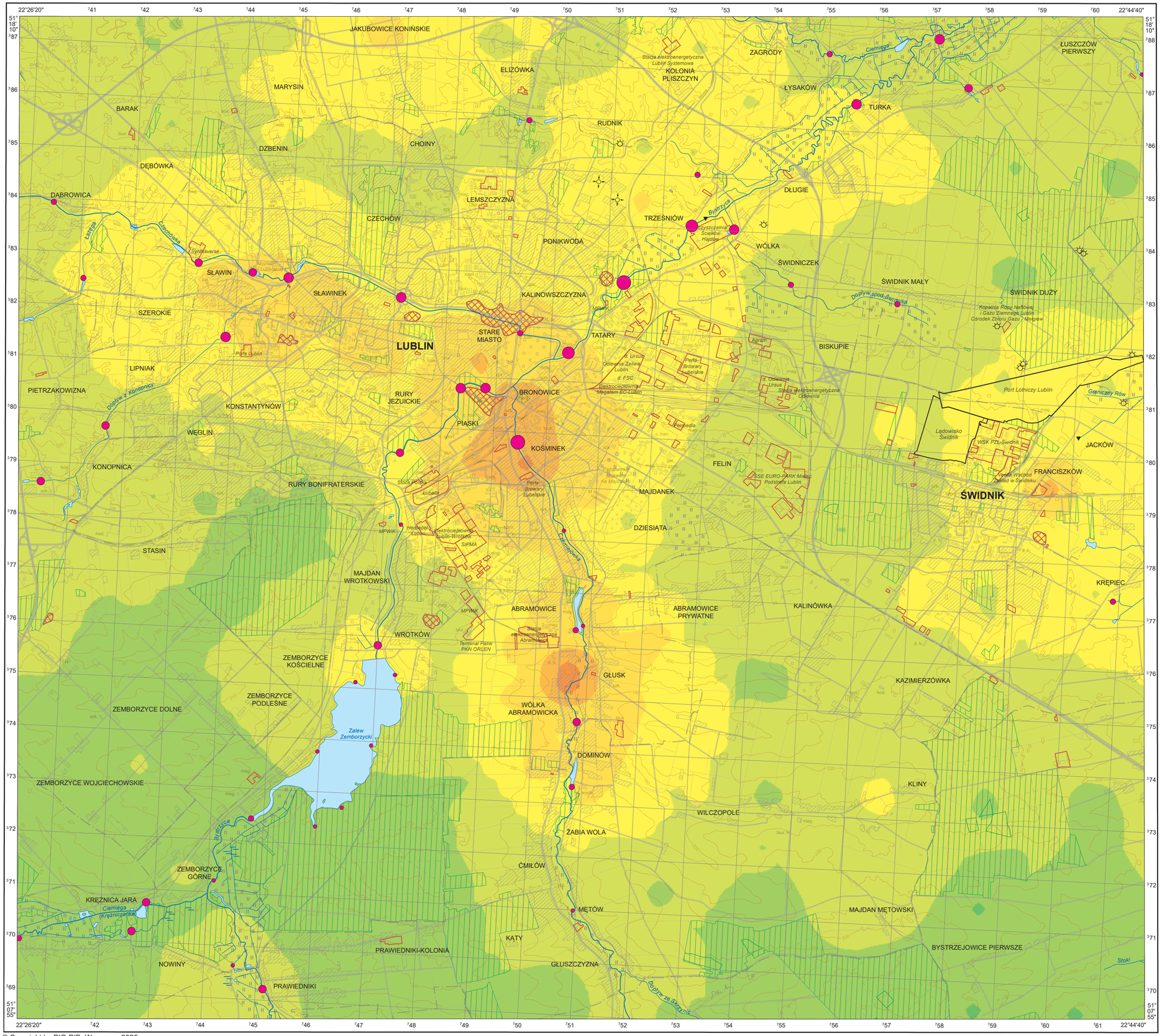
0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Benzo(a)piren w glebach i osadach wodnych
Benzo(a)pyrene in soil and aquatic sediment

Benzo(a)piren
Benzo(a)pyrene



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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Gleby – parametry statystyczne
Soil – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	223	Arithmetic mean
Średnia geometryczna	47	Geometric mean
Mediana	37	Median
Granica oznaczalności	3	Determination limit

Percentyl Percentile	µg/kg	
100		6900 max.
98		2200
95		1237
90		521
75		144
50		37
25		12
0		min. <3

n = 237

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	168	Arithmetic mean
Średnia geometryczna	62	Geometric mean
Mediana	99	Median
Granica oznaczalności	3	Determination limit

Percentyl Percentile	µg/kg
95 – 100	677 – 856 max.
90 – 95	493 – 677
75 – 90	195 – 493
50 – 75	99 – 195
25 – 50	42 – 99
0 – 25	min. <3 – 42

n = 49

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

Benzo(b)fluoranten w glebach i osadach wodnych
Benzo(b)fluoranthene in soil and aquatic sediment

Benzo(b)fluoranten
Benzo(b)fluoranthene

Gleby – parametry statystyczne
Soil – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	180	Arithmetic mean
Średnia geometryczna	50	Geometric mean
Mediana	36	Median
Granica oznaczalności	3	Determination limit

Percentyl Percentile	µg/kg	
100		5900 max.
98		1588
95		815
90		437
75		120
50		36
25		16
0		min. <3

n = 237

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	183	Arithmetic mean
Średnia geometryczna	69	Geometric mean
Mediana	106	Median
Granica oznaczalności	3	Determination limit

Percentyl Percentile	µg/kg
95 – 100	654 – 966 max.
90 – 95	595 – 654
75 – 90	236 – 595
50 – 75	106 – 236
25 – 50	47 – 106
0 – 25	min. <3 – 47

n = 49

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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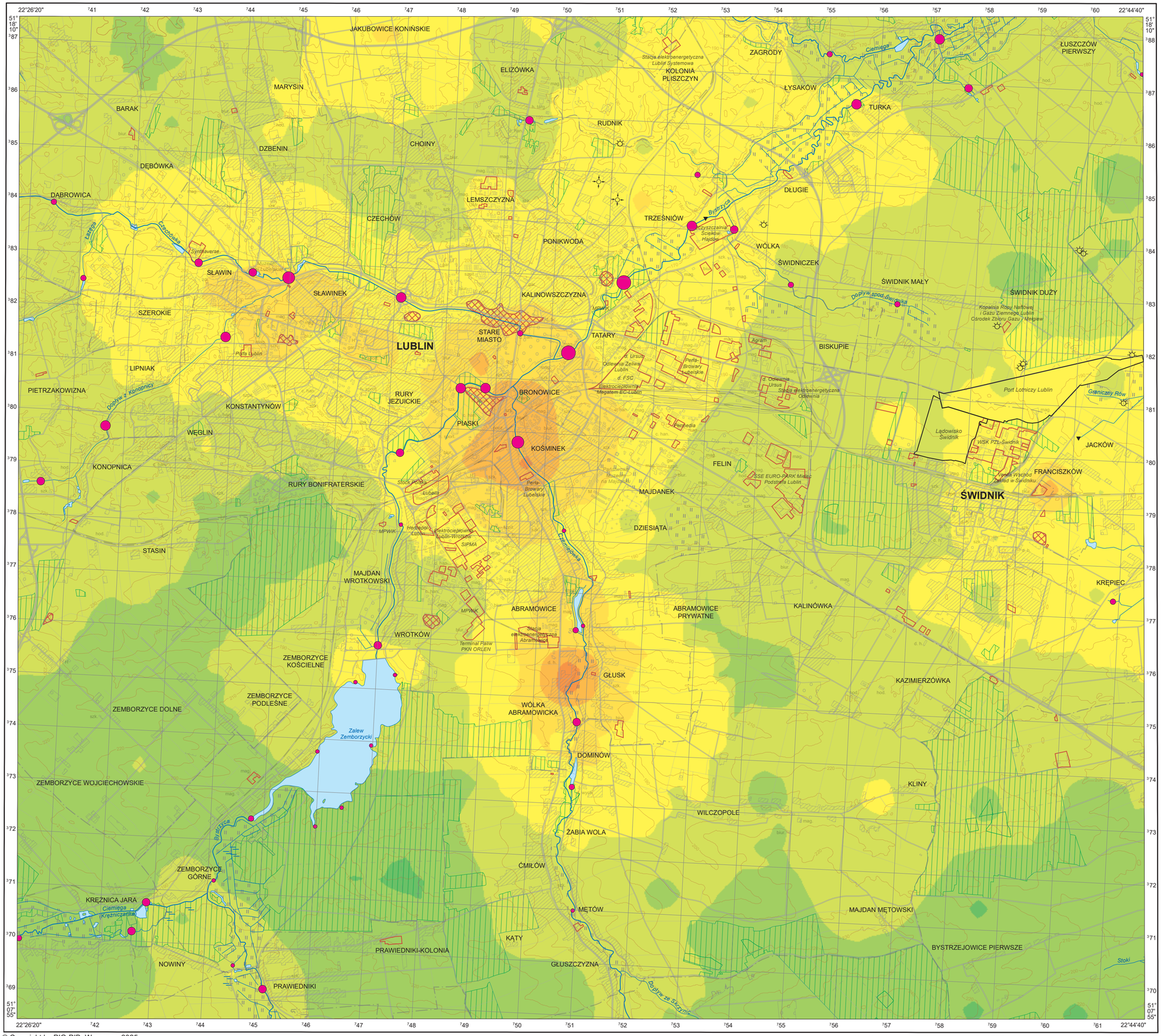
0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Benzo(e)piren w glebach i osadach wodnych
Benzo(e)pyrene in soil and aquatic sediment

Benzo(e)piren
Benzo(e)pyrene



Gleby – parametry statystyczne
Soil – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	138	Arithmetic mean
Średnia geometryczna	38	Geometric mean
Mediana	30	Median
Granica oznaczalności	3	Determination limit

Percentyl Percentile	µg/kg	
100		4000 max.
98		1274
95		714
90		342
75		100
50		30
25		12
0		min. <3

n = 237

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	157	Arithmetic mean
Średnia geometryczna	60	Geometric mean
Mediana	86	Median
Granica oznaczalności	3	Determination limit

Percentyl Percentile	µg/kg
95 – 100	624 – 823 max.
90 – 95	489 – 624
75 – 90	199 – 489
50 – 75	86 – 199
25 – 50	48 – 86
0 – 25	min. <3 – 48

n = 49

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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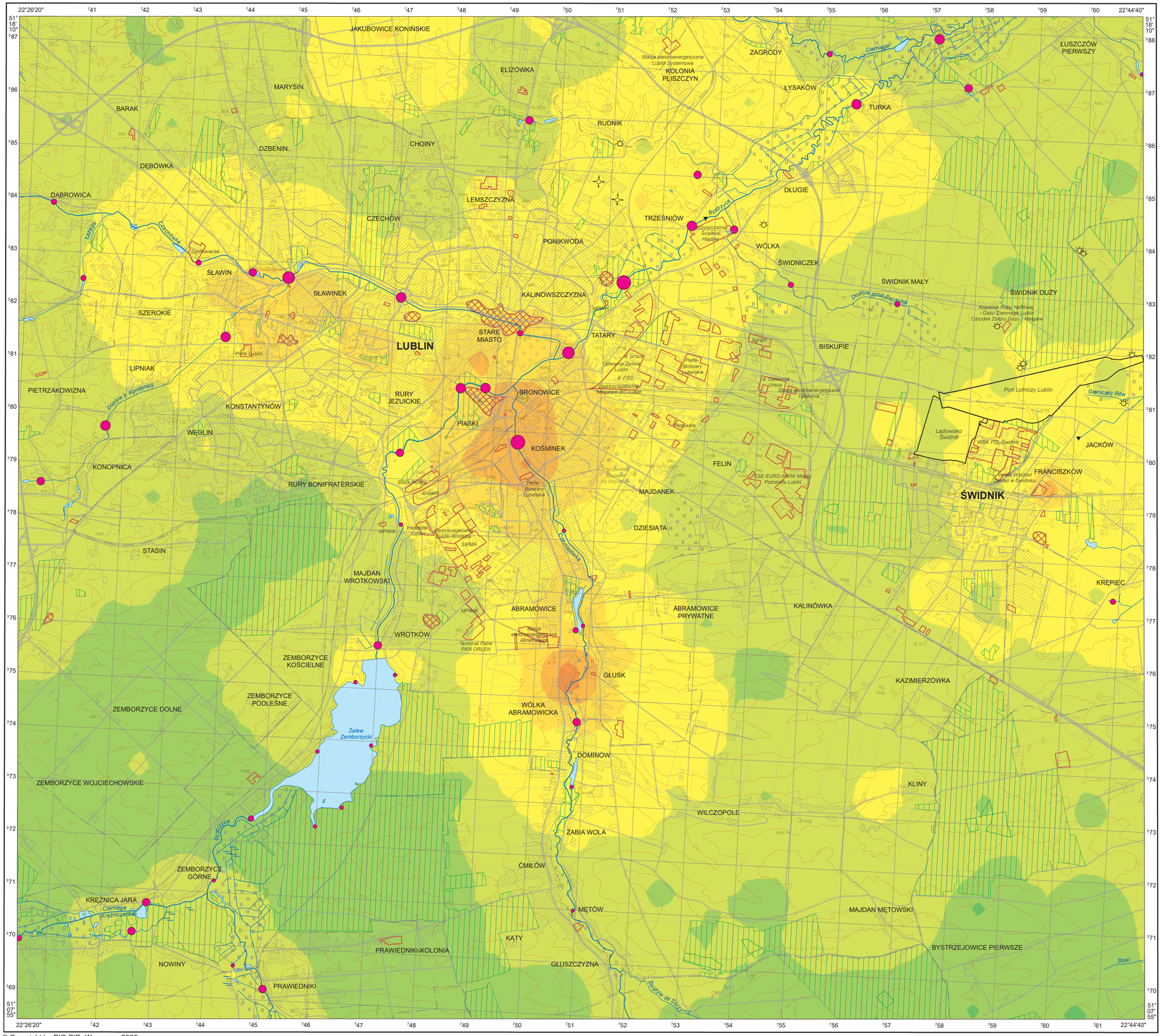
0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Benzo(g,h,i)perylen w glebach i osadach wodnych
Benzo(g,h,i)perylene in soil and aquatic sediment

Benzo(g,h,i)perylen
Benzo(g,h,i)perylene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RURY JEZUICKIE
BRONOWICE
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KRĘPIEC
ABRAMOWICE
ABRAMOWICE PRYWATNE
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MAJDAN MĘTOWSKI
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PRAWIEDNIKI-KOLONIA
BYSTRZEJOWICE PIERWSZE
NOWINY
GŁUSZCZYZNA
PRAWIEDNIKI
Ciemięga
Bystrzyca
Czechówka
Symtaverse
Dopływ z Konopnicy
Zalew Zemborzycki
Ciemięga (Krężniczanka)
Bystrzyca
Dopływ spod Świdnika
Grabina
Grabina
Stoki
Bystrzyca
Stacja elektroenergetyczna Lublin Systemowa
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WSK PZL-Świdnik
Vestas Wschód Zakład w Świdniku
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Perła Lublin
Perła-Browary Lubelskie
Agram
d. Ursus Odlewnia Żeliwa Lublin
d. FSC
d. Odlewnia Ursus
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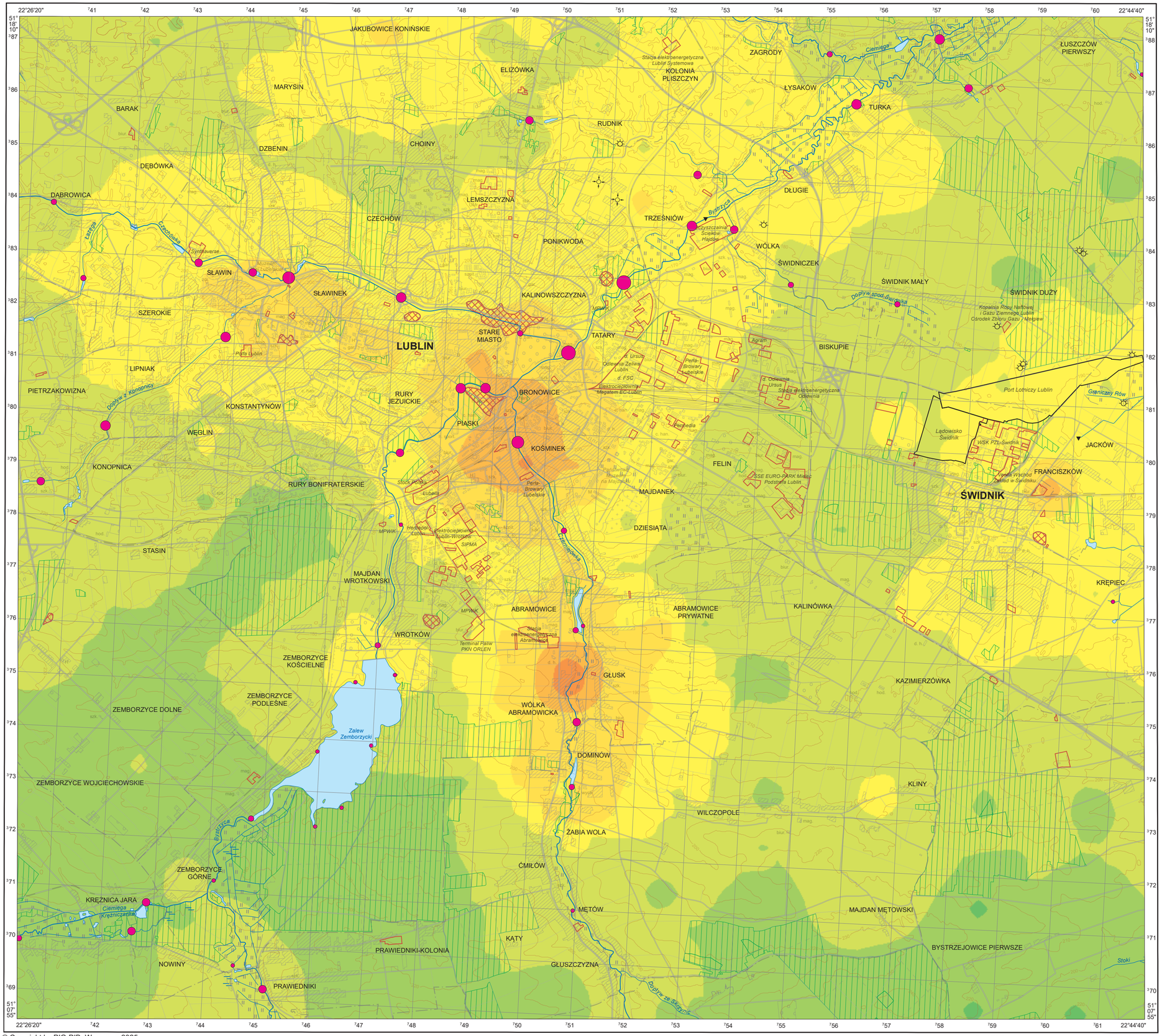
Magazyn Gazu
Magazyn Gazu
Magazyn Gazu

Benzo(k)fluoranten w glebach i osadach wodnych
Benzo(k)fluoranthene in soil and aquatic sediment

Benzo(k)fluoranten
Benzo(k)fluoranthene



Gleby – parametry statystyczne
Soil – statistical parameters

Średnia arytmetyczna	83	Arithmetic mean
Średnia geometryczna	20	Geometric mean
Mediana	15	Median
Granica oznaczalności	3	Determination limit

Percentyl Percentile	µg/kg
100	2800 max.
98	774
95	412
90	196
75	51
50	15
25	6
0	min. <3

n = 237

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	92	Arithmetic mean
Średnia geometryczna	34	Geometric mean
Mediana	49	Median
Granica oznaczalności	3	Determination limit

Percentyl Percentile	µg/kg
95 – 100	411 – 486 max.
90 – 95	303 – 411
75 – 90	106 – 303
50 – 75	49 – 106
25 – 50	23 – 49
0 – 25	min. <3 – 23

n = 49

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Chryzen w glebach i osadach wodnych
Chrysene in soil and aquatic sediment

Chryzen
Chrysene

Gleby – parametry statystyczne
Soil – statistical parameters

Średnia arytmetyczna	151	Arithmetic mean
Średnia geometryczna	38	Geometric mean
Mediana	28	Median
Granica oznaczalności	2	Determination limit

Percentyl Percentile	µg/kg
100	4700 max.
98	1550
95	774
90	358
75	91
50	28
25	11
0	min. 2

n = 237

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	145	Arithmetic mean
Średnia geometryczna	55	Geometric mean
Mediana	82	Median
Granica oznaczalności	2	Determination limit

Percentyl Percentile	µg/kg
95 – 100	617 – 731 max.
90 – 95	466 – 617
75 – 90	148 – 466
50 – 75	82 – 148
25 – 50	40 – 82
0 – 25	min. <2 – 40

n = 49

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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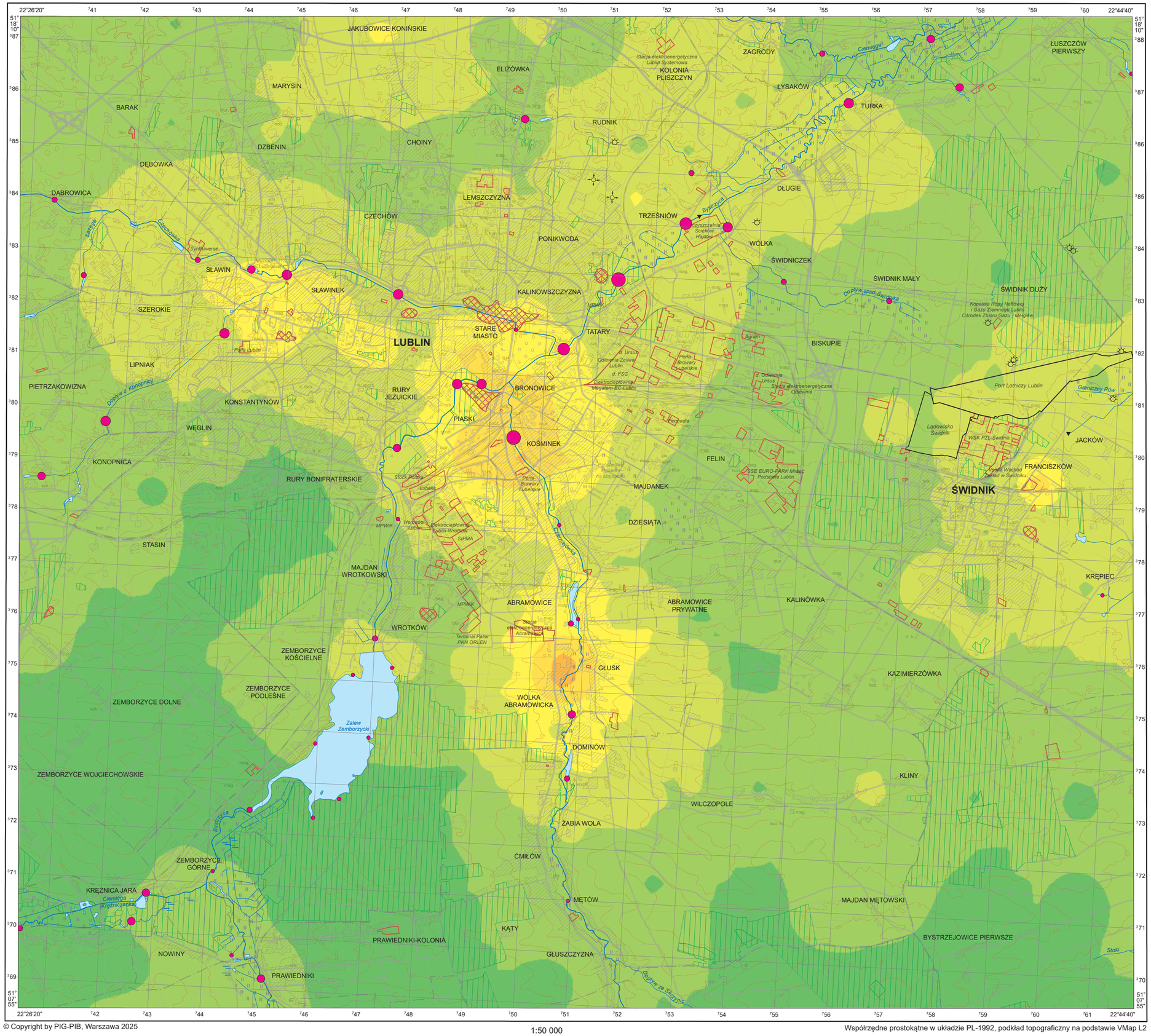
Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Dibenzo(a,h)antracen w glebach i osadach wodnych
Dibenz(a,h)anthracene in soil and aquatic sediment

Dibenzo(a,h)antracen
Dibenz(a,h)anthracene



Gleby – parametry statystyczne
Soil – statistical parameters

Średnia arytmetyczna	33	Arithmetic mean
Średnia geometryczna	9	Geometric mean
Mediana	6	Median
Granica oznaczalności	5	Determination limit

Percentyl Percentile	µg/kg
100	1014 max.
98	312
95	159
90	81
75	22
50	6
0	min. <5

n = 237

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	34	Arithmetic mean
Średnia geometryczna	16	Geometric mean
Mediana	19	Median
Granica oznaczalności	5	Determination limit

Percentyl Percentile	µg/kg
95 – 100	120 – 190 max.
90 – 95	108 – 120
75 – 90	43 – 108
50 – 75	19 – 43
25 – 50	8 – 19
0 – 25	min. <5 – 8

n = 49

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Fenantren w glebach i osadach wodnych
Phenanthrene in soil and aquatic sediment

Fenantren
Phenanthrene

Gleby – parametry statystyczne
Soil – statistical parameters

Średnia arytmetyczna	148	Arithmetic mean
Średnia geometryczna	44	Geometric mean
Mediana	31	Median
Granica oznaczalności	1	Determination limit

Percentyl Percentile	µg/kg	
100		4200 max.
98		1739
95		653
90		342
75		89
50		31
25		17
0		min. 3

n = 237

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	133	Arithmetic mean
Średnia geometryczna	65	Geometric mean
Mediana	86	Median
Granica oznaczalności	1	Determination limit

Percentyl Percentile	µg/kg
95 – 100	486 – 609 max.
90 – 95	372 – 486
75 – 90	178 – 372
50 – 75	86 – 178
25 – 50	47 – 86
10 – 25	6 – 47
0 – 10	min. 2 – 6

n = 49

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Fluoranten w glebach i osadach wodnych
Fluoranthene in soil and aquatic sediment

Fluoranten
Fluoranthene

Gleby – parametry statystyczne
Soil – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	307	Arithmetic mean
Średnia geometryczna	72	Geometric mean
Mediana	54	Median
Granica oznaczalności	1	Determination limit

Percentyl / Percentile	µg/kg
100	10 000 max.
98	3100
95	1476
90	727
75	185
50	54
25	20
10	13
0	min. 5

n = 237

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	275	Arithmetic mean
Średnia geometryczna	107	Geometric mean
Mediana	158	Median
Granica oznaczalności	1	Determination limit

Percentyl / Percentile	µg/kg
95 – 100	1178 – 1321 max.
90 – 95	895 – 1178
75 – 90	282 – 895
50 – 75	158 – 282
25 – 50	67 – 158
10 – 25	6 – 67
0 – 10	min. 1 – 6

n = 49

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Fluoren w glebach i osadach wodnych
Fluorene in soil and aquatic sediment

Fluoren
Fluorene

Gleby – parametry statystyczne
Soil – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	13	Arithmetic mean
Średnia geometryczna	4	Geometric mean
Mediana	3	Median
Granica oznaczalności	1	Determination limit

Percentyl Percentile	µg/kg
100	310 max.
98	113
95	68
90	25
75	8
50	3
25	2
0	min. <1

n = 237

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	17	Arithmetic mean
Średnia geometryczna	8	Geometric mean
Mediana	12	Median
Granica oznaczalności	1	Determination limit

Percentyl Percentile	µg/kg
95 – 100	55 – 72 max.
90 – 95	49 – 55
75 – 90	21 – 49
50 – 75	12 – 21
25 – 50	4 – 12
0 – 25	min. <1 – 4

n = 49

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
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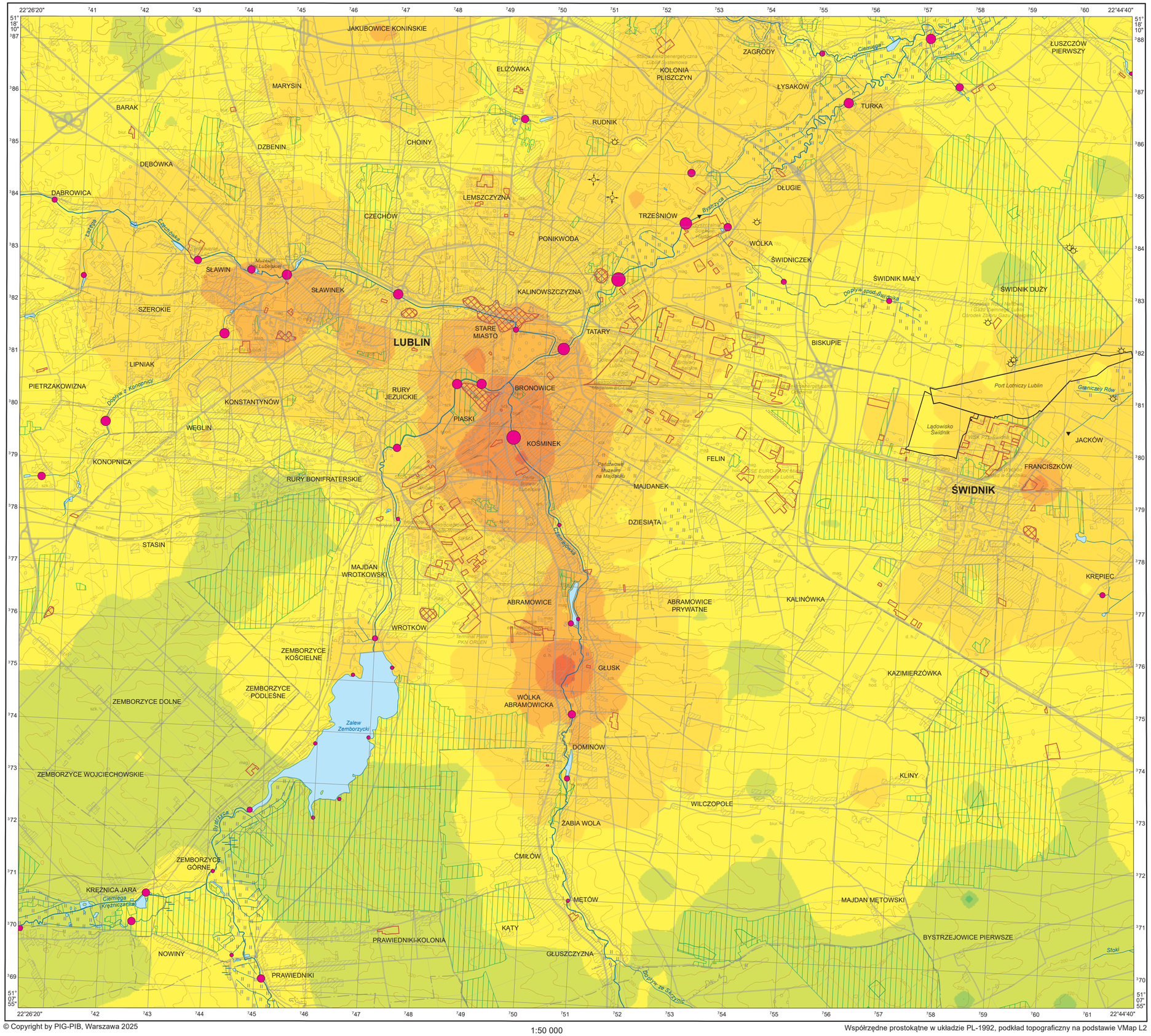
0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Indeno(1,2,3-cd)piren w glebach i osadach wodnych
Indeno(1,2,3-cd)pyrene in soil and aquatic sediment

Indeno(1,2,3-cd)piren
Indeno(1,2,3-cd)pyrene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ABRAMOWICE
ABRAMOWICE PRYWATNE
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ZEMBORZYCE PODLEŚNE
ZEMBORZYCE DOLNE
WÓLKA ABRAMOWICKA
Zalew Zemborzycki
DOMINÓW
KLINY
ZEMBORZYCE WOJCIECHOWSKIE
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NOWINY
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PRAWIEDNIKI
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Czarnogóra
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Dopływ z Konopnicy
Dopływ spod Świdnika
Graniczny Rów
Port Lotniczy Lublin
Lądowisko Świdnik
Ciemięga Krężnicka
Dopływ ze Stecznic
Stoki
Muzeum Wsi Lubelskiej
Państwowe Muzeum na Majdanku
Elektrociepłownia Lublin-Wrotków
Terminal Paliw PKN ORLEN
Stacja Elektroenergetyczna Lublin Systemowa
Elektrociepłownia Lublin EC Lublin
Kopalnia Piasku Kalinowa
Ośrodek Zabiegowy Gazu Ziemnego Lublin
Ośrodek Zabiegowy Gazu Ziemnego Motycz
MSK PZBSwidnik
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Lubelskie Zakłady Zbożowe
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Lubelskie Zakłady Przemysłu Mleczarskiego
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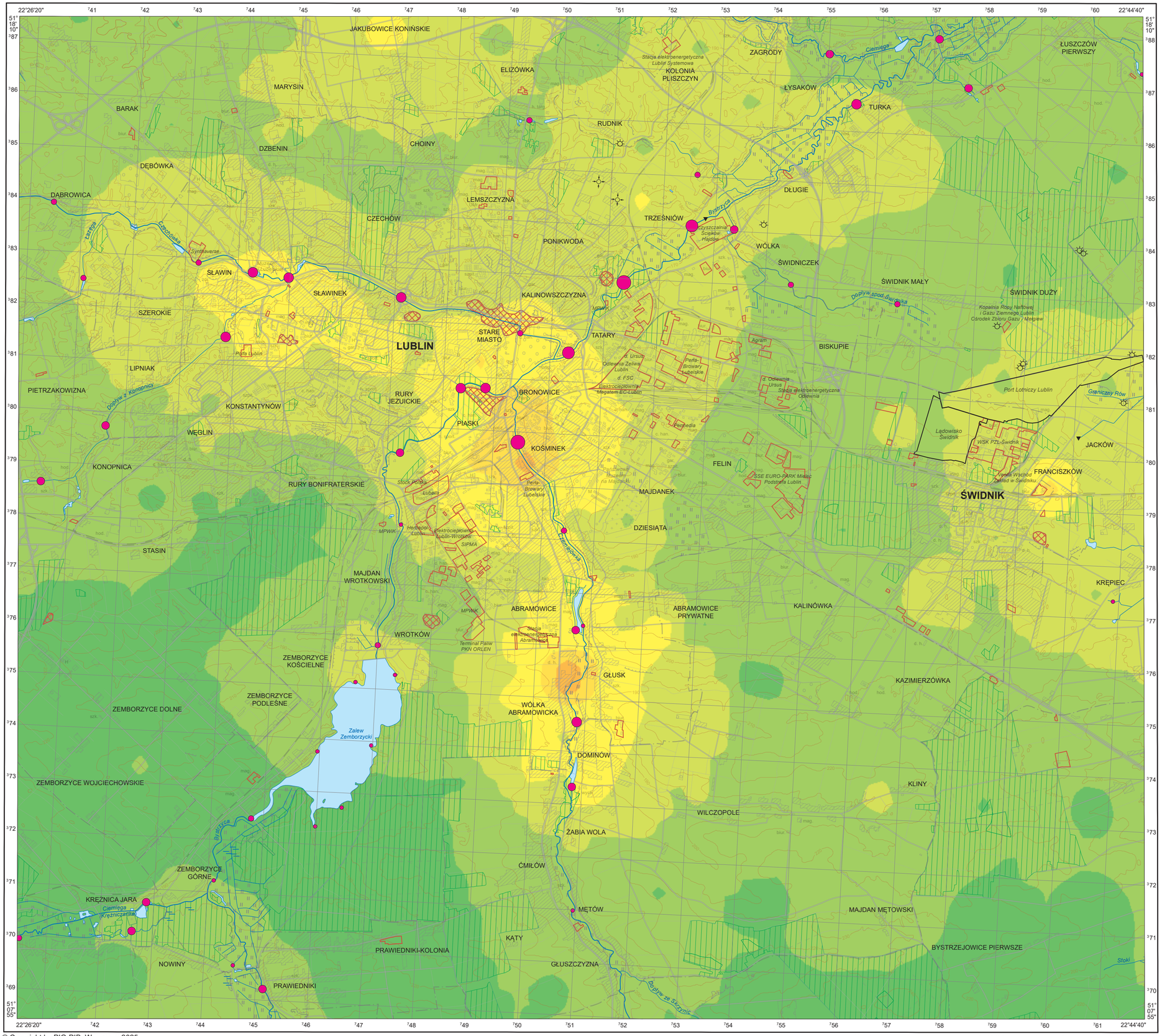
Perylen w glebach i osadach wodnych
Perylene in soil and aquatic sediment

Perylen
Perylene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MAJDAN WROTKOWSKI
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ABRAMÓWICE
ABRAMOWICE PRYWATNE
KALINÓWKA
WROTKÓW
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GŁUSK
KAZIMIERZÓWKA
ZEMBORZYCE PODLEŚNE
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DOMINÓW
ZEMBORZYCE WOJCIECHOWSKIE
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Muzeum Majdanek
Zakład w Świdniku
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Fabryka Centrum-Północ-Zachód-Północ

Piren w glebach i osadach wodnych
Pyrene in soil and aquatic sediment

Piren
Pyrene

Gleby – parametry statystyczne
Soil – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	283	Arithmetic mean
Średnia geometryczna	63	Geometric mean
Mediana	45	Median
Granica oznaczalności	1	Determination limit

Percentyl Percentile	µg/kg	
100		9100 max.
98		2900
95		1527
90		667
75		172
50		45
25		17
10		11
0		min. 4

n = 237

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	243	Arithmetic mean
Średnia geometryczna	87	Geometric mean
Mediana	136	Median
Granica oznaczalności	1	Determination limit

Percentyl Percentile	µg/kg
95 – 100	1037 – 1199 max.
90 – 95	755 – 1037
75 – 90	247 – 755
50 – 75	136 – 247
25 – 50	60 – 136
10 – 25	5 – 60
0 – 10	min. <1 – 5

n = 49

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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0 1 2 3 4 5 km

Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Dieldryna w glebach i osadach wodnych
Dieldrin in soil and aquatic sediment

Dieldryna
Dieldrin

Gleby – parametry statystyczne
Soil – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	n.o.	Arithmetic mean
Średnia geometryczna	n.o.	Geometric mean
Mediana	<0,1	Median
Granica oznaczalności	0,1	Determination limit

Percentyl Percentile	µg/kg
100	8,4 max.
98	0,4
95	0,1
0	min. <0,1

n = 237

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	n.o.	Arithmetic mean
Średnia geometryczna	n.o.	Geometric mean
Mediana	<0,1	Median
Granica oznaczalności	0,1	Determination limit

Percentyl Percentile	µg/kg
95 – 100	0,5 – 1,4 max.
90 – 95	0,4 – 0,5
0 – 90	min.<0,1 – 0,4

n = 49

„n.o." nie obliczono, gdy odsetek wyników poniżej granicy oznaczalności przekraczał 50%
not calculated when the percentage of the results below determination limit exceeded 50%

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Heksachlorobenzen w glebach i osadach wodnych
Hexachlorobenzene in soil and aquatic sediment

Heksachlorobenzen
Hexachlorobenzene

Gleby – parametry statystyczne
Soil – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	n.o.	Arithmetic mean
Średnia geometryczna	n.o.	Geometric mean
Mediana	<0,1	Median
Granica oznaczalności	0,1	Determination limit

Percentyl Percentile	µg/kg
100	10,8 max.
98	1,9
95	0,8
90	0,4
75	0,2
0	min. <0,1

n = 237

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	0,4	Arithmetic mean
Średnia geometryczna	0,1	Geometric mean
Mediana	0,1	Median
Granica oznaczalności	0,1	Determination limit

Percentyl Percentile	µg/kg
95 – 100	1,4 – 5,5 max.
90 – 95	0,8 – 1,4
75 – 90	0,3 – 0,8
50 – 75	0,1 – 0,3
0 – 50	min. <0,1 – 0,1

n = 49

„n.o." nie obliczono, gdy odsetek wyników poniżej granicy oznaczalności przekraczał 50%
not calculated when the percentage of the results below determination limit exceeded 50%

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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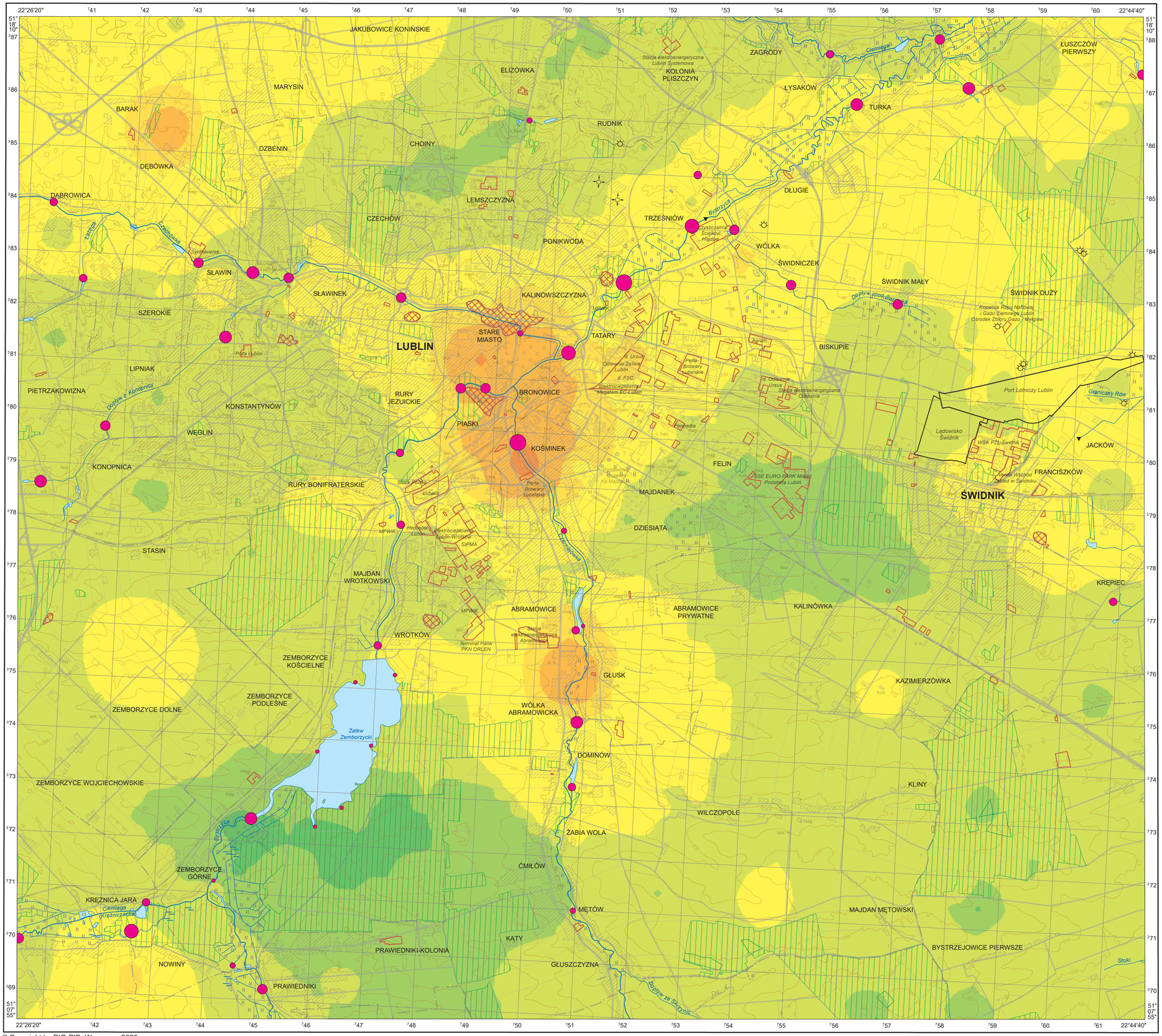
Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

p,p'-DDT i jego metabolity (suma) w glebach i osadach wodnych

p,p'-DDT and its metabolites (sum) in soil and aquatic sediment

DDT, DDE i DDD (suma)

DDT, DDE and DDD (sum)



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Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Gleby – parametry statystyczne
Soil – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	18,6	Arithmetic mean
Średnia geometryczna	6,2	Geometric mean
Mediana	5,3	Median
Granica oznaczalności	0,1	Determination limit

Percentyl / Percentile	µg/kg
100	391 max.
98	147
95	68
90	46
75	15
50	5,3
25	2,1
0	0,1

n = 237

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	6,5	Arithmetic mean
Średnia geometryczna	3,2	Geometric mean
Mediana	5,1	Median
Granica oznaczalności	0,1	Determination limit

Percentyl / Percentile	µg/kg
95 – 100	20 – 40 max.
90 – 95	16 – 20
75 – 90	7,7 – 16
50 – 75	5,1 – 7,7
25 – 50	1,8 – 5,1
10 – 25	0,3 – 1,8
0 – 10	min. 0,1 – 0,3

n = 49

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

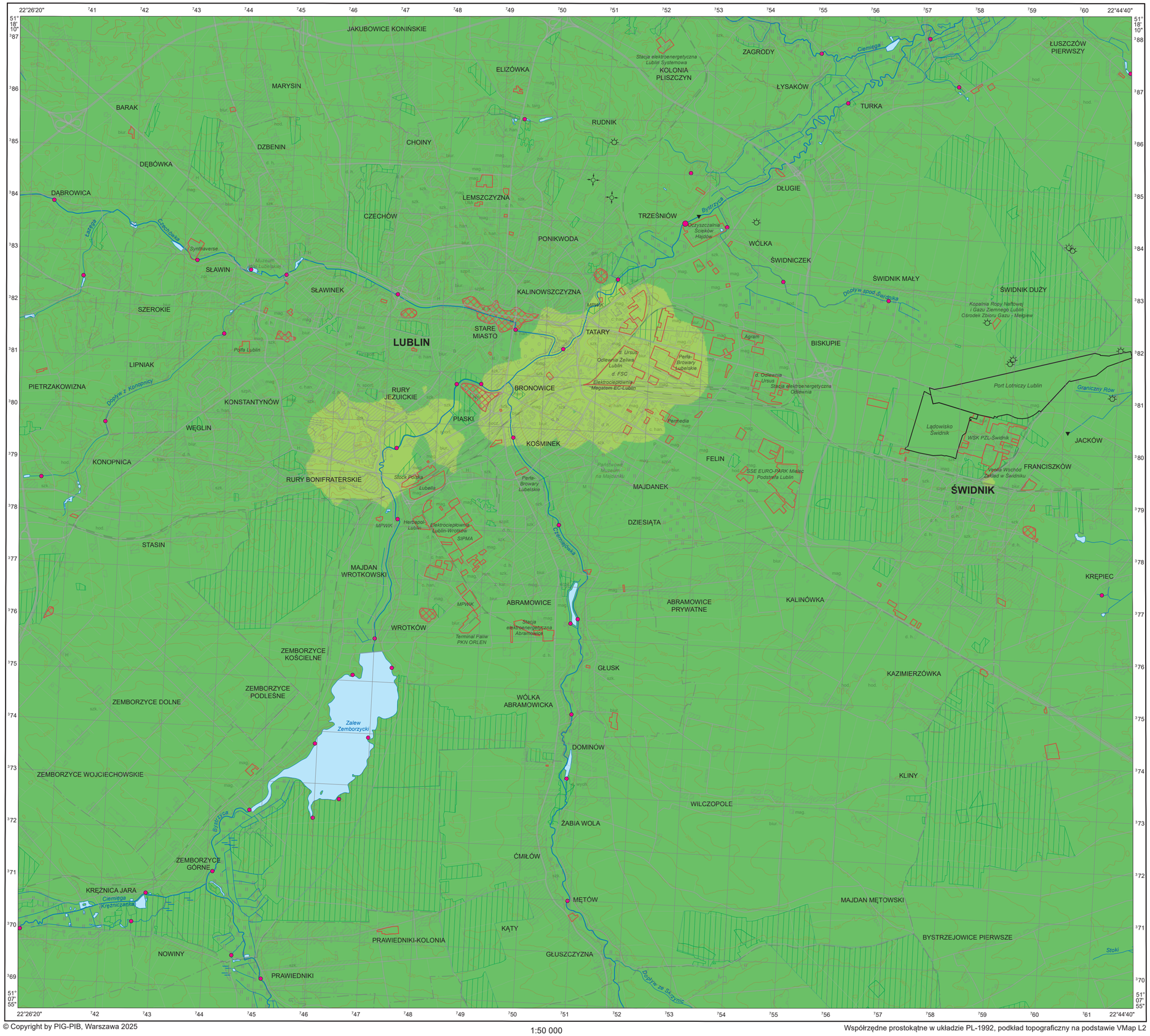
- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

Heksachlorocykloheksan (suma) w glebach i osadach wodnych

Hexachlorocyclohexane (sum) in soil and aquatic sediment

HCH (suma)

HCH (sum)



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Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Gleby – parametry statystyczne
Soil – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	n.o.	Arithmetic mean
Średnia geometryczna	n.o.	Geometric mean
Mediana	<0,5	Median
Granica oznaczalności	0,5	Determination limit

Percentyl Percentile	µg/kg
100	5,8 max.
98	0,6
0	min. <0,5

n = 237

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	n.o.	Arithmetic mean
Średnia geometryczna	n.o.	Geometric mean
Mediana	<0,5	Median
Granica oznaczalności	0,5	Determination limit

Percentyl Percentile	µg/kg
95 – 100	0,5 – 1,9 max.
0 – 95	min. <0,5 – 0,5

n = 49

„n.o." nie obliczono, gdy odsetek wyników poniżej granicy oznaczalności przekraczał 50%
not calculated when the percentage of the results below determination limit exceeded 50%

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

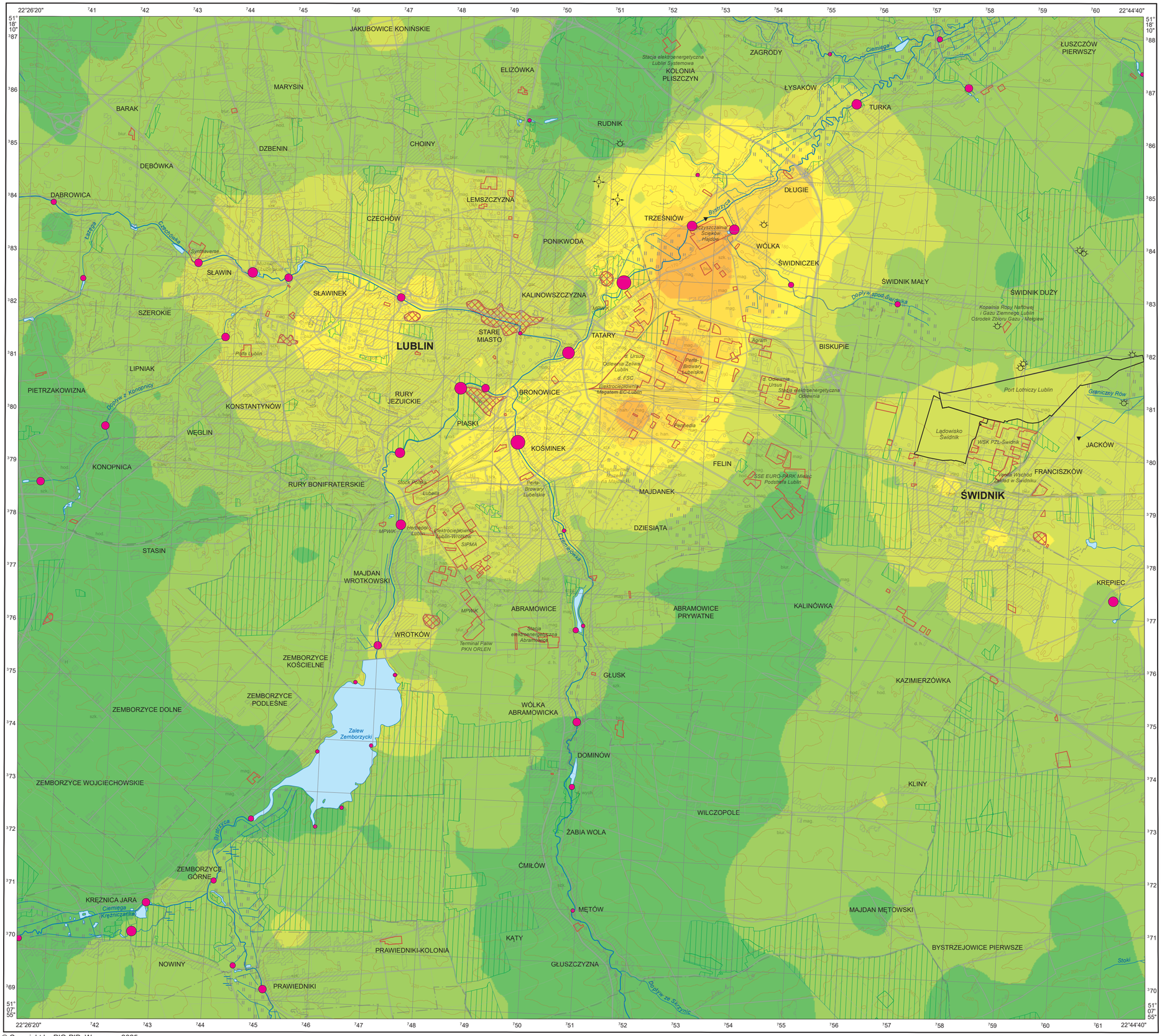
- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

Polichlorowane bifenyle (suma) w glebach i osadach wodnych

Polychlorinated biphenyls (sum) in soil and aquatic sediment

PCB (suma)

PCB (sum)



Gleby – parametry statystyczne
Soil – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	1,0	Arithmetic mean
Średnia geometryczna	0,2	Geometric mean
Mediana	0,2	Median
Granica oznaczalności	0,1	Determination limit

Percentyl Percentile	µg/kg
100	46 max.
98	6,5
95	4,1
90	2,2
75	0,7
50	0,2
0	min. <0,1

n = 237

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppb = µg/kg

Średnia arytmetyczna	3,8	Arithmetic mean
Średnia geometryczna	1,1	Geometric mean
Mediana	2,1	Median
Granica oznaczalności	0,1	Determination limit

Percentyl Percentile	µg/kg
95 – 100	11 – 50 max.
90 – 95	7,4 – 11
75 – 90	4,3 – 7,4
50 – 75	2,1 – 4,3
25 – 50	0,3 – 2,1
0 – 25	min. <0,1 – 0,3

n = 49

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
- Miejsca zrzutu ścieków / Sewage discharge points
- Odwierty eksploatacyjne / Production boreholes
- Odwierty zatłaczające / Injection boreholes

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Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

Suma olejów mineralnych w glebach i osadach wodnych
Sum of mineral oils in soil and aquatic sediment

Suma olejów mineralnych
Sum of mineral oils

Gleby – parametry statystyczne
Soil – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	38,7	Arithmetic mean
Średnia geometryczna	15,8	Geometric mean
Mediana	12,6	Median
Granica oznaczalności	10,0	Determination limit

Percentyl Percentile	mg/kg
100	950 max.
98	346
95	148
90	86,0
75	36,2
50	12,6
0	min. <10,0

n = 237

Osady wodne – parametry statystyczne
Aquatic sediment – statistical parameters

ppm = mg/kg = g/t

Średnia arytmetyczna	318	Arithmetic mean
Średnia geometryczna	93,0	Geometric mean
Mediana	149	Median
Granica oznaczalności	10,0	Determination limit

Percentyl Percentile	mg/kg
95 – 100	1400 – 2000 max.
90 – 95	820 – 1400
75 – 90	347 – 820
50 – 75	149 – 347
25 – 50	25,5 – 149
0 – 25	min.<10,0 – 25,5

n = 49

Objaśnienia wybranych znaków topograficznych
Explanation of selected topographic signs

- Lasy / Forests
- Obszary przemysłowe / Industrial areas
- Lotniska / Airports
- Hałdy i nasypy / Dumps and embankments
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Współrzędne prostokątne w układzie PL-1992, podkład topograficzny na podstawie VMap L2

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