POLISH GEOLOGICAL INSTITUTE

GEOCHEMICAL ATLAS OF UPPER SILESIA

1:200 000

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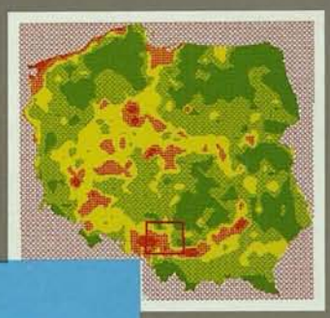

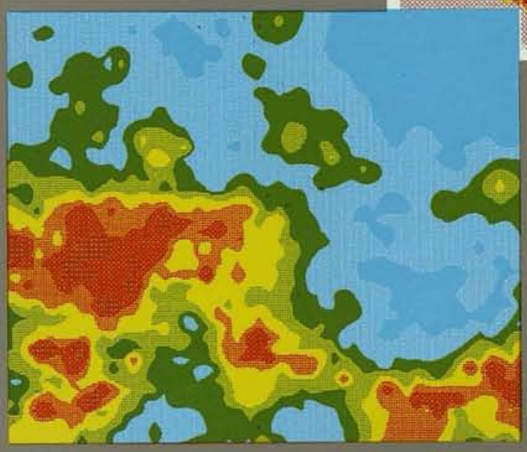

Warsaw 1995

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Warsaw 1995

Work carried out at the behest
of the Minister of Environmental Protection, Natural Resources, and Forestry

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Accepted for print 10.02.1995
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Printed by Polish Ecological Agency Co. Ltd., D-3.

PREFACE

One of the fundamental goals of the Polish Geological Institute is to provide a scientific background for planned management of the country's area, with special regard to the protection of the natural environment. In the last few tens of years, the natural environment in Poland has been widely degraded as a result of the development of industry and modern agriculture as well as significant demographic change. The most conspicuous example of environment degradation can be seen in Upper Silesia, a region of real ecological disaster. Concerning an increasing public demand for a pollution-free environment, the Polish Geological Institute has undertaken research to recognize the degree and extent of chemical pollution in a spectrum of surficial environments in Poland.

One of the most important approaches in this task is geochemical mapping. This method has widely been used in prospecting for mineral deposits. However, now it is also used to locate industrial and agricultural pollution sources in the polluted areas. Geochemical maps, which are constructed under standardized rules, provide exact information on the land chemistry, including soils, water sediments, and surface waters. Therefore, they are helpful in various activities aimed at protection of the environment and neutralization of pollution.

"The Geochemical Atlas of Upper Silesia to Scale 1:200,000" presented here is a part of results of a widespread investigation program of the geochemistry of the natural environment in Poland. The Atlas can be considered a source of geochemical information for the State Inspectorate for Environmental Protection as well as other services dealing with environmental protection, geology, agriculture and forestry, land management, and health.

The Atlas has been completed at the Polish Geological Institute. The National Fund for Environmental Protection and Water Management provided necessary funds for its realization and publication. The Atlas contains general information on the surficial geochemistry of Upper Silesia, which may be updated and elaborated in detail in the future. For the purposes of local communities, it may be necessary to elaborate detailed geochemical maps to 1:25,000 the scale, and even maps to 1:10,000 the scale in areas of particular ecological disaster. Detailed geochemical mapping should be helpful in revealing and outlining fields of low, close to the geochemical background, content of toxic substances in severely polluted areas, and heavily polluted fields in areas of apparently non-degraded environment.

The above mentioned problems are important to planned development of industry, management of land, and health of the society. Therefore, they are at the centre of attention of the Polish Geological Institute.

The Director
of the Polish Geological Institute
Prof. dr habil. Stanisław Speczik

INTRODUCTION

The "Geochemical Atlas of Upper Silesia 1:200,000" is one of a series of geochemical atlases completed at the Polish Geological Institute. These atlases provide cartographic information on the chemistry of the surficial environment in Poland. General lines of geochemical mapping for the area of Poland were defined under the aegis of the Research Program – Poland 2010 (J. Lis, 1987). The execution of this program was however postponed, owing to a shortage of funds and a lack of fast, multi-element analytical techniques at accessible chemical laboratories. Research activities were resumed in 1989, thanks to prof. Stefan Kozłowski, who introduced a new program entitled "Protection of the Lithosphere" (S. Kozłowski, 1989). A proposal for a "Geochemical Map of Poland to Scale 1:500,000" was included in this program. Scientific work related to the program started in 1991, with financial support coming from the Ministry of Environmental Protection, Natural Resources and Forestry.

Samples of soils, water sediments and surface waters were analysed geochemically. Sampling for the geochemical analysis was carried out using a topographic grid of 5×5 km. In urbanized and industrial agglomerations, a more detailed grid of 2×2 km was used. This latter grid was exclusively used in Upper Silesia, a region of real ecological disaster. The realization of the program was scheduled for a period from 1991 to 1995.

From 1992, the program was supported financially by the National Fund for Environmental Protection and Water Management. Sampling and geochemical analysis were first completed for the Silesia-Cracow region. Therefore, this region was separated from the main program and elaborated in 1991–1993 in the form of "The Geochemical Atlas of the Silesia-Cracow Region to Scale 1:200,000" (J. Lis & A. Pasieczna, 1993).

The field work was carried out in 1991 and 1992, in co-operation with the geological company POLGEOL. All the samples were analysed at the Central Chemical Lab of the Polish Geological Institute.

This Atlas is a part of the results of research that lasted three years and was carried out under the aegis of the above mentioned programs. It encompasses a selection of maps providing insight into the geochemistry of surficial environments in Upper Silesia. The maps were elaborated on the basis of 87,243 element measurements in 4,211 samples of soils, water sediments and surficial waters. The maps cover an area of 6,290 square kilometres.

This Atlas is the cooperative work of the following research team:

- J. Lis, A. Pasieczna: geochemistry – concepts and project proposal, supervising and research coordination, elaboration of geochemical maps, interpretation of results,
- S. Przeniosło: geology and deposits,
- H. Biernat – POLGEOL: supervision of field work,
- T. Depciuch, H. Tomassi-Morawiec: data bases,
- T. Gliwicz, G. Przeniosło: data processing,
- P. Pasławski, K. Jakimowicz-Hnatyszak: analytical work – supervision and coordination,
- A. Bellok, H. Bellok, E. Górecka, I. Jaroń, A. Jaklewicz, G. Jaskólska, J. Kucharczyk, B. Kudowska, D. Lech, M. Liszewska, T. Liszewski, E. Maciołek: chemical analysis,
- B. Budzicka, B. Karolak, I. Witowska, D. Woźnica: chemical preparation of samples,
- T. Sztyrak, M. Cichorski, J. Duszyński, A. Nyc, T. Paszkowska, Z. Prasol: preparation of samples.

*
* *

We wish to extend cordial thanks to all those who helped in realization of this project and publication of the Atlas. Special thanks are due to Professor Stefan Kozłowski, whose initiative and effort triggered the research program on the protection of the lithosphere in Poland. We are grateful to Professor Andrzej Paulo for many valuable suggestions and critical review of this work.

FIELD WORK

The field work for this project was carried out during the 1991 and 1992 summer seasons. The Polish Geological Institute engaged three field sampling teams from the geological company POLGEOL. Members of the teams were adequately trained before the beginning of the field work. Each of the teams was provided with a set of topographic maps, equipment and materials for sampling, and detailed instructions of the field work procedure.

Topographic maps to scale 1:50,000 (State Coordinate System 1965) were used as a base for location of sampling points. Each of these maps, corresponding to 640 km^2, were divided into 160 square blocks of 4 km^2 using a grid of 2×2 km. From these blocks, samples of soils, water sediments, and surface waters were collected. The grid of 2×2 km was applied to the whole urbanized area of Upper Silesia. Only in the northern and western margins of the

mapped area was a topographic grid of 5×5 km used, because this part of the area shows dominantly agricultural and forested land development. Standardized sampling cards were used for the description of sampling points, including information on the nature and development of land, employment of soils and/or type of surface water reservoir, petrographic characterization of sampled material as well as a sketch plan of sampling point location. The location of sampling points is shown in Plates 1, 1a, 1b, 23, and 45 of the Atlas.

Samples of soils were taken using an 80 mm sounding bar from two depth intervals: 0.0–0.2 m and 0.4–0.6 m. Samples of approximately 500 g were collected and packed in cloth sacks. Fine-grained water sediments were sampled from a variety of surface water reservoirs, i.e. rivers, streams, lakes and ponds. These samples were also of approximately 500 g, and they were collected in cloth sacks. Samples of surface waters were taken from water columns directly overlying the points of water sediment sampling. In the field, water samples were filtered through a hard filter, and then acidified with hydrochloric acid in 20 ml sample vessels.

PREPARATION AND FILING OF SAMPLES

Samples of soils and water sediments were temporarily drained in the field, and then transported to a storage-place, where they were drained at room temperature. Subsequently, samples of soils and water sediments were passed through 1.0 mm and 0.2 mm nylon sieves, respectively. After quartering, 100 g samples were stored in polyethylene vessels.

All samples were stored in a storage-place on shelves with numbered vessel holders. Samples were classified according to genetic type and map sheet. Each sample was given an analytical file number.

LABORATORY WORK

LEACHING OF SAMPLES

Many different leaching procedures of soil and water sediment samples have been used for the purposes of geochemical mapping in various countries. In the case of this Atlas, the principal scientific goal was to present and characterize the element associations related to anthropogenic contamination of the natural environment rather than the bulk geochemical composition of the surface. Polluting elements are usually mobile in the surficial environment, being also preferentially assimilated and concentrated in living organisms. Therefore, they can easily be extracted from samples using acid treatment. In an attempt to select an acid treatment technique that would provide best characteristics of the mapped environments (and also inexpensive, fast, and suitable for standard analytical methods), a comparative study of different leaching procedures was carried out at the Lab of the Polish Geological Institute (E. Górecka, K. Hnatyszak & P. Pasławski, 1993). The results of this study allowed selection of an extraction technique with hydrochloric acid (HCl 1+4). In this technique, 2 g samples were located in special vessels where they were poured with 20 ml HCl (1+4). The vessels were heated in an aluminium block for one hour at 90°C. Subsequently, the solutions were filtered and collected in 100 ml glass flasks.

In the applied HCl-extraction technique, the spectrum and amounts of dissolved elements are different from their absolute amounts in samples. The dissolution efficiency varies from a few percent to nearly 100%, depending on the form of element occurrence and element reactivity. Most resistant to acid leaching are elements bound in some primary minerals, such as silicon, aluminium, potassium and sodium in feldspars, iron, magnesium and calcium in amphiboles and pyroxenes as well as zirconium, yttrium and thorium in heavy minerals of soils and water sediments. Easily acid-soluble elements are those building lattices of carbonate, chloride and sulphate minerals as well as those occurring in a sorbed form. The latter elements are typically concentrated in anthropogenically polluted soils and water sediments.

ELEMENTAL ANALYSIS AND ACIDITY MEASUREMENTS

The content of Ag, As, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Mg, Mn, Ni, P, Pb, S, Sr, Ti, V, and Zn in samples of soils and water sediments was measured using inductively coupled plasma atomic emission spectrometry (ICP). A Philips spectrometer PV 8060 was used for the analysis of soil samples, and Jobin-Yvon spectrometer JY 70 Plus Geoplasma for samples of water sediments. Detection limits of the measured elements are listed in Tables I and II.

The content of mercury (Hg) was measured using cold vapour atomic absorbtion spectrometry (AAS). Two spectrometers were used: Zeiss AAS-3 and Perkin-Elmer 4100 ZL with FIAS-100 flow system.

Measurements of pH were performed in an aquatic environment according to a standard procedure accepted in soil science (Agricultural and Chemical Analysis of Soil. Measurement of pH, BN-75/9180-33).

The content of Al, As, B, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Na, Ni, P, Pb, SO_4, SiO_2, Sr, Ti, V, and Zn in samples of surface waters was measured using inductively coupled plasma atomic emission spectrometry (ICP) on Philips spectrometer PV 8060. Detection limits of the measured elements are listed in Table III.

DATA BASES

For the purposes of this Atlas, three computer data bases were created using the dBase III-plus software system: a base of sampling point coordinates, a base of field observations, and a base of analytical results.

SAMPLING POINT COORDINATE BASE

The sampling point coordinates were recorded from topographic maps 1:50,000 using a Huston Instrument digitizer and SINUS software system.

The recorded coordinate values in the State Coordinate System 1965 were transformed to values of the State Coordinate System 1942, and then re-calculated to obtain angular coordinate values. Thus the created data base consists of a source coordinate file (State Coordinate System 1965), and a transformed coordinate file (State Coordinate System 1942 and geographic coordinates). This data base was used for the construction of geochemical maps of the Atlas.

FIELD DATA BASE

Descriptional data collected in the field and listed in sampling cards were computed to form a numerical field data base. Each of the descriptional elements in the sampling cards was given a numerical code. Selected files of the data base were elaborated statistically in order to provide information on different factors affecting the surficial environment in Upper Silesia (e.g. concentration of elements in agricultural soils, forested soils, soils in urban areas, etc.).

ANALYTICAL DATA BASE

The results of chemical analysis of the samples were provided by the Central Chemical Lab of the Polish Geological Institute. They were filed in the analytical data base. The analytical data base for the mapped area of Upper Silesia consists of 87,243 element measurements in 4,211 samples.

CONSTRUCTION OF GEOCHEMICAL MAPS

TOPOGRAPHIC BASE

Two sheets of the 1:200,000 topografic map in the State Coordinate System 1942 were used as a base for the construction of geochemical maps: M-34-XIII sheet Gliwice, and M-34-XIV sheet Kraków. The area covered by the geochemical mapping is bordered by longitudes 18°30′ and 19°45′ and latitudes 50°00′ and 50°40′. It covers 6,290 square kilometres.

STATISTICAL CALCULATIONS

Statistical calculations of the data sets and sub-sets, representing a spectrum of types of soils, water sediments and surface waters, were done using the STATIGRAPHICS software system. Arithmetic and geometric means, median, and maximum and minimum values were calculated. The respective values are listed in Tables IV to VI. The calculated parameters provided a base for the generation of geochemical maps. For most of the maps, the geometric mean was accepted as a leading parameter because it provides best representation of the analysed data populations, being also least sensitive to extreme values. Other parameters, such as variance and standard deviation, were not used because the analysed populations are characterized by undefined natural distributions.

GENERATION OF GEOCHEMICAL MAPS

A PC 486 computer with 16 MB RAM and HDD 320 MB was used to generate the geochemical maps. The maps were generated using the inverse distance method under the SURFER for WINDOWS software system. In order to avoid deformation of isolines at the map margins, the data base was extended for sampling points located in a belt directly surrounding the mapped area. This procedure will help correlation of the geochemical maps presented here with similar maps of adjoining areas, which may be elaborated in the future.

The sequences of concentration levels for the generation of isolines were selected in a way that the lowermost level corresponds to geometric mean of the measured element values. For the pH map, the sequence of value levels is consistent with threshold values accepted in the standard classification of soils (strongly acidic, acidic, slightly acidic, neutral, and alkaline). All the generated geochemical images were saved and stored as HPGL files.

DRAWING OF GEOCHEMICAL MAPS

The geochemical maps were drawn on a NOVAJET II ink-jet plotter. In plates containing the geochemical maps, there were added tables with lists of statistical parameters and corresponding histograms as well as sketch geochemical maps of Poland to scale 1:7,500,000. The latter maps were simplified and reproduced from the "Geochemical Atlas of Poland to Scale 1:2,500,000" (J. Lis & A. Pasieczna, 1995).

GEOLOGY AND DEPOSITS

GEOLOGICAL SETTING

Two regional geological units, superimposed in part, occur within the mapped area: the Upper Silesian Coal Basin (GZW), and its northern and north-eastern sedimentary cover, the latter belonging to the Silesian-Cracow Monocline. To the south, the two units are covered by a Tertiary sedimentary sequence. Both the industrial development of Upper Silesia and density of population, which is one of the highest in Poland, are related to the occurrence of many economically important deposits in the region.

Upper Silesian Coal Basin (GZW)

The geochemical maps of the Atlas cover the central part of the Upper Silesian Coal Basin and its north-western, northern, and eastern margins. Within the boundaries of Poland, the GZW covers an area of approximately 5,800 square kilometers. Mined coal deposits account for 31% of the GZW area.

The Upper Silesian Coal Basin is mainly composed of the Upper Carboniferous (productive) sedimentary sequence, which crops out at the surface and extends downwards

to a depth of approximately 4,500 m. In the Silesian Syncline, the sequence is a few hundred metres thick. The thickness consequently increases southwards, attaining maximum in the central and western parts of the Coal Basin. The underlying Lower Carboniferous marine sequence crops out along the western margin of the mapped area, and also at isolated places in its north-eastern part. The Upper Carboniferous sequence is developed in the form of the coal-bearing molasse facies that fills up a fore-mountain depression. The sequence is characterized by a cyclic development of coal-bearing and clastic sedimentary units, and by a lack of depositional carbonates.

The productive Carboniferous sequence begins with a paralic coal-bearing formation (Namurian A), which encompasses marine to deltaic deposits with thin coal seams. The content of coal is less than 1% here. The formation is overlain by a limnic coal-bearing formation showing greater content of coal. The latter formation can be subdivided from bottom to top into: the Upper Silesian Sandstone Series, the Mudstone Series, and the Cracow Sandstone Series.

The Upper Silesian Sandstone Series (Namurian B and C) contains thick coal seams (up to 15 m in thickness) that occur within medium- to coarse-grained sandstones interfingered with other sediments. There exist small tuffite interbeds in the sequence (A. Kotas & W. Malczyk, 1972). The content of coal may attain 12%.

The Mudstone Series (Westphalian A and B) consists of a monotonous sequence of claystones and mudstones with concretionary siderite at some levels. Thickness of the series varies considerably. It attains 2,000 m in the western part of the coal basin, but it is only 100 m in the eastern part. The content of coal fluctuates from 3 to 6% between different localities.

The Cracow Sandstone Series (Westphalian C and D) contains recurrent coal seams up to 7 m thick. The seams tend to concentrate in fine-grained sediment facies. This series occurs in the central and eastern parts of the Coal Basin. The content of coal is up to 8% here.

In the eastern part of the Upper Silesian Coal Basin (vicinity of Chrzanów), there occur the youngest Carboniferous sediments. These are represented by the Kwaczała Arkose and the Karniowice Sandstone, both of Stephanian age.

Northern and north-eastern margin of the GZW

Devonian dolomites represent the oldest rock complex cropping out in the mapped area. They are known from Brudziowice, Dziewki, Nowa Wieś, and Żelisławice in the vicinity of Siewierz. The dolomites crop out only locally in erosional windows within the Triassic rocks. The marine sequence of the Devonian and Lower Carboniferous and the Upper Carboniferous productive sequence are folded and discordantly overlain by Permian, Triassic, Jurassic and Tertiary sediments.

Permian is represented by a conglomeratic and tuffogenic rock sequence, which is classified into the Myślachowice Conglomerate and the Filipowice Tuffs, the latter encompassing acidic and basic volcanic intrusions. The se rocks crop out only in the eastern margin of the Coal Basin. Their outcrops are located to the south-west of Ząbkowice Będzińskie, and also between Strzemieszyce, Trzebinia and Krzeszowice.

A nearly complete stratigraphic sequence of the Triassic is known in the mapped area. The Triassic sediments form isolated patches in the central part of the Coal Basin, and an extended cover in its northern and north-eastern margins.

Lower Triassic is developed as multi-grained sandstones and conglomerates that pass upwards into clay and marly sediments overlain, in turn, by a dolostone sequence. These rocks fill local depressions in the Carboniferous and Permian substratum. Outcrops of the Lower Triassic rocks occur near Chorzów, Mikołów, Sosnowiec, Sławków, Będzin, Chrzanów and Jaworzno (S. Kotlicki & N. Kotlicka, 1980; H. Kaziuk & J. Lewandowski, 1980).

Middle Triassic is represented by the Muschelkalk facies. It is of economic importance because it contains industrial sulphide ores of zinc and lead. The Muschelkalk makes an extended cover in the northern and eastern margins of the Coal Basin, and it also occurs in the form of isolated patches within the basin centre.

The lower part of the Muschelkalk is classified into the Błotnice and Gogolin Beds. These lithostratigraphical units encompass a sequence of cavernous and banded limestones that pass upwards into marls. The sequence is overlain by a limestone complex, which is classified into three superimposed lithostratigraphical units: the Górażdże Beds, the Terebratula Beds, and the Karchowice Beds. In the eastern part of the Silesia region, the whole limestone complex is classified into the Olkusz Beds. Thickness of this complex varies from 80 m to 130 m. The limestone complex is a significant metallogenic unit because it is commonly dolomitized to form the Ore-Bearing Dolomites containing economic deposits of zinc and lead.

The limestone complex is overlain by the Diplopora Dolomites of the Jemielnice Beds, and by a sequence of platy, oolitic and marly dolomites of the Tarnowskie Góry Beds.

It is generally accepted that the Ore-Bearing Dolomites represent a "chemical" horizon of post-genetic dolomitization of sedimentary units, which most frequently replaces the Górażdże, Terebratula, and Karchowice Beds (S. Śliwiński, 1978). The Ore-Bearing Dolomites may also be developed in the Lower Triassic carbonate units (Rhaetian) as well as in the Devonian rocks in places where they directly underlie the Triassic sequence (S. Przeniosło, 1974). At some other places, the Ore-Bearing Dolomites are noted within the Diplopora Dolomites, which overlie the main metallogenic complex of the Middle Triassic. Thickness of the Ore-Bearing Dolomites usually varies between 40 m and 50 m, though in rare cases it may attain 100 m. The Ore-Bearing Dolomites is a collective name for a spectrum of dolomitic rock types, including crystalline, porous, and cavernous dolomites. The dolomites are often fissured and at places represented by a dolomitic breccia. Pores, caverns and fissures in the host dolomitic rock are filled with zinc and lead sulphide minerals (zinc blende, galenite), iron sulphide minerals (pyrite, marcasite), calcite, and sometimes also barite. The ore minerals are frequently concentrated to form economic deposits. These are discussed below in detail. The Ore-Bearing Dolomites can be generally regarded as a metasomatic aureole of zinc and lead mineralization. The geochemical background of zinc and lead in the dolomites is high, fluctuating around 0.085% Zn and 0.015% Pb outside mineralization zones (S. Przeniosło & J. Serafin-Radlicz, 1978).

In the outcrop belt of the Ore-Bearing Dolomites, subaerial weathering of the sulphidic mineralization zones leads to the development of an oxide ore called calamine (W. Żabiński, 1978). At numerous locations, this ore was the subject of mining. The calamine is a friable ore material. Therefore, it easily disintegrates and is redistributed to soils and fluvial sediments. Natural processes of weathering, denudation and water transport have contributed to the

development of geochemical anomalies of zinc and lead in the mapped area. Economic activity can also be considered a factor affecting the absolute values and lateral extent of these anomalies.

The Upper Triassic sediments (Keuper and Rhaetian) discordantly overlie the Muschelkalk sequence. Clays and claystones of the Keuper occur mainly in the Chrzanów depression, where they make a flat-lying sequence on older rocks. In the north-eastern and northern parts of the mapped area, there occurs a Rhaetian sequence of variegated claystones laminated with recurrent layers of sandstone and mudstone. There are also interbeds of resistant pelitic limestones, which are referred to as the Woźniki Limestones in the local lithostratigraphic scheme. The limestones make positive morphological forms in the field. A total thickness of the Upper Triassic sequence is more than 100 m.

The Jurassic sediments rest discordantly, and usually transgressively, over the Triassic. The oldest Jurassic sediments occur only in the northern part of the area, where they form isolated patches. The Lower Jurassic is represented by a sequence of sands and sandstones with clay intercalations and thin seams of brown coal in its upper part. In the uppermost part of the Lower Jurassic, there also occur siderite intercalations (J. Znosko, 1955). The Middle Jurassic is developed in the form of a marginal marine facies, which progrades towards the south up the sequence. The progradation of this facies contributed to a different development of the Middle Jurassic in the southern and northern parts of the area (J. Kopik, 1967). The Bathonian ore-bearing clayey sequence with clay-rich siderite, sideritic mudstone and abundant spherosiderites, attaining a thickness of more than 150 m in the Częstochowa area, thins towards the south and disappears in the vicinity of Ogrodzieniec. In the outcrop belt between Kłobuck and Zawiercie, iron ore was mined from this sequence. The upper part of the Middle Jurassic and the Upper Jurassic are represented by a sequence of gray limestones, dolomitic in part, passing upwards into a complex of compact limestones.

A small area in the north-eastern margin of the map is covered by the Cretaceous sediments. Both Lower and Upper Cretaceous carbonate sediments are present.

In the vast majority of the mapped area, the Tertiary sediments are represented by a marine and fresh-water Miocene sequence (S.W. Alexandrowicz, 1963). Continental Pliocene facies are limited to the western part of the area, where they make isolated patches. The oldest part of the Miocene sequence, which is of Carpathian age, consists of fresh-water clays and marly clays with seams of brown coal. The overlying Badenian complex is of marine origin. It is classified into the Skawina, Wieliczka, and Grabowiec Beds. The Skawina Beds are gray and greenish-gray marly clays up to 50 m thick. The overlying Wieliczka Beds encompass a clayey sequence with gypsum and salt rock interbeds. Thickness of this sequence is 40 m. The Grabowiec Beds are the youngest in the Badenian marine complex. They are represented by gray marly clays up to 200 m thick. Only in the western part of the mapped area, there occur Tertiary sediments younger than Badenian. These are Sarmatian fresh-water clays with sandy intercalations.

DEPOSITS

Black coal

In the Upper Silesian Coal Basin, the black coal deposits are documented down to a depth of 1,000 m. One hundred and five deposits covering an area of more than 3,000 km^2 have been surveyed geologically. This accounts for approximately 53% of the Polish part of the Coal Basin. The black coal is currently being mined in 67 underground mines, with estimated economic deposits covering 1,800 km^2.

In coal-rich parts of the Basin, total thickness of coal seams, counted to a depth of 1,000 m, is approximately 65 m. There are about 200 minable seams (i.e. seams more than 1 m thick) in the Coal Basin.

According to the estimate of 31 December 1993, the reserves of black coal in the Upper Silesian Coal Basin are 5.6×10^{10} t, of which 2.7×10^{10} t is proved in mined deposits. In 1993, the production of coal was more than 1.3×10^{8} t (Resource Balance..., 1994).

In Upper Silesia, black coal was already being mined in the XVIth century. The first underground mines were opened at the end of XVIIIth century. The historical mining of coal has contributed to only negligible modification of geochemistry of surficial environments in Upper Silesia. The exception is the recent stage of mining development, because of the shift of exploitation to deeper parts of the productive sequence, where abundant brines and saline waters occur.

Black coal and the associated barren rocks contain admixtures of pyrite and sulphur as well as trace elements, such as beryllium, germanium, cobalt, molybdenum, and vanadium. There also occur gases (methane, carbon dioxide, and others). In some parts of the Coal Basin, increased contents of uranium are noted, mostly in tectonic zones.

The most important challenges environment degradation that are associated with mining and treatment of black coal can be related to:
- mine waters,
- mine and treatment waste-rock,
- rockmass deformation,
- combustion of coal.

In recent years, the amount of mine waters pumped out to the surface has fluctuated between 3.3 and 3.4×10^{8} m^3 per annum, out of which $1.5-1.6\times10^{8}$ m^3 falls to saline waters and brines highly enriched in chloride ion (Cl^-) and, to a lesser extent, also in sulphate ion (SO_4^{2-}). For the purpose of this presentation, the measured amounts of saline waters and brines were re-calculated for an equivalent of pure NaCl, using mean concentration values representing the period from 1991 to 1993. The amount of salt (eq NaCl) pumped out to the surface is 3.2×10^{6} t/year on the average. Out of this amount, 2.9×10^{6} t of NaCl annually enter the surficial water system and flow down the Wisła and Odra rivers. The map in Plate C shows the amount and distribution of mine waters, re-calculated to eq NaCl values, which are pumped out of coal mines in the study area. It seems clear from the map that nearly half of the total amount of salt comes from only three mines.

Mine and treatment waste-rocks accumulate as the usual by-product of coal mining. The annual accumulation of these wastes amounts to 3.9×10^{7} t, out of which 2.4×10^{7} t is deposited on mine banks, and the remainder (1.5×10^{7} t) is used in land engineering projects. The accumulation of waste rocks degrades the natural environment due to the occupation of land and modification of the landscape structure, and due to the pollution of ground waters with chlorides, sulphates and heavy metals.

On the surface, the deformation of mountain building structure is manifested by the common development of morphological depressions above the mined coal seams. However, the mountain building deformation also leads to destruction of structural shields separating water-bearing

horizons, and, as a consequence, to contamination of underground aquifers related to sudden water mixing and migration of polluting elements.

Plants consuming high amounts of coal, such as smelting works, power and cement plants, contribute significantly to the pollution of natural environment because of continuous emission of combustion gases and ash with a spectrum of concentrated elements. A minimum content of sulphur and ash in black coal is noted in seams of the Upper Silesian Sandstone Series, where it is 0.85% and 11.0%, respectively. A maximum of sulphur and ash is noted in coals of the Cracow Sandstone Series, where it reaches 2.0% and 16.2% (Z. Buła & A. Zdanowski, 1993). In the latter series, there is also a noted concentration of uranium (up to a few hundred ppm) in some fault zones.

Zinc and lead ores

The ores of zinc and lead tend to concentrate in a few deposit areas, namely in the Tarnowskie Góry, Bytom, Chrzanów, Olkusz, and Zawiercie Areas. Some of these areas, e.g. the Tarnowskie Góry and Bytom Areas, are of historical value only.

According to the estimate of 31 December 1993, the Zn-Pb reserves are proved at $2.16-10^8$ t of ore containing 8.4×10^6 t of zinc and $3.7-10^6$ t of lead. The reserves have been estimated in 20 deposits occurring in the Chrzanów, Olkusz and Zawiercie Areas. Four deposits are currently being mined: the Trzebionka deposit in the Chrzanów Area, and the Bolesław, Olkusz and Pomorzany deposits in the Olkusz Area. In 1993, 4.8×10^6 t of ore containing 18.6×10^4 t of zinc and 6.9×10^4 t of lead was mined.

The Zn-Pb deposits are of stratified type. They are developed in the form of pseudo-beds, lens-like and nest-like bodies, and karst-collapse breccias, that tend to follow indistinct mineralization horizons, mostly in the Ore-Bearing Dolomites but also in some other lithological units. Primary ores are sulphidic. They contain galena with an admixture of silver, zinc blende with an elevated content of cadmium, gallium, germanium and thallium, and important amounts of iron sulphide minerals, such as marcasite and pyrite. At shallow depths, there occur epigenetically oxidized ores (the so-called calamine) containing a spectrum of minerals, out of which smithsonite, cerussite, goethite, hemimorphite, and hydrozincite are most common.

The metal mining in the Silesia-Cracow region began in the middle ages. First written information on the mining activity comes from the reign of Bolesław Krzywousty. It is contained in the papal edict of Innocent II announced in 1136, where Bytom and "silver diggers" are mentioned (S. Grzechnik, 1978). It is, however, highly probable that the mining activity in the region began earlier. Until the XVII–Ith century, the mining concentrated on lead ores, from which silver and then lead and silver were recovered (D. Molenda, 1972). Remnants of old mining works are known from some locations in the vicinity of Tarnowskie Góry and Piekary Śląskie as well as from Ząbkowice Śląskie, Tuczna Baba, Sławków, Olkusz, Siersza, Jaworzno and Chrzanów. The ores occurring at deeper horizons were mined after draining of the rockmass by a drain adit system. Old drain adits are known in the vicinity of Tarnowskie Góry, Bytom and Olkusz. They were given specific names, which have persisted in use to the present: Boże Wspomóż, Św. Jakub, Dar Boży, Krakowska, Od Szarlejki, Krokwińska, Ponikowska, Starczynowska, Staroolkuska, Czajakowa Leśna, and Centauryjska adits. Galena was smelted at many places that concentrate near Tarnowskie Góry–Strzybnica–Miasteczko Śląskie, Olkusz–Starczynów–Hutki, Chrzanów–Trzebinia, and Siersza.

A detailed location of old smelting works, in particular those from the XVI–XVIIIth centuries, is important for a proper understanding of the geochemical distribution of metals in the mapped area. From the XVIth to the XVIIIth centuries, only galena was smelted. Therefore, the sulphidic and oxide zinc ores as well as high-grade oxide lead ores were left as waste-rock. These ores, in particular the oxide lead ore, easily disintegrated at the surface and were disseminated in the surrounding environment.

It is worth noting that there exists a good correlation between the distribution of old mining and treatment works from before the XIXth century and the pattern of modern zinc and lead anomalies. The high contents of lead in soils occurring to the west of Tarnowskie Góry and Piekary Śląskie, in the vicinity of Chrzanów, and in the area between Sławków, Ząbkowice Śląskie and Tuczna Baba serve as examples. In the last area, there was no younger mining or treatment activity.

From the beginning of the XIXth century, a new stage of mining in the region was triggered by introducing a smelting technology that gave metallic zinc, especially from the calamine. As a result, many new mines were opened on oxide ore deposits located close to the surface. Treatment of the oxide ore involved mechanical concentration of raw material, which led to severe degradation of the environment. It was only in 1990 that the mining of calamine for the production of zinc oxide concentrate ceased.

After introducing smelting technology of zinc blende during the seventies of the XIXth century, sulphidic zinc ores begun to be the subject of increasing economic interest. This opened a new stage of development of metal mining in the region. At the end of the XIXth century, there were 120 working mines and many zinc-smelting works in Upper Silesia, with total zinc production accounting for 25% of world production. In 1900, 5×10^5 t of ore were mined, and 1×10^5 t of metallic zinc were produced. The production of zinc attained a maximum in 1912 and 1913, amounting to 1.7×10^5 t per annum (A. Melich, 1961). The current zinc production is kept at a comparable level. After the First World War, there were about 20 working mines, several zinc-smelting works and two lead-smelting works in the Silesia region. Important zinc plants were located at Szopienice (Wilhelmina plant), Rozdzienie–Szopienice (Bernhardi plant), Wełnowiec (Hohenlohe plant), Bogucice (Kunegunda plant), Radzików (Łazarz plant), Dąbrówka Mała (Paweł plant), Nowy Bytom (Rozamunda plant), Lipnice (Silesia plant), Nowa Wieś (Miłej Nadziei plant), and Chropaczów (Guidotto plant). The lead plants were located at Strzybnica (Fryderyk plant) and Dąbrówka Mała (Walter Croneck plant). During the first half of the XXth century, there were huge variations in ore mining and metal production in the region.

Changes in economic interest between different types of ores over the last few hundred years related to consequent progress in the mining and treatment technologies brought about common shifts of the metal production from one deposit to another, and the accumulation of many generations of mine banks and waste-rock dumps. These accumulations also became subjects of subsequent exploitation and metal production.

Extensive geological prospecting for Zn-Pb ores carried out over the last fifty years have resulted in the documentation of new reserves in all the known deposit areas. Most economic reserves have been proved in the Olkusz Area. There were also revealed economic deposits in the vicinity

of Zawiercie, which allowed to distinction of the Zawiercie Area as a new deposit area in the region. The deposits in this area have not yet been mined. Besides the geologically documented deposits, which are shown in Plate C, in the northern part of the mapped area, there have been revealed and preliminarily described Zn-Pb mineralization zones near Żarki Letnisko, Myszków, Winowno and Ligota Woźnicka (R. Kacprzak & B. Kerber, in: S. Przeniosło & S. Wołkowicz, 1993).

After the Second World War, the following deposits were mined: Orzeł Biały deposit, Nowy Orzeł Biały–Marchlewski deposit, Nowy Dwór deposit and Dąbrówka deposit in the Bytom Area, Jaworzno deposit, Matylda deposit, and Trzebionka deposit in the Chrzanów Area, and Bolesław deposit, Olkusz deposit and Pomorzany deposit in the Olkusz Area. All the mines were of underground type. The underground mining in the region requires significant drainage works. The water pumped out from the Zn-Pb mines is characterized by low level of mineralization. Therefore, it is used as drinking and industrial water. In 1993, 13.4×10^7 m^3 of water were pumped out to the surface, half of which was used by industry.

Metal-ore treatment plants are usually located close to the mines. Treatment and metallurgy of zinc and lead are one of the most important factors affecting the degradation of the natural environment in the region. Flotation methods are applied to obtain ore concentrates from the sulphidic ore. Small amounts of galena are also recovered using a gravitational concentration method. Sphalerite, galena, and mixed galena-sphalerite concentrates are produced in the Bolesław, Olkusz–Pomorzany and Trzebionka treatment plants. Dolomites and limestones are waste-rocks of the flotation process, though their further use is limited owing to residual content of zinc and lead as well as other polluting elements (M. Szuwarzyński & A. Kryza, 1993).

The concentration of raw Zn-Pb oxide ores involves mechanical pre-treatment (grinding), which is followed by a thermal treatment and caking of the thus obtained zinc oxide powder. Up to 1990, the calamine was treated in the Miasteczko Śląskie treatment plant where zinc oxide powder was produced. The powder was further treated in the Orzeł Biały–Waryński caking plant and also in the Bolesław plant. Oxide ores, which are mined together with sulphidic ores, as well as calamine sludges and wastes, and zinc cinder and clinker are currently treated in the Bolesław plant. Treatment of oxide ores is associated with important emission of heavy metal-containing dusts, which settle to the surface in areas surrounding treatment plants, polluting soils and ground waters.

Metallic zinc is produced from the zinc concentrates using pyrometallurgy in smelting works in the Miasteczko Śląskie, and in the Bolesław and the Szopienice smelting works where electrolytic methods are applied. In the "Silesia" smelting works in Katowice, rectified zinc is produced (S. Przeniosło et al., 1992).

Smelting of lead, in particular the raw lead, in the Silesia-Cracow region has been confined recently. The Lead Plant in Bolesław as well as a part of the smelting works in Miasteczko Śląskie have been closed. The production of lead is still carried out in Miasteczko Śląskie, in the ZGH Orzeł Biały plant in Piekary Śląskie, in the HMN Szopienice plant in Katowice, and in the "Wtórmet" plant in Bytom (A. Bolewski, R. Ney & T. Smakowski (Eds), 1994).

In the Zn-Pb metallurgy, apart from the two basic metals, also cadmium, cadmium sponge, silver, and sulphuric acid are produced. However, under current technologic processes, it is hardly possible to recover other important elements from the ores, such as gallium, germanium, thallium and tellurium. These elements may escape at many stages of the treatment procedure and add to the pollution pool in the natural environment.

The geochemical distribution of zinc, lead and other associated elements in surficial environments of Upper Silesia reflects an interplay of natural processes and anthropogenic contamination. The contents of these elements vary considerably between different localities of the mapped area. The occurrence of Zn-Pb deposits and mineralization zones close to and/or at the surface can be considered the most important natural factor affecting the distribution of the metals. The mining and treatment activity as well as transport and other industrial use of the metals significantly modify this natural distribution and lead to the pollution of the environment with zinc and lead.

Rock salt

In the southern part of the mapped area, the Rybnik–Żory–Orzesze salt deposit has been documented geologically, with estimated reserves of approximately 2×10^9 t. The deposit occurs within the Miocene sedimentary sequence. It is not mined.

Other deposits and mineralizations

There is a variety of other mineral deposits in Upper Silesia, such as dolomites, limestones, stone deposits and building stone, ceramic clays, and sands. About 70 deposits are currently being mined in open-pits and quarries. This production also affects the degradation of the natural environment. However, the mined deposits are not shown on the map, because recovered stony and mineral materials provide only insignificant and local modifications of the geochemical distribution of elements.

The occurrence of sulphur deposits at Kokoszyce and Pszów near Rybnik should be mentioned. This deposit is located outside the mapped area, in the south-western part of the Silesia region. It was mined at the end of the XIXth century (T. Osmólski, 1969). The deposit and the associated sulphate-rich waters known from a nearby health resort can be considered a source of sulphur and strontium that migrate to the mapped area and are monitored on the geochemical maps.

IMPORTANT POLLUTION SOURCES

The geochemical composition of surficial environments in Upper Silesia reflects an interplay of natural factors, in particular the geological structure and composition of rock substratum and anthropogenic influence related mainly to economic activity in the region.

Plate C of the Atlas shows the distribution of main deposits in Upper Silesia on a sketch geological map without Quaternary sediments. The geological map was simplified to show only major and thick formations. The Permian and Lower Triassic sediments, which make a thin

cover on the Carboniferous, are not shown. On the other hand, the carbonate complex of the Middle Triassic is shown as a separate unit, because of its ore-bearing nature and elevated contents of zinc, lead and associated elements. The Upper Triassic clayey complex, which occurs between the ore-bearing Middle Triassic and the ore-bearing Lower Jurassic, is also shown as a separate unit.

Only currently mined coal deposits are shown on the map. A also shown are locations of mine-related saline waters as well as locations of major combustion plants. Non-exploited coal deposits were omitted, because of their negligible influence on the modification of the natural environment.

Mining of coal is inherently associated with accumulation of waste-rocks on mine banks and dumps. Only in Katowice voivodeship, there exist 65 mine waste-rock accumulation dumps (Cz. Królikowski at al., 1992). Waste-rock accumulations degrade the natural environment due to the occupation of land and modification of the landscape structure. They also interact chemically with the surrounding environment. Some of these accumulations are highly enriched with pyritic sulphur, which combines with meteoric water and atmospheric oxygen to form acidic fluids. These fluids escape the dump areas and pollute the surrounding environment. Acidic fluids migrating through the waste-rock accumulations also dissolve and redistribute heavy metals. Among other mobile phases present in waste-rock accumulations, the role of chlorides, which are easily soluble in water, should be highlighted. The dissolution of chlorides contributes to a significant remobilization and migration of ions (I. Twardowska et al., 1988).

Power industry also contributes to a significant degradation of natural environment in Upper Silesia. Several power plants are located in the mapped area, including the Łagisza, Chorzów, Halemba, Katowice, Jaworzno, and Siersza plants. Continuous combustion of coal at these plants is associated with emission of large amounts of gases and light and heavy dusts.

The Zn-Pb deposits strongly affect the distribution of elements in surficial environments of Upper Silesia. Therefore, in Plate C, all the known Zn-Pb deposits are shown. Even deposits that are covered by impermeable clayey formations may influence concentration of heavy metals in surface waters. The distribution of outcrops of the Ore-Bearing Dolomites can be considered a leading natural factor that governs the concentration of metals in waters, soils, and alluvial sediments.

Also shown on the map are locations of old mining and treatment activity, including remnants of old mines, drainage adits, smelting works, and concentration plants as well as old waste-rock accumulations. Only historical mining places, which occur at locations of modern Zn-Pb industry, are not shown on the map.

Among various wastes of the Zn-Pb industry, the flotation wastes are most dangerous ecologically. These wastes contain considerable amounts of cadmium, lead, and zinc. Leaching of the wastes, along with wind-driven redistribution of their fine fractions, contributes to migration and concentration of metals in waters, soils, and living plants. In flotation wastes, the content of zinc and lead reaches 2.90% and 0.60%, respectively (M. Szuwarzyński & A. Kryza, 1993).

Besides the pollution related to the mining and treatment of mineral materials (Plate C), there exists a variety of other pollution sources in Upper Silesia. Among these sources, the smelting works and chemical industry are most important. Cz. Królikowski et al. (1992) present a list of several waste and sludge dumps of smelting works and metal plants occurring in the study area. Sludges of iron- and steel-smelting works contain suspended oxides of iron, aluminium, calcium, magnesium, and sulphur as well as oil, sulphate, hydrogen sulphide, cyanide, and many other toxic substances. There is a variety of chemical plants located in the study area, including the nitrate plant in Chorzów, the grease plant in Trzebinia, and the "Alwernia" and "Tarnowskie Góry" plants. The waste dump of the "Tarnowskie Góry" plant covers an area of 0.35 km^2 and contains 3×10^5 t of chemical substances. In this dump, there are accumulated wastes after the production of BaS, $BaCl_2$, $Ba(NO_3)_2$, boric acid, borax, copper and zinc sulphides as well as waste fabrics, filter paper and sludges from a refinery plant.

Municipal and industrial waste dumps and sludges affect the degradation of the natural environment. Municipal dumps in Upper Silesia also collect wastes coming from small industry plants and handicraft works. The Upper Silesian rivers are severely polluted. In the catchment area of Kłodnica river, there are about 40 places of industrial and municipal sludge input (J. Szturc, 1993). Czarna Przemsza river collects sludges from eight mines, four smelting works, and ten towns. In the Rawa catchment area, there are about 400 known sludge input locations, including municipal sludges coming from Katowice, Chorzów, Świętochłowice and Ruda Śląska.

GEOCHEMICAL MAPS

In order to provide better insight into the extent of pollution in Upper Silesia, the maps of this Atlas have supplementary geochemical information added. On the maps, red isolines mark limit values of elements, which have been accepted as levels of their permissible concentration in the natural environment. It was, however, impossible to present a full list of standardized limit values because there are no official norms, either in Poland or in other countries, which would define levels of permissible concentration of some of the studied elements.

Limit values for cultivated soils were accepted for all the studied soils in Upper Silesia (Plates 3–33). The values were accepted after the Canadian soil standard (11)*, the standard of the European Community (13), and other published values (16, 27). For those elements, for which there are no published permissible concentration levels, the geochemical background values in soils of Poland were used (47). The background values were accepted to be geometric mean values of elements (measured in 10,840 soil samples of Poland) multiplied by a factor of 3 (47).

There are no officially accepted levels of permissible concentration of elements in water sediments. Therefore, geochemical background values are shown on the maps (Plates 24–44). These values were calculated in a similar way to the soil background values, using geometric mean values of 12,778 water sediment samples (47).

In Poland, for only a few elements have the permissible concentration levels in surface waters been published

* Numbers refer to references listed at the end of the text.

so far. There are distinguished three consequent value ranges, which define three classes of water purity. On the maps (Plates 46–65), there are shown either limit values of the first class of water purity for elements included in the Polish standard (70), or geochemical background values for other elements. The background values were calculated from element measurements in 12,955 samples of surface waters.

The geochemical maps of soils are results of mathematical elaboration and modelling of the recorded data base. This means, that the presented element patterns may not exactly reflect the absolute values recorded at sampling points. The accuracy of map projection depends on the density of sampling points and, as a consequence, on the map scale. Sampling density of one sample per 4 km^2 was accepted for this Atlas. This density is appropriate for maps to scale 1:200,000. However, it should be realized that the maps contain only general information on the land chemistry. Therefore, by using them it may be hardly possible to discriminate and characterize pollution fields covering areas smaller than the sampling blocks. Nonetheless, the presented element patterns should be found helpful in locating future investigation projects aimed towards identification of detailed contours of geochemical anomalies and polluted fields of both natural and anthropogenic origin. After detailed geochemical mapping (using a sampling grid of 100×100 m, or even a grid of 50×50 m), it may appear that the revealed geochemical patterns are far more complex than those presented in the Atlas. Severely polluted fields may adjoin fields of low contents of polluting elements, close to the local background values. It should also be stressed that in Upper Silesia there occur anomalously high concentrations of elements of both anthropogenic and natural origin. Anthropogenic anomalies reflect economic activity in the region, whereas the natural ones already existed before the human modification of the environment.

In this Atlas, aerial type presentation was used to show the composition of water sediments and surface waters. This type of presentation has been used in many other regional geochemical atlases (e.g. Geochemical Atlas of the Republic of Austria, Geochemischer Atlas Bundesrepublik Deutschland, Regional Geochemistry of Southern Scotland, and others). Other types of presentation, such as circle diagrams or ribbon diagrams, were found to be inappropriate for the purposes of this Atlas. Circle diagrams are normally included in detailed geochemical maps, whereas ribbon diagrams are used to present rather scarce data collected along big rivers. As an example the "Atlas of Pollution in Rivers of the Vistula Drainage Basin", may serve here (J. Woyciechowska & P. Morawiec, 1994), developed on the basis of monitoring analysis of eleven rivers. Similar presentation may be found in the "Atlas of Pollution in the Rivers of Poland: 1990–1992" (R. Korol et al., 1993), developed using the results of monitoring analysis of 53 rivers in Poland. Out of the rivers analysed therein, only Mała Panew and Przemsza occur in our study area. However, representative concentrations of polluting elements in Mała Panew were not specified, owing to scarcity of recorded data. The exception was zinc, whose values were found to be above the limit value of the third class of water purity.

For the purposes of this Atlas, the location of individual sampling points of surface waters and water sediments within the sampling blocks was carried out in a way to provide best representation of the Upper Silesian water system at the accepted map scale. Geochemical maps of water sediments are important for a proper assessment of the degree of pollution of the natural environment. Geochemical information contained in the maps may serve as an "early warning" signal of pollution sources. This is because water sediments contain substances with high sorption capacity. These substances sorb and store elements, which are present in surface waters at only slightly elevated concentrations, yet below the detection limits of standard chemical analysis. Therefore, detailed analysis of the maps may help in revealing and characterizing local pollution sources.

pH ACIDITY

Soils: Plate 2, Table IV

pH limit values of different types of soils (pH–H_2O), (56):

– strongly acidic soils		≤5
– acidic soils	>5	≤6
– slightly acidic soils	>6	≤6.7
– neutral soils	>6.7	≤7.4
– alkaline soils	>7.4	

Basic values for Poland (47) and the study area:

– soils of Poland	2.1–9.7; average 5.9**
– cultivated soils of Poland	2.8–8.7; average 6.2
– soils of Upper Silesia	2.2–9.7; average 6.2
– cultivated soils of Upper Silesia	3.5–8.7; average 6.5

Area covered by different pH types of soils:

– strongly acidic soils	698 km^2	11.1%
– acidic and slightly acidic soils	2766 km^2	44.0%
– neutral soils	1955 km^2	31.1%
– alkaline soils	871 km^2	13.8%

Several factors influence the distribution of the pH types of soils in the study area. Out of these factors, the geological structure and composition of rock substratum (presence of carbonate rocks) and the industrial and mining activity seem to be most important. Type of employment also affects the soil acidity. Low pH values are frequently noted in forest soils. On the map, two dense areas of soils showing low pH values can be distinguished. One area embraces the forest complex located between Siewierz and Krupski Młyn in the northern part of the mapped area. The other is located between Oświęcim and Rybnik in the southern part. A noticeable contribution of neutral and alkaline soils in the eastern part can most probably be related to the presence of Triassic and Jurassic carbonate rocks in the substratum. Elevated alkalinity of soils in urban agglomerations of Upper Silesia is caused by settled industrial dusts. In fact, soils in urbanized areas show the highest measured pH values: 6.8 in city park soils, 7.5 in lawn soils, and 7.1 in allotment soils. The effect of urbanization on the increase of pH values of soils can also be noted in forested and agricultural fields. Afforested soils in urban areas show higher pH values (5.8 on the average) than forest soils in non-urbanized areas (4.5 on the average). Likewise, cultivated soils within and outside the urban areas show average pH values of 7.2 and 6.5, respectively.

** All average values are geometric mean values.

Ag SILVER

Soils: Plate 3, Table IV; ppm = mg/kg = g/t

Approximate limit values (11):

- cultivated soils ≤20
- soils of city parks, recreation fields, and soils in house building areas ≤20
- soils in industrial and commercial building areas ≤40

Basic values for Poland (47) and the study area:

- soils of Poland <1–41; average <1
- cultivated soils of Poland <1–12; average <1
- soils of Upper Silesia <1–13; average <1
- cultivated soils of Upper Silesia <1– 3; average <1

The content of HCl-soluble silver in soils of Upper Silesia is in general less than 1 ppm. Soils showing elevated silver content (>1 ppm) make isolated patches on outcrops of the Ore-Bearing Dolomites. They also occur in areas of old Zn-Pb waste-rock accumulations as well as in areas of both old and modern Zn-Pb industry (Plate C). Silver anomalies of similar origin (up to 20 ppm) have also been observed in soils in areas of old lead-ore mining in the Holy Cross Mountains (L. Lenartowicz, 1994).

Water sediments: Plate 24, Table V; ppm = mg/kg = g/t

Basic values for Poland (47) and the study area:

- water sediments of Poland <1–117; average <1
- alluvium of Vistula <1– 5; average <1
- alluvium of Odra <1– 5; average 1
- water sediments of Upper Silesia <1–117; average <1

As opposed to soils, there is a noticeable concentration of silver in water sediments of Upper Silesia, in particular in the outcrop area of the Middle Triassic carbonate sequence. High contents of silver are usually found in alluvial sediments of small streams and water reservoirs.

On the map, the silver anomaly (>2 ppm) correlates well to the outline of the Middle Triassic outcrop belt. Maximum content of silver in water sediments usually marks the areas of both modern and old mining, treatment and smelting of metal ores.

Contamination of water sediments by silver is known from highly industrialized regions. For instance, sediments of the Elbe river in the vicinity of Hradec Kralove show Ag values ranging from less than 1 ppm to 35 ppm (J. Vesely, 1991).

Al ALUMINIUM

Surface waters: Plate 46, Table VI; ppm = mg/l

Approximate limit values (27, 82):

- river waters 0.06–0.30; average 0.20
- polluted river waters >2.00
- drinking water 0.05–0.30

Basic values for Poland (47) and the study area:

- surface waters of Poland <0.1–1.2; average 0.1
- Vistula river <0.1–0.7; average 0.1
- Odra river <0.1–0.9; average 0.2
- surface waters of Upper Silesia <0.1–1.2; average 0.2

Water masses with elevated content of aluminium occur at random throughout the surface water system of the mapped area. Their occurrence can neither be related to the nature of rock substratum nor to the distribution of forest areas with predominant acidic soils, where one would expect enhanced remobilization of aluminium. Maximum content of aluminium (1.0–1.2 mg/l) is noted in small streams, artificial water reservoirs, and fish ponds.

The measured contents of aluminium in surface waters of Upper Silesia fall within the range typically noted in other mining regions of the world 0.7–2.5 mg/l (J. Ek, 1974).

As ARSENIC

Soils: Plate 4, Table IV; ppm = mg/kg = g/t

Approximate limit values (16, 27):

- cultivated soils ≤20; toxic level >50
- soils in children's play parks ≤20; toxic level >50
- soils in city parks and recreation fields ≤40; toxic level >80
- soils in house building areas ≤40; toxic level >80
- soils in industrial building areas ≤50; toxic level >200

Basic values for Poland (47) and the study area:

- soils of Poland <5–3444; average <5
- cultivated soils of Poland <5– 168; average <5
- soils of Upper Silesia <5– 238; average <5
- cultivated soils of Upper Silesia <5– 95; average <5

Area covered by limit values (for cultivated soils):

- within the tolerance range (20–50 ppm) 170 km^2 2.7%
- above the toxic level (>50 ppm) 7 km^2 0.1%

Average content of arsenic in soils of Upper Silesia is low, and only rarely is it greater than 5 ppm. The As value range recorded in the study area is not much different from the average As value in soils of Poland presented above, or from the background value in cultivated soils of Poland reported by S. Dudka (1993). This author showed that the content of arsenic in sandy soils ranges from 0.5 ppm to 15.0 ppm, and in loam and clay soils – from 1.4 ppm to 10.0 ppm. In the study area, slightly elevated As values were noted in lawn, city park, and fallow soils of urban areas. Similar distribution of arsenic in soils of the urban-industrial area of Berlin was observed by M. Brike & U. Rauch (1994).

On the map, soils containing more than 20 ppm As can be observed in urban areas, and also near Zn-Pb mines in the vicinity of Olkusz. The anomalies are of anthropogenic origin, and can be related to the mining and smelting of metal ores.

Combustion of black coal can be considered an additional source of arsenic in soils. Some coals contain up to 200 ppm As (A. Kabata-Pendias, H. Pendias, 1993).

J. Verner et al. (1994) also showed anomalously high concentration of arsenic (up to 150 ppm) in agricultural and allotment soils surrounding the Bukowno smelting works.

Investigation of the As pollution in a region of long-standing mining and smelting of Zn-Pb ores in Great Britain has revealed the content of arsenic in soils in the mine areas ranging from 6.5 ppm to 42.3 ppm. In a 0.00–0.15 m depth interval of soil profile taken near the Derbyshire lead-smelting works, the content of arsenic varies from 5.9 ppm to 44.4 ppm (L. Xiangdong & I.Thornton, 1993).

Water sediments: Plate 25, Table V; ppm = mg/kg = g/t

Basic values for Poland (47) and the study area:

- water sediments of Poland <5–6215; average <5
- alluvium of Vistula <5– 43; average <5
- alluvium of Odra <5– 118; average 10
- water sediments of Upper Silesia <5– 915; average 6

Alluvial sediments of big rivers in Upper Silesia usually show arsenic values close to the background value (<5 ppm). It is essential to stress that artificial water reservoirs and fish ponds show no elevated As values.

On the geochemical map, several water sediment fields can be distinguished with anomalously high concentration of arsenic (>20 ppm). These fields seem to be tied to areas of both old and modern mining, treatment, and smelting of metal ores.

The results of monitoring analysis of alluvial sediments in Upper Silesia (I. Bojakowska, G. Sokołowska, 1994), carried out from 1991 to 1993, point to a noticeable decrease of the average values of arsenic measured in 12 rivers from 9.0 to 4.7 ppm.

Surface waters: Table VI; ppm = mg/l

Classes of surface water purity (70):

I ≤0.05
II ≤0.05
III ≥0.05 – ≤0.20

Basic values for Poland (47) and the study area:

- surface waters of Poland <0.04–6.77; average <0.04
- Vistula river <0.04–0.04; average <0.04
- Odra river <0.04–0.04; average <0.04
- surface waters of Upper Silesia <0.04–1.71; average <0.04

Because of relatively low As detection limit (0.04 ppm) of the applied analytical methods, a geochemical map of arsenic in surface waters of Upper Silesia was not developed.

B BORON

Surface waters: Plate 47, Table VI; ppm = mg/l

Classes of surface water purity (70):

I ≤1
II ≤1
III ≤1

Basic values for Poland (47) and the study area:

- surface waters of Poland <0.02–12.87; average <0.04
- Vistula river <0.02– 0.80; average <0.17
- Odra river <0.06– 0.24; average <0.14
- surface waters of Upper Silesia <0.02– 7.92; average <0.09

The geochemical background of boron in surface waters of Upper Silesia is elevated and falls within the range between 0.12 ppm and 0.50 ppm. Slightly lower background values are noted in the eastern and northern parts of the mapped area. The increase of the background values can be related to the input of mine waters to the surface water system as well as to the surface drainage in outcrop areas of the Upper Carboniferous sedimentary sequence. In barren intervals of this sequence, which intersperse coal seams in the paralic series, the content of boron may reach 350 ppm (C. T. Walker, 1968). Measurements of boron in the Poręba Beds in the NW part of the Coal Basin yielded values as high as 210 ppm (T. Krzoska, 1981). These data suggest that boron present in surface waters comes from mine brines as well as from leaching of coal mine waste--rock accumulations.

Combustion of coal is an additional source of boron in waters occurring near power plants and combustion-dust accumulation dumps. The content of boron in coal may reach 470 ppm, and in the coal combustion dusts even 6,000 ppm (A. Kabata-Pendias, H. Pendias, 1979).

Water fields of anomalously high boron concentration, which are shown on the map, may also reflect pollution coming from chemical industry and/or from waste dumps.

Ba BARIUM

Soils: Plate 5, Table IV; ppm = mg/kg = g/t

Approximate limit values (11):

- cultivated soils ≤750
- soils in city parks, recreation fields and in house building areas ≤500
- soils in industrial and commercial building areas ≤2000

Basic values for Poland (47) and the study area:

- soils of Poland <1–1777; average 32
- cultivated soils of Poland 2–1273; average 31
- soils of Upper Silesia 2–1777; average 54
- cultivated soils of Upper Silesia 2– 282; average 51

The distribution of HCl-soluble barium in soils of Upper Silesia is rather uniform. Maximum barium values (commonly above 200 ppm) were recorded in some urban soils. Among cultivated soils, those occurring in urbanized areas and in allotment fields are characterized by high Ba values.

The elevated barium values of Upper Silesian soils may in part also reflect the barium input along with settled coal combustion dusts. A. Różkowska & B. Ptak (1995) showed that the average Ba content in coal is 176 ppm, reaching 1274 ppm in coal combustion dusts.

According to results of E. Peterson & M. Sanka (1994), road traffic may cause an enrichment of urban soils with respect to barium. By studying urban soils in slightly industrialized towns (Aberdeen in Scotland and Brno in the Czech Republic), these authors noticed that barium attains maximum concentration of up to 800 ppm in roadside lawns where it positively correlates with lead. The concentration of lead reaches 500 ppm there. Allotment soils in the above mentioned towns show lower Ba values, usually less than 200 ppm.

Cultivated soils in Upper Silesia show far lower barium values. In sandy and loam soils, the Ba content averages 42 ppm and 61 ppm, respectively. Soils in forested grounds show comparable Ba values. The lowest barium values are recorded in forest soils, where they average 33 ppm. Soils showing Ba values higher than 100 ppm occur mainly in outcrop areas of sandy-clayey sediments of the productive Carboniferous (Plates A, B, and C).

Water sediments: Plate 26, table V; ppm = mg/kg = g/t

Basic values for Poland (47) and the study area:

- water sediments of Poland <1–1794; average 52
- alluvium of Vistula 9– 437; average 76
- alluvium of Odra 20–1240; average 234
- water sediments of Upper Silesia 3–1794; average 93

The content of barium in alluvial and other water sediments of Upper Silesia varies insignificantly. Slightly elevated Ba values were recorded in rivers draining the Carboniferous outcrop belt, and also in rivers collecting waters pumped out from coal mines. In general, alluvial sediments of the Odra catchment area show elevated Ba values. Relatively low Ba values are noted in small streams, ponds, small artificial water reservoirs, and fish ponds. The distribution pattern of barium in the study area suggests that mine waters represent the major Ba source for alluvial sediments of Upper Silesia, in particular for the sediments in the Odra catchment area.

Surface waters: Plate 48, Table VI, ppb = µg/l

Approximate limit values: (11, 27)

- river waters 10– 100
- polluted river waters ≤450
- drinking water 500–1500

Basic values for Poland (47) and the study area:

- surface waters of Poland <1–3470; average 55
- Vistula river 32–1254; average 90
- Odra river 51– 664; average 170
- surface waters of Upper Silesia 2–3470; average 87

The geochemical map of surface waters in Upper Silesia shows a rather uniform distribution of barium, though slightly elevated Ba values can be noted in rivers and streams draining outcrop areas of the Triassic carbonate sequence and the Carboniferous sequence. Waters of small streams and reservoirs as well as waters of ponds and artificial reservoirs are characterized by a moderate Ba content. Mine waters pumped out from coal and metal-ore mines represent the main source of barium in Upper Silesian rivers.

For comparison, it may be important to show that the content of barium in surface waters of the Netherlands, ranging from 48 ppb to 121 ppb, is regarded as reflecting natural concentration (I. Rejniewicz, 1994). In waters of the Biały Dunajec river, the measured Ba values, fluctuating from 32 ppb to 74 ppb, are also interpreted in terms of natural processes (J. Małecki, 1988).

Be BERYLLIUM

Water sediments: Plate 27, Table V; ppm = mg/kg = g/t

Basic values for Poland (47) and the study area:

- water sediments of Poland <0.5–21.0; average 0.5
- alluvium of Vistula <0.5– 1.1; average 0.5
- alluvium of Odra <0.5– 1.5; average 0.5
- water sediments of Upper Silesia <0.5–19.9; average 0.6

The beryllium anomaly in water sediments of Upper Silesia outlines elongated fields, which are aligned in the NW-SE direction and imprint main outcrops of the Triassic sedimentary sequence. It is therefore reasonable to assume that the distribution of beryllium in water sediments is widely controlled by the regional geological structure. However, coal combustion plants, such as Jaworzno and Siersza power plants, and Łagisza, Będzin and Cieśle heat and power plants, provide additional sources of beryllium in the study area. According to data presented by A. Kabata-Pendias & H. Pendias (1979), the content of beryllium in black coals ranges from 0.1 ppm to 31 ppm. In coal combustion dusts, the content of beryllium may reach 45.0 ppm.

Ca CALCIUM

Soils: Plate 6; Table IV, %

Basic values for Poland (47) and the study area:

- soils of Poland <0.01–25.45; average 0.17
- cultivated soils of Poland <0.01–13.50; average 0.18
- soils of Upper Silesia <0.01–13.47; average 0.23
- cultivated soils of Upper Silesia 0.01–10.40; average 0.23

The content of calcium in soils of Upper Silesia is usually between 0.08% and 0.74%. There are two main factors controlling the distribution of calcium in the studied soils: geological structure and economic activity in the region. The content of calcium greater than 1% is typically noted in soils developed on the Jurassic and Cretaceous carbonate rocks, and also on Middle Triassic carbonate rocks. However, similar concentration of calcium (>1%) in soils of the Upper Silesian urban agglomeration is of anthropogenic origin. This is documented by a twofold calcium increase in urban soils (lawn, city park, allotment, and fallow soils) compared to agricultural soils of the region. The concentration of calcium in urban soils can most probably be related to the calcium input from settled industrial dusts, in particular from coal combustion dusts. Soils in forest fields are characterized by noticeably low calcium values, averaging 0.08%.

Water sediments: Plate 28, Table V; %

Basic values for Poland (47) and the study area:

- water sediments of Poland 0.01–43.15; average 0.84
- alluvium of Vistula 0.09–31.95; average 1.38
- alluvium of Odra 0.12– 4.42; average 0.73
- water sediments of Upper Silesia 0.02–26.55; average 0.71

The distribution pattern of calcium in water sediments of Upper Silesia is widely controlled by the regional geological structure. Maximum concentration of calcium (>2%) is noted in the NW–SE aligned belts, which imprint the main outcrops of the Triassic and Jurassic carbonate sequences. Alluvial sediments of big rivers are enriched with calcium compared to alluvium and sediments of small streams and water reservoirs.

Surface waters: Plate 49; Table VI; ppm = mg/l

Approximate limit values (88):

- surface waters used as drinking water reservoirs postulated limit value 100

Basic values for Poland (47) and the study area:

- surface waters of Poland 3–6400; average 79
- Vistula river 14– 199; average 87
- Odra river 73– 132; average 89
- surface waters of Upper Silesia 3–6400; average 83

Surface waters in the study area are characterized by a rather uniform distribution of calcium. Most measured calcium values fall within the range between 50 mg/l and 100 mg/l. Maximum concentration of calcium in water, exceeding 800 mg/l, was recorded in the vicinity of a cement plant located to the north-west of Ogrodzieniec.

Published data suggest that the content of calcium in surface waters depends on the content of calcium in the rock substratum. Natural content of calcium in streams of the Dutch Lowland fluctuates from 16 mg/l to 36 mg/l, whereas the Ca content in surface water systems draining carbonate rock areas increases to 55–74 mg/l (I. Rejniewicz, 1994). Measurements of surface waters in areas of magmatic metal-ore mining in northern Sweden revealed Ca values ranging from 2.7 to 14.5 mg/l (J. Ek, 1974).

Cd CADMIUM

Soils: Plate 7, Table IV; ppm = mg/kg = g/t

Approximate limit values (13, 16, 27):

- cultivated soils 1–5; toxic level ≥5
- soils in children's play parks ≤2; toxic level ≥10
- soils in city parks and recreation fields ≤4; toxic level ≥15
- soils in house building areas ≤2; toxic level ≥5
- soils in industrial building areas ≤10; toxic level ≥20

Basic values for Poland (47) and the study area:

– soils of Poland	<0.5–253.3; average <0.5
– cultivated soils of Poland	<0.5– 16.7; average <0.5
– soils of Upper Silesia	<0.5–253.3; average 1.4
– cultivated soils of Upper Silesia	<0.5– 16.7; average 1.3

Area covered by limit values (for cultivated soils):

– within the tolerance range (1–5 ppm)	4110 km²	65.3%
– above the toxic level (≥5 ppm)	889 km²	14.1%

Among soils of Poland, the soils of Upper Silesia are characterized by the highest Cd concentration. Most cadmium values are higher than 1 ppm here. In the literature, several different values from the range between 1 ppm and 5 ppm have been proposed as the permissible concentration level of cadmium in cultivated soils. In this Atlas, the value of 4 ppm is accepted as the cadmium limit value. The area outlined by the Cd-4 ppm isoline overlaps the area of Zn and Pb concentration above the limit values (Plates 17 and 22). The anomalously high concentration of cadmium (>4 ppm) is most frequently noted in soils covering the Ore-Bearing Dolomites. However, maximum soil concentration of cadmium (>16 ppm) was found in areas of extensive mining, treatment, and smelting of metal ores. The vicinity of the Bukowno smelting works may serve as an example of such a concentration area, which was studied in detail by J. Vernier et al. (1994). These authors reported Cd values in soils ranging from 25 ppm to 133 ppm.

A study of the cadmium distribution in areas of mining and treatment of metal ores in Great Britain has revealed Cd values as high as 372 ppm in soils occurring close to the mines, and the values ranging from 0.2 ppm to 19.7 ppm in soils surrounding the smelting works (L. Xiangdong & I. Thornton, 1993).

Among various types of soils in Upper Silesia, lawn and city park soils as well as cultivated soils in urban areas have the greatest cadmium content. Earlier studies on the geochemistry of soils in Katowice voivodeship, carried out by the OBiKS in Katowice, showed that the content of cadmium in allotment and agricultural soils varies from 0.3 ppm to 143 ppm (E. Marchwińska & R. Kucharski, 1990).

Water sediments: Plate 29, Table V; ppm = mg/kg = g/t

Basic values for Poland (47) and the study area:

– water sediments of Poland	<0.5–8736.0; average 0.6
– alluvium of Vistula	<0.5– 109.5; average 2.5
– alluvium of Odra	<0.5– 18.0; average 1.6
– water sediments of Upper Silesia	<0.5–8736.0; average 2.8

The content of cadmium in water sediments in the study area is usually greater than 1 ppm. Values lower than 1 ppm were recorded only in the north-eastern margin of the area, where Jurassic and Cretaceous carbonate rocks crop out. Among big rivers of Upper Silesia, average Cd values higher than 10 ppm are noted in alluvium of Biała Przemsza, Brynica, Baba, Chechło, Sztoła, and Vistula in the Vistula dranage basin, and in Bytomka and Stoła in the Odra drainage basin.

Detailed distribution of cadmium in sediments of Biała Przemsza (S. Ryborz & J. Suschka,1992) is consistent with general pattern of the element presented in this Atlas. The analysis of nine sections in the Biała Przemsza sediments revealed the cadmium content ranging from 0.9 ppm to 73.0 ppm. According to the results of E. Helios-Rybicka (1994), the maximum content of cadmium in the Biała Przemsza sediments reaches 500 ppm. Alluvium of Chechło and Stoła also show anomalously high Cd values, falling within the range of 40.8–130.1 ppm (70.8 ppm on the average) and 6.6–290.3 ppm (31.0 ppm on the average), respectively.

On the map, there can be distinguished a narrow belt of anomalously high cadmium values (>12 ppm), stretching from Piekary Śląskie in the north-west to Chorzów in the south-east. In this belt, maximum concentration of cadmium in water sediments is observed close to Zn-Pb mines. A second, parallel belt of cadmium anomalies stretches from the Katowice smelting works in the north-west to Olkusz in the south-east, with maximum concentration observed in the vicinity of the Bolesław and Bukowno mines and smelting works. A widespread, irregular field of cadmium anomalies can also be distinguished in the catchment area of Mała Panew and Stoła rivers between Tarnowskie Góry, Miasteczko Śląskie, Strzybnica and Krupski Młyn. The development of this anomaly field may only in part be explained by the input of mine waters from numerous drainage adits present in the Stoła valley. Detailed geochemical investigation seems to be necessary to provide a satisfying explanation of the genesis of this anomaly.

Surface waters: Plate 50, Table VI; ppb = µg/l

Classes of surface water purity (70):

I	≤5
II	>5 – ≤30
III	>30 – ≤100

Basic values for Poland (47) and the study area:

– surface waters of Poland	<3–238; average <3
– Vistula river	<3– 14; average <3
– Odra river	<3; average <3
– surface waters of Upper Silesia	<3–238; average <3

The content of cadmium in the majority of surface waters in Upper Silesia is within the limits of the first class of water purity (<5 ppb). Isolated fields of cadmium concentration (>5 ppb) are observed in surface waters in the vicinity of Ogrodzieniec, and also between Bolesław and Bukowno. Prominent Cd anomalies, sometimes with values higher than 100 ppb, are noted at locations of the smelting industry (Szopienice, Mysłowice), and also to the north of Tarnowskie Góry. The latter Cd anomaly in surface waters correlates well with a distinct Cd anomaly revealed in alluvial sediments.

There are published data showing the presence of cadmium anomalies in surface waters of other Zn-ore mining regions of the world. In some of these regions, the Cd values are higher than those recorded in Upper Silesia. For instance, the concentration of cadmium in surface waters occurring close to old Zn mines and waste-rock accumulations in Wales attains 2500 ppb (R. Fuge et al., 1991). The average Cd contents in surface waters in this mining region are between 6.5 ppb and 15.6 ppb. In Germany, there is known cadmium concentration (up to 48 ppb) in surface waters of the Rhenisches Schiefergebirge, and also in waters in the vicinity of Bodenmais in the Bavarian Forest (H. Fauth et al., 1985). Waters of the Biały Dunajec catchment area show cadmium values as high as 43 ppb, which are interpreted to reflect pollution coming from chemical industry (J. Małecki, 1988).

Co COBALT

Soils: Plate 8, Table IV; ppm = mg/kg = g/t

Approximate limit values (11,27):

- cultivated soils ≤30
- soils in city parks,recreation fields and in house building areas ≤50
- soils in industrial and commercial building areas ≤300

Basic values for Poland (47) and the study area:

- soils of Poland 1–46; average 1.7
- cultivated soils of Poland 1–29; average 2
- soils of Upper Silesia 1–21; average 2
- cultivated soils of Upper Silesia 1–13; average 3

The content of HCl-soluble cobalt in soils of Upper Silesia is low. It ranges from less than 1 ppm to 13 ppm. The distribution pattern of cobalt in soils can be related to the regional geological structure and composition of rock substratum. Slightly elevated Co values are usually noted in areas where the Carboniferous clastic sequence or the clastic sequences of the Upper Triassic and Lower Jurassic crop out.

Water sediments: Plate 30, Table V; ppm = mg/kg = g/t

Basic values for Poland (47) and the study area:

- water sediments of Poland <1–357; average 3
- alluvium of Vistula 1– 14; average 5
- alluvium of Odra 1– 22; average 6
- water sediments of Upper Silesia <1–164; average 4

There are only slight variations in the content of cobalt in water sediments of Upper Silesia. Concentration of cobalt (10 ppm) is observed in water sediments in urban agglomerations and towns. This concentration is of anthropogenic origin. A comparable level of cobalt concentration (10 ppm on the average) was noted in water sediments of eastern Germany (M. Birke & U. Rauch, 1993).

Surface waters: Plate 51, Table VI; ppb = µg/l

Approximate limit values (27):

- river waters 0.04–8.00
- drinking water 0.01–0.13

Basic values for Poland (47) and the study area:

- surface waters of Poland <5–136; average <5
- Vistula river <5– 5; average <5
- Odra river <5– 5; average <5
- surface waters of Upper Silesia <5–136; average <5

It is difficult to present a detailed distribution of cobalt in surface waters of Upper Silesia because Co detection limit (5 ppm) in the applied analytical methods was too low. Distinct Co anomalies, which have been revealed in the vicinity of Ogrodzieniec (>20 ppb at maximum) and Mierzęcice (>50 ppb at maximum), require further study. It seems important to add that in the same areas there exists a prominent nickel anomaly.

H. Fauth et al. (1985) showed that the content of cobalt in surface waters of western Germany varies from 1 ppb up to 540 ppb. These authors failed to identify natural sources for the observed Co anomalies, which might suggest their anthropogenic origin.

Cr CHROMIUM

Soils: Plate 9, Table IV; ppm = mg/kg = g/t

Approximate limit values (16, 27):

- cultivated soils ≤100; toxic level ≥500
- soils in children's play parks ≤50; toxic level ≥250
- soils in city parks and recreation fields ≤150; toxic level ≥600
- soils in house building areas ≤100; toxic level ≥350
- soils in industrial building areas ≤200; toxic level ≥800

Basic values for Poland (47) and the study area:

- soils of Poland 1–1873; average 4
- cultivated soils of Poland 1–1873; average 5
- soils of Upper Silesia 1– 95; average 5
- cultivated soils of Upper Silesia <1– 67; average 6

The content of HCl-soluble chromium in soils of Upper Silesia is low, usually less than 10 ppm. The recorded Cr value range is similar to the range in soils of Poland (J. Lis & A. Pasieczna, 1994, 1995). The exceptions are soils close to waste accumulation dumps, where the content of chromium may reach hundreds of ppm (J. Borkowski, E. Roszyk, 1991). Geochemical analysis of allotment soils in several towns of the region confirms the low content of chromium (up to 25 ppm) in Upper Silesian soils (R. Kucharski & E. Marchwińska, 1990; M. Trafas et al., 1990). Concentration of chromium is noted in urban and industrial agglomerations in Upper Silesia.

Water sediments: Plate 31, Table V; ppm = mg/kg = g/t

Basic values for Poland (47) and the study area:

- water sediments of Poland <1–12,251; average 6
- alluvium of Vistula 1– 420; average 23
- alluvium of Odra 2– 234; average 30
- water sediments of Upper Silesia <1–12,251; average 10

There are significant variations in the content of chromium in water sediments of Upper Silesia. Elevated Cr values (>10 ppm) are typically noted in water sediments occurring in urban areas, such as the Katowice agglomeration, Rybnik, and the Olkusz–Gołaczewy–Ogrodzieniec–Zawiercie–Myszków urban belt. A distinct chromium anomaly (>80 ppm) can be observed in alluvium occurring close to the industrial and railway centres. This anomaly is of anthropogenic origin.

According to the study of E. Helios-Rybicka & M. Wardas (1989), chromium occurring in the smaller than 63 m fraction is preferentially associated with ferruginous mineral phases. An increase in the content of chromium in sediments of the upper Vistula can be related to mining and smelting activity in Upper Silesia.

The prominent Cr anomaly observed to the south of Alvernia can be related to pollution coming from the "Alvernia" chemical plant.

Surface waters: Plate 52, Table VI, ppb = µg/l

Classes of surface water purity (70):

I ≤50
II >50 – ≤100
III >100

Basic values for Poland (47) and the study area:

- surface waters of Poland <5–4445; average <5
- Vistula river <5– 49; average <5
- Odra river <5– 28; average <5
- surface waters of Upper Silesia <5–4445; average <5

As far as chromium is concerned, nearly all surface waters of the study area fall within the limits of the first class of water purity (<5 ppb Cr). A strong chromium anomaly has been identified in waters of Kozi Bród near Jaworzno–Szczakowa railway station. At this place, maximum content of chromium as high as 4,445 ppb was recorded. The Cr anomaly in waters overlaps a similar Cr anomaly in alluvial sediments.

Cu COPPER

Soils: Plate 10, Table IV; ppm = mg/kg = g/t

Approximate limit values (16, 27):

– cultivated soils	50–150; toxic level ≥200
– soils in children's play parks	≤50; toxic level ≥250
– soils in city parks and recreation fields	≤200; toxic level ≥600
– soils in house building areas	≤50; toxic level ≥200
– soils in industrial building areas	≤200; toxic level ≥2000

Basic values for Poland (47) and the study area:

– soils of Poland	<1–6401; average 5
– cultivated soils of Poland	<1–2190; average 5
– soils of Upper Silesia	<1– 805; average 7
– cultivated soils of Upper Silesia	<1– 54; average 6

Area covered by limit values (for cultivated soils):

– within the tolerance range	(50–200 ppm) –	103 km² 1.6%
– above the toxic level	(>200 ppm) –	5 km² 0.1%

The content of copper in soils of Upper Silesia is low (from less than 1 ppm up to 805 ppm, 7 ppm on the average). For comparison, it is worth providing some results from the work of W. Lux (1993) on geochemistry of the Hamburg urban agglomeration. This author measured HCl-soluble copper in the surficial layer (0–5 cm) of urban soils, and found Cu values ranging from less than 2 ppm to 3688 ppm, averaging 103 ppm. On the other hand, in undeveloped areas of Belarus (the Polesie region), the content of copper in soils is very low, ranging from 1.6 ppm to 13.5 ppm (T. Belousova, 1994).

Concentration of copper (>10 ppm) in soils of Upper Silesia is associated with anthropogenic contamination. Lawn, city park, and allotment soils as well as cultivated soils within urban areas are enriched with copper compared to soils in non-urbanized areas.

A distinct copper anomaly can be observed at locations of some old and modern smelting works (Plate C).

Intense road traffic may also affect concentration of copper in soils. Z. Czerwiński (1987) showed that the content of copper in soils along roads with intense traffic reaches 67 ppm, and sharply decreases to 17 ppm over a distance of 300 m.

According to the observarions of M. Trafas et al. (1990), smelting of Zn-Pb ores does not influence copper concentration in soils. These authors demonstrated that the Cu values in soils in the neighbourhood of the Bolesław metal plant are lower than 40 ppm. However, a contradictory opinion was presented by E. Lorek (1993), who documented an increase of copper content in soils around zinc-smelting works from 20 ppm to 36 ppm over a period of eleven years. A similar increase from 3 ppm Cu to 37 ppm Cu was found near the Katowice smelting works.

Water sediments: Plate 32, Table V; ppm = mg/kg = g/t

Basic values for Poland (47) and the study area:

– water sediments of Poland	<1–15,460; average 8
– alluvium of Vistula	1– 419; average 23
– alluvium of Odra	3– 371; average 44
– water sediments of Upper Silesia	1– 1886; average 16

Over a background of low Cu values (<40 ppm) in water sediments of Upper Silesia, there can clearly be seen a belt of anomalous Cu concentration, which stretches from Tarnowskie Góry, Strzybnica and Miasteczko Śląskie in the north-western part of the mapped area, through the densely urbanized district from Gliwice to Chrzanów, to the vicinity of Olkusz and Bolesław. The high Cu concentration is noted in alluvial sediments of big rivers and streams. On the other hand, low Cu values characterize water sediments of fish ponds. Contamination of water sediments by copper can be related to the input of industrial and urban wastes to the surface water system. On the basis of monitoring analysis of rivers in the Bielsko-Biała and Katowice provinces, I Bojakowska & G. Sokołowska (1994) showed that the average Cu values in alluvium of some big rivers vary from 54 ppm to 84 ppm.

Surface waters: Plate 53, Table VI; ppb = µg/l

Classes of surface water purity (70):

I ≤50
II ≤50
III ≤50

Basic values for Poland (47) and the study area:

– surface waters of Poland	<5–3732; average <5
– Vistula river	<5– 84; average <5
– Odra river	<5– 26; average 6
– surface waters of Upper Silesia	<5– 994; average 5

The distribution of copper in surface waters of Upper Silesia seems to be rather uniform. In most analysed samples, the content of copper falls within the limits of the first class of water purity (<50 ppb). Cu values higher than 10 ppb are usually recorded in waters of big rivers. Waters of the Biały Dunajec catchment in the Carpathians show Cu content ranging from 8 ppb to 25 ppb (J. Małecki, 1988). These values are interpreted to reflect in part anthropogenic contamination.

Fe IRON

Soils: Plate 11, Table IV; %

Basic values for Poland (47) and the study area:

– soils of Poland	<0.01–9.57; average 0.50
– cultivated soils of Poland	0.05–5.99; average 0.52
– soils of Upper Silesia	<0.01–5.06; average 0.56
– cultivated soils of Upper Silesia	0.06–5.06; average 0.67

Variation of iron content in soils of Upper Silesia reflects interplay of two factors: geologic and anthropogenic. Low Fe values (<0.5%) are noted in soils covering carbonate rock substrata. These soils make a dense area in the eastern part of the map, where they cap the Cretaceous and Upper Jurassic rock sequences. High Fe values are typically recorded in soils of the Katowice urban agglomeration (Rokitnica, Bytom, Świętochłowice, Siemianowice, Chorzów, Katowice, Mysłowice, and Będzin).

Loam soils are usually enriched with iron compared to sandy soils. The lowest Fe values are noted in sandy soils of forests.

Investigations carried out in the vicinity of the Katowice smelting works revealed that the content of iron in a surficial depth interval of soil profile (0–5 cm) increased by a factor of 66 over a period of eleven years, attaining 1% Fe (E. Lorek, 1993). A similar increase was noted in the vicinity of the "Miasteczko Śląskie" zinc-smelting works, where the Fe content attained 0.7%. These results strongly suggest that the Fe anomalies in the industrial areas are of anthropogenic origin.

Water sediments: Plate 33, Table V; %

Basic values for Poland (47) and the study area:

– water sediments of Poland	<0.01–31.14; average 0.75
– alluvium of Vistula	0.22– 3.18; average 1.11
– alluvium of Odra	0.18– 5.64; average 1.59
– water sediments of Upper Silesia	0.03–26.43; average 1.01

The distribution pattern of acid-soluble iron in water sediments of Upper Silesia is generally similar to the Fe pattern in soils. A broad area of low Fe values (<1%) is observed in the eastern part of the map, whereas very high Fe values are noted in water sediments of some urban areas. The lowest measured Fe values characterize sediments of fish ponds and artificial water reservoirs.

Surface waters: Plate 54, Table VI, ppm = mg/l

Classes of surface water purity (70):

I	≤1.0
II	>1.0 – ≤1.5
III	>1.5 – ≤2.0

Basic values for Poland (47) and the study area:

– surface waters of Poland	<0.02–438.72; average 0.52
– Vistula river	0.09– 3.87; average 0.43
– Odra river	0.10– 2.98; average 0.59
– surface waters of Upper Silesia	<0.02– 93.44; average 1.01

Most of surface water masses in Upper Silesia are noticeably enriched with iron. Waters showing low Fe values, falling within the limits of the first class of water purity, mainly occur in the eastern part of the mapped area. A similar pattern of iron, with its low values in the eastern part of the map, is observed in soils and water sediments (Plates 11 and 33). Surface waters of the first purity class also exist in the outcrop belt of the Ore-Bearing Dolomites between Tarnowskie Góry and Olkusz, and in the vicinity of Chrzanów. Very high content of iron, frequently above the limit of the third class of water purity, is noted in surficial waters in areas of coal deposits, and also at places where mine waters enter the surface water system.

Hg MERCURY

Soils: Plate 12, Table IV; ppm = mg/kg = g/t

Approximate limit values (13, 16, 27):

– cultivated soils	1–2; toxic level ≥10
– soils in children's play parks	0.5; toxic level ≥10
– soils in city parks and recreation fields	5; toxic level ≥15
– soils in house building areas	2; toxic level ≥20
– soils in industrial building areas	10; toxic level ≥50

Basic values for Poland (47) and the study area:

– soils of Poland	<0.05–7.55; average <0.05
– cultivated soils of Poland	<0.05–4.75; average <0.05
– soils of Upper Silesia	<0.05–4.00; average 0.08
– cultivated soils of Upper Silesia	<0.05–0.40; average 0.08

Average content of mercury in soils is accepted to be 0.06 ppm (B. Freedman, 1989). In urban soils and in soils of industrial areas, mercury may be significantly concentrated as a result of environment pollution. In the urban agglomeration of Warsaw, there is a noticeable mercury anomaly related to anthropogenic contamination. Here, Hg values are sometimes higher than 2 ppm, attaining measured maximum at 10.78 ppm (J. Lis, 1992).

The content of HCl-soluble mercury in soils of Upper Silesia is low, usually less than 0.15 ppm. However, the average Hg values are slightly higher than those reported from soils in other regions of Poland. In Upper Silesia, elevated Hg values have been recorded in soils of some urban areas. Maximum Hg concentration, with values higher than the limit value for cultivated soils (>1 ppm), was noted in a small area near Jaworzno. In this area, the source of surplus mercury can be located in coal combustion dusts emitted by power plants.

Water sediments: Plate 34, Table V; ppm = mg/kg = g/t

Basic values for Poland (47) and the study area:

– water sediments of Poland	<0.05–11.00; average <0.05
– alluvium of Vistula	<0.05– 2.15; average 0.14
– alluvium of Odra	<0.05– 2.52; average 0.34
– water sediments of Upper Silesia	<0.05–10.50; average <0.05

Elevated content of mercury in water sediments of Upper Silesia is observed in a broad belt stretching from Gliwice in the north-west to Oświęcim in the south-east, in the vicinity of Tarnowskie Góry, and in the upper part of the Warta and Biała Przemsza catchment areas.

In the course of monitoring analysis of alluvial sediments in Upper Silesia, carried out from 1991 to 1993, there were recorded mercury values ranging from 0.01 ppm to 1.04 ppm (I. Bojakowska & G. Sokołowska, 1994). Similar analysis of the fraction less than 63 μm in the Elbe sediments showed the presence of mercury in concentrations as high as 15.5 ppm (J. Vesely, 1991). The latter value is far higher than the maximum Hg values recorded in water sediments of Upper Silesia.

A rather uniform Hg distribution in water reservoirs of Upper Silesia suggests that mercury enters the surface water system via atmospheric transport of coal combustion dusts. However, local mercury anomalies near Oświęcim and Jaworzno may reflect pollution coming from chemical industry.

K POTASSIUM

Surface waters: Plate 55, Table VI; ppm = mg/l

Classes of surface water purity (70):

I	≤10
II	>10 – ≤12
III	>12 – ≤15

Basic values for Poland (47) and the study area:

– surface waters of Poland	<1–473; average 5
– Vistula river	2– 92; average 11
– Odra river	6– 23; average 11
– surface waters of Upper Silesia	<1–473; average 8

The potassium content of waters in Upper Silesia is widely controlled by coal mining activity, in particular by the input of K-bearing mine waters to the surface water system. In underground waters occurring in the Paleozoic rock sequence of Upper Silesia, the potassium content is usually greater than 350 mg/l (Z. Płochniewski & W. Bidzińska, 1970). According to these authors, maximum content of potassium in mine brines may attain 15,500 mg/l. These data suggest that mine brines provide a predominant source of potassium in surface waters of Upper Silesia.

Agricultural and industrial pollution contributes to a negligible input of potassium to the surface water system.

The content of potassium in rivers and streams in the north-western part of the mapped area is usually above the limit value of the third class of water purity. On the other hand, small streams and ponds usually show K values falling within the first purity class. Likewise, waters of artificial reservoirs and fish ponds are pure with respect to potassium.

Li LITHIUM

Surface waters: Plate 56, Table VI; ppm = mg/l

Approximate limit values (11, 27, 50):

- waters used in irrigation ≤2.50
- river waters <0.02
- underground waters 0.002–0.04

Basic values for Poland (47) and the study area:

- surface waters of Poland <0.02–2.78; average <0.02
- Vistula river <0.02–0.15; average 0.02
- Odra river <0.02–0.09; average 0.03
- surface waters of Upper Silesia <0.02–2.78; average <0.02

Similarly to potassium and sodium, the concentration of lithium in the studied waters reflects the input of coal-mine waters to the surface water system of Upper Silesia. In some mineral waters, lithium is present in concentrations as high as 26.5 mg/l (A. Macioszczyk, 1987). In brines of oil fields, Li values fluctuate around 2.7 mg/l (A. Polański, 1988). In the analysed samples of surface waters in Upper Silesia, there were recorded comparable Li values.

On the map, the area outlined by the Li-0.04 mg/l isoline correlates well with the area of main coal deposits (Plate C).

Mg MAGNESIUM

Soils: Plate 13, Table IV; %

Basic values for Poland (47) and the study area:

- soils of Poland <0.01–4.90; average <0.06
- cultivated soils of Poland <0.01–1.75; average <0.07
- soils of Upper Silesia <0.01–4.90; average 0.06
- cultivated soils of Upper Silesia <0.01–1.75; average 0.08

The distribution pattern of magnesium in soils of Upper Silesia is similar to that of calcium. Elevated Mg values are frequently found in soils developed upon carbonate rock substrata. However, the Mg concentration in soils of the Upper Silesian urban agglomeration reflects anthropogenic contamination. The content of magnesium in urban soils is twice as high as in agricultural soils of the region. On the other hand, very low content of magnesium is noted in forest soils. The Mg concentration in urban soils seems to reflect an input of magnesium from settled industrial dusts, in particular from coal combustion dusts.

In the Katowice area, approximately 9.4×10^5 g Mg/km^2 is settled per annum with industrial dusts (E. Lorek, 1993).

Water sediments: Plate 35, Table V; %

Basic values for Poland (47) and the study area:

- water sediments of Poland <0.01–10.62; average <0.11
- alluvium of Vistula 0.04–2.04; average 0.22
- alluvium of Odra 0.03–0.38; average 0.15
- water sediments of Upper Silesia 0.01–5.87; average 0.13

Similarly to calcium, the distribution of magnesium in water sediments of Upper Silesia is widely controlled by the regional geological structure. It can be seen on the map that areas of Mg concentration (>0.4%) tend to form NW-SE oriented belts, which follow the pattern of the Triassic and Jurassic outcrop belts. Alluvial sediments of big rivers and streams are enriched with magnesium compared to alluvium of small streams and water reservoirs.

Surface waters: Plate 57, Table VI; ppm = mg/l

Approximate limit values (88):

- surface waters used as drinking water reservoirs postulated 30, permissible 50

Basic values for Poland (47) and the study area:

- surface waters of Poland 0.2–833.8; average 11.5
- Vistula river 2.6–224.3; average 24.7
- Odra river 11.1–33.6; average 20.0
- surface waters of Upper Silesia 0.2–833.8; average 14.1

The content of magnesium in underground waters of Upper Silesia varies from 300 mg/l to 1000 mg/l. In some Carboniferous brines, the content of magnesium may be as high as 4000 mg/l (Z. Płochniewski & H. Ważny, 1971).

The input of coal-mine waters can be considered a leading factor that affects anomalous concentration of magnesium (>50 ppm) in surface waters of Upper Silesia.

Mn MANGANESE

Soils: Plate 14, Table IV; ppm = mg/kg = g/t

Approximate limit values (27):

- permissible concentration in cultivated soils: 1500–3000

Basic values for Poland (47) and the study area:

- soils of Poland <1–24,270; average 173
- cultivated soils of Poland 2–24,270; average 222
- soils of Upper Silesia 2– 7000; average 186
- cultivated soils of Upper Silesia 6– 2016; average 296

Similarly to the distribution pattern of iron, the pattern of manganese in soils of Upper Silesia reflects an interplay of the geologic and anthropogenic factors. High concentration of manganese (>500 ppm) is noted in some urban soils. Loam soils are enriched with manganese compared to sandy soils. Forest soils are characterized by the lowest measured Mn values. Mn values in surficial layer of soils occurring around the Katowice smelting works and Miasteczko Śląskie zinc plant, recorded during a period from 1977 to 1988, show random scatter without any noticeable increasing or decreasing trend (E. Lorek, 1993). These values fall within the range from 10 ppm Mn to 360 ppm Mn.

Water sediments: Plate 36, Table V; ppm = mg/kg = g/t

Basic values for Poland (47) and the study area:

- water sediments of Poland <1–63,719; average 255
- alluvium of Vistula 72– 2648; average 401
- alluvium of Odra 95– 5313; average 457
- water sediments of Upper Silesia 4–21,295; average 280

On the map, a broad belt of manganese concentration in water sediments can be distinguished that stretches from Gliwice in the west to Bolesław in the east. Here, manganese is commonly present in concentrations higher than 2,000 ppm. This concentration belt is of anthropogenic origin and can be related to pollution coming from metal-

-ore mines and smelting industry of the region. The lowest Mn values are noted in sediments of fish ponds and artificial water reservoirs.

Surface waters: Plate 58, Table VI; ppb = µg/l

Classes of surface water purity (70):

I ≤100
II >100 – ≤300
III >300 – ≤800

Basic values for Poland (47) and the study area:

– surface waters of Poland	<1–34,500; average 107
– Vistula river	17– 1087; average 122
– Odra river	45– 969; average 154
– surface waters of Upper Silesia	1–16,829; average 186

The content of manganese in most of surface water masses in Upper Silesia is above the limit value of the first class of water purity. Waters with Mn contents falling within the first purity class occur only on the eastern part of the map. Waters occurring in the areas of coal deposits and in the areas where mine waters enter the surface water system show very high concentration of manganese, frequently above the limit of the third class of water purity.

Comparable level of manganese concentration (248 ppm on the average) was reported from waters of Elbe river draining severely polluted area of brown coal mining (J. Vesely, 1991).

A pronounced inhomogeneity in the distribution of manganese in alluvial sediments and surface waters of Upper Silesia points to significant differences in the chemical composition of waters pumped out from the coal mines and from the Zn-Pb mines.

Na SODIUM

Surface waters: Plate 59, Table VI; ppm = mg/l

Classes of surface water purity (70):

I ≤100
II >100 – ≤120
III >120 – ≤150

Basic values for Poland (47) and the study area:

– surface waters of Poland	<1–5723; average 16
– Vistula river	4–1817; average 156
– Odra river	31– 377; average 154
– surface waters of Upper Silesia	1–5723; average 28

The distribution pattern of sodium in surface waters of Upper Silesia is similar to the pattern of potassium and lithium. In slightly mineralized waters, the content of sodium is usually less than 1 mg/l (A. Macioszczyk, 1987). In strongly mineralized waters, sodium may be present in concentrations higher than 100 g/l. Mine waters pumped out from deep structural horizons of the productive Carboniferous are usually enriched with sodium and potassium chlorides. The waters coming from shallow horizons contain mostly dissolved sulphate (H. Szymańska, 1990).

Outside the Upper Silesian Coal Basin, the content of sodium in surface waters falls within the limits of the first class of water purity. In the Coal Basin, only a small portion of surface water masses is pure with respect to sodium. Waters of rivers and big streams in the areas of coal deposits are extremely polluted with sodium. It is worth noting that only during a period from 1991 to 1993, about 2.9×10^6 t of NaCl entered the Upper Silesian surface water system as a result of coal mine draining (S. Przeniosło et al. (Red), 1994).

The content of sodium in small streams and ponds, fish ponds, and artificial water reservoirs varies from a few ppm (fish ponds) to 28 ppm.

For comparison, it may be important to provide some data pointing to the low sodium content in surface waters draining crystalline rock substrata. The content of sodium in such waters varies from 1.1 mg/l to 14.9 mg/l in Finland, from 0.7 mg/l to 15.1 mg/l in Sweden, and from 0.6 mg/l to 3.1 mg/l in Norway (P. Eden & A. Bjørklund, 1992).

Ni NICKEL

Soils: Plate 15, Table IV; ppm = mg/kg = g/t

Approximate limit values (16, 27):

– cultivated soils	≤100 ; toxic level ≥200
– soils in children's play parks	≤40; toxic level ≥200
– soils in city parks and recreation fields	≤100; toxic level ≥250
– soils in house building areas	≤80; toxic level ≥200
– soils in industrial building areas	≤200; toxic level ≥500

Basic values for Poland (47) and the study area:

– soils of Poland	<1–146; average 4
– cultivated soils of Poland	<1– 48; average 4
– soils of Upper Silesia	<1– 89; average 4
– cultivated soils of Upper Silesia	<1– 48; average 5

The content of HCl-soluble nickel in soils of Upper Silesia is low, usually less than 10 ppm. Soils, which are slightly enriched with nickel (>10 ppm), occur in the urban area between Zabrze and Sosnowiec, in the vicinity of Oświęcim, and also farther to the east in the Vistula valley.

According to the results of T. Pletnewa et al. (1990), in areas dominated by metal industry the content of nickel in soils may be as high as 206 ppm. These authors showed that the nickel values in soils near a galvanizing plant are two to three times higher than the values recorded in forest soils occurring 10 km away from the plant. On the other hand, it may be interesting to mention very low Ni values of up to 2 ppm reported from soils of the Frisian Islands in the North Sea (S.C. Severson et al., 1992).

Water sediments: Plate 37, Table V; ppm = mg/kg = g/t

Basic values for Poland (47) and the study area:

– water sediments of Poland	<1–1298; average 6
– alluvium of Vistula	2– 282; average 17
– alluvium of Odra	2– 64; average 17
– water sediments of Upper Silesia	<1– 795; average 10

There are only slight variations in nickel content in water sediments of Upper Silesia. Elevated Ni values were recorded in the Upper Silesian urban agglomeration, and also in some other towns of the region. Clearly, these values reflect anthropogenic contamination.

Surface waters: Plate 60, Table VI; ppb = µg/l

Classes of surface water purity (70):

I ≤1000
II ≤1000
III ≤1000

Basic values for Poland (47) and the study area:

– surface waters of Poland	<8–1326; average <8
– Vistula river	<8– 30; average <8
– Odra river	<8– 36; average <8
– surface waters of Upper Silesia	<8– 194; average <8

The content of nickel in surface waters of Upper Silesia is within the background value range, i.e. less than 8 ppb Ni.

P PHOSPHORUS

Soils: Plate 16, Table IV; %

Basic values for Poland (47) and the study area:

- soils of Poland <0.005–1.613; average 0.033
- cultivated soils of Poland <0.005–0.476; average 0.038
- soils of Upper Silesia <0.005–0.476; average 0.027
- cultivated soils of Upper Silesia <0.005–0.476; average 0.033

The content of phosphorus in soils of Upper Silesia varies insignificantly. Only forest soils can be distinguished by their low phosphorus values (0.019% P on the average). These soils can be classified as P-poor type soils. In other soils, the type of soil employment does not seem to affect the measured P values. Fallow soils show average P values up to 0.029%, and allotment soils – up to 0.049%.

Water sediments: Plate 38, Table V; %

Basic values for Poland (47) and the study area:

- water sediments of Poland <0.005–5.866; average 0.064
- alluvium of Vistula 0.023–5.866; average 0.094
- alluvium of Odra 0.026–1.128; average 0.170
- water sediments of Upper Silesia <0.005–3.961; average 0.067

There are variations in the content of phosphorus in water sediments of Upper Silesia. It is, however, difficult to present a detailed speciation of sources that contribute to the phosphorus pool in the study area. These sources may include phosphorus leached from the rock substratum, phosphate fertilizers spread in agricultural fields, and local phosphorus inputs from industrial and municipal wastes. The industrial and municipal wastes seem to provide important amounts of phosphorus in the study area. This can be demonstrated by the increased P contents in sediments of big rivers passing through highly urbanized and industrial areas of the region. Alluvium of small streams and water reservoirs is depleted in phosphorus, though local concentration fields can be observed at some locations.

Surface waters: Plate 61, Table VI; ppm = mg/l

Classes of surface water purity (70):

I ≤0.1
II ≥0.1 – ≤0.25
III ≥0.25 – ≤0.40

Basic values for Poland (47) and the study area:

- surface waters of Poland <0.04–45.12; average 0.19
- Vistula river <0.04– 2.80; average 0.24
- Odra river <0.04– 1.53; average 0.39
- surface waters of Upper Silesia <0.04–45.12; average 0.31

The geochemical map of phosphorus shows that only a small portion of surface water masses in Upper Silesia can be classified to the first class of water purity. A regional variation in the content of phosphorus in surface waters is observed. Waters occurring in areas of dominant agricultural development and slight industrial influence show low phosphorus values. In these areas, surface drainage (leaching of rock substratum and fertilizers) seems to provide the major source of phosphorus dissolved in water.

According to the results of R. Taylor et al. (1992), surface drainage accounts for 90-98% of the phosphorus polluting surface waters.

In urban and industrial areas of Upper Silesia, the distribution of phosphorus in surface waters is widely controlled by the presence of strong local P sources. The highest average phosphorus values are noted in waters of rivers; also showing P-rich alluvial sediments. Waters of small reservoirs, such as streams, ditches and ponds, are depleted in phosphorus, though fields of P concentration may locally develop here.

Measurements of phosphorus in Vistula waters, carried out by A. Tonderski et al. (1994), yielded values varying from 0.4 mg/l to 2.0 mg/l. These values are comparable to the P values recorded in small streams.

Pb LEAD

Soils: Plate 17, Table IV; ppm = mg/kg = g/t

Approximate limit values (16, 27):

- cultivated soils ≤100; toxic level ≥1000
- soils in children's play parks ≤200; toxic level ≥1000
- soils in city parks and recreation fields ≤500; toxic level ≥2000
- soils in house building areas ≤300; toxic level ≥1000
- soils in industrial building areas ≤1000; toxic level ≥2000

Basic values for Poland (47) and the study area:

- soils of Poland <3–16,972; average 16
- cultivated soils of Poland <3– 1963; average 13
- soils of Upper Silesia <3–16,972; average 53
- cultivated soils of Upper Silesia <3– 1963; average 39

Area covered by limit values (for cultivated soils):

- within the tolerance range (100–1000 ppm) 1067 km^2 17.0%
- above the toxic level (>1000 ppm) 783 km^2 12.4%

The distribution pattern of lead in soils of Upper Silesia, with respect to the recorded value range and the extent of anomalous concentrations, is similar to the pattern of zinc and cadmium. As in the case of zinc and cadmium, the concentration of lead in the study area reflects an interplay of the geologic and anthropogenic factors. Both the presence of the Ore-Bearing Dolomites in the direct substratum and the mining, treatment and smelting of metal ores imprint on the pattern of lead in Upper Silesian soils. On the map, the area outlined by the Pb-100 ppm isoline, which marks the Pb limit value for cultivated soils, correlates well with similar areas of cadmium and zinc anomalies (Plates 7 and 22). This high concentration of lead in soils (>100 ppm) is noted in a broad belt stretching from Tarnowskie Góry and Ruda Śląska in the north-western part of the map to Chrzanów and Olkusz in the south-eastern part. Distinct Pb anomalies in soils (>200 ppm) can be observed at locations of mining, treatment, and smelting of metal ores (Plate C). Clearly, these anomalies are of anthropogenic origin.

Among various types of soils, the highest lead values are recorded in urban soils and in cultivated soils occurring in industrial areas. Average lead values in cultivated soils of Upper Silesia are three times higher than the values noted in other regions of Poland (39 ppm Pb and 13 ppm Pb, respectively).

Results of earlier study on the pollution of allotment soils in Katowice voivodeship also point to a very high degree of lead concentration, attaining 4,959 ppm (B. Gulbicka, 1993).

Water sediments: Plate 39, Table V; ppm = mg/kg = g/t

Basic values for Poland (47) and the study area:

- water sediments of Poland <5–43,878; average 15
- alluvium of Vistula <5– 1920; average 35
- alluvium of Odra 11– 407; average 63
- water sediments of Upper Silesia <5–43,878; average 72

The area of high lead values in water sediments (>200 ppm) overlaps the area of high Pb values in soils. Anomalously high lead values in water sediments (>1,600 ppm) are noted near locations of both modern and old zinc industry. A distinct Pb anomaly in water sediments was revealed in the vicinity of Miasteczko Śląskie and Bukowno. Here, the maximum Pb value was found to be 43,878 ppm. It was recorded in the sediment of a water ditch without outflow located near the "Miasteczko Śląskie" smelting works. In this sediment, high contents of zinc (43,963 ppm), cadmium (508 ppm), arsenic (229), copper (216), and silver (10 ppm) were also noted. In the northern part of the mapped area, a broad area of anomalous Pb values can also be distinguished. This area extends in the NW-SE direction, embracing alluvial sediments of the upper Warta catchment area.

Surface waters: Table VI; ppm = mg/l

Classes of surface water purity (70):

I ≤0.05
II ≤0.05
III ≤0.05

Basic values for Poland (47) and the study area:

- surface waters of Poland <0.03–1.87; average <0.03
- Vistula river <0.03–0.29; average <0.03
- Odra river <0.03–0.28; average 0.04
- surface waters of Upper Silesia <0.03–1.87; average 0.04

Geochemical map of lead in surface waters of Upper Silesia has not been developed because Pb sensitivity of the applied analytical methods was too low. Lead values higher than 0.1 ppm were recorded in rivers collecting mine waters and wastes. The maximum Pb value (1.87 ppm) was recorded in a sewer dyke collecting treatment waters from the "Bolesław" and "Olkusz" mines (W. Wójcik, I. Szydło & Z. Stolarski, 1990). In the same water sample, the content of zinc was found to be as high as 3.18 ppm.

S SULPHUR

Soils: Plate 18, Table IV, %

Basic values for Poland (47) and the study area:

- soils of Poland <0.005–3.263; average 0.012
- cultivated soils of Poland <0.005–0.177; average 0.011
- soils of Upper Silesia <0.005–0.516; average 0.015
- cultivated soils of Upper Silesia <0.005–0.121; average 0.014

The average content of HCl-soluble sulphur in soils of Upper Silesia is 0.015%. This value is slightly higher than the average S values in soils in other regions of Poland. Dense areas of soils showing elevated content of sulphur (>0.020%) are observed in the Upper Silesian urban agglomeration.

Water sediments: Plate 40, Table V; %

Basic values for Poland (47) and the study area:

- water sediments of Poland <0.005–8.610; average 0.047
- alluvium of Vistula 0.005–1.056; average 0.047
- alluvium of Odra 0.007–1.501; average 0.071
- water sediments of Upper Silesia <0.005–2.193; average 0.064

Elevated content of sulphur in water sediments of Upper Silesia can be related to both geologic and anthropogenic factors. In the central part of the map, the area outlined by the S-0.1% isoline overlaps the area of anomalous concentration of zinc and lead. This suggests that both the ore deposits and the metal industry are sources of sulphur in water sediments of the area.

Maximum sulphur values in water sediments (>0.6%) were recorded near coal mines. These values are likely to reflect both the mine water input to the surface water system and the emission of sulphur by coal combustion plants.

SO_4 SULPHATE

Surface waters: Plate 63, Table VI; ppm = mg/l

Classes of surface water purity (70):

I ≤150
II >150 – ≤200
III >200 – ≤250

Basic values for Poland (47) and the study area:

- surface waters of Poland 2–7085; average 58
- Vistula river 25– 522; average 106
- Odra river 80– 192; average 139
- surface waters of Upper Silesia 3–7085; average 85

High concentration of sulphate in surface waters, frequently above the limit values of the second and third classes of water purity, is noted in the Upper Silesian Coal Basin, and also in its eastern margin, where the main centres of the Zn-Pb industry are located. The SO_4 concentration mainly reflects the input of mine waters and other industrial sludges to the surface water system. Municipal wastes and sulphide-rich waste-rock accumulations can also be considered significant sources of sulphur dissolved in the surface waters (I. Bojakowska, 1994, I. Twardowska & al., 1988).

Low sulphate values are recorded in most of small streams and ponds, though locally there may be observed fields of high SO_4 concentration. Artificial water reservoirs and fish ponds also show low sulphate content.

In general, surface waters of Poland are strongly polluted with sulphate (58 mg/l SO_4 on the average) compared to other European countries (e.g. 15–30 mg/l SO_4 in the Netherlands according to data of I. Rejniewicz, 1994). Upper Silesia is a region of particular concentration of sulphate in surface waters.

SiO_2 SILICA

Surface waters: Plate 62, Table VI; ppm = mg/l

Basic values for Poland (47) and the study area:

- surface waters of Poland <0.3–83.1; average 10.2
- Vistula river 0.4–17.7; average 4.7
- Odra river 0.6–22.3; average 3.3
- surface waters of Upper Silesia 0.3–82.5; average 10.2

The distribution of dissolved silica in surface waters of Upper Silesia is rather uniform. On the map, there can be seen slight variations in the silica content, with lower values recorded in waters of urban areas. This distribution pattern is consistent with a general negative correlation between the content of dissolved silica in water and the degree of water mineralization (A. Macioszczyk, 1987).

Sr STRONTIUM

Soils: Plate 19, Table IV; ppm = mg/kg = g/t

Basic values for Poland (47) and the study area:

- soils of Poland <1–1298; average 8
- cultivated soils of Poland <1– 654; average 8
- soils of Upper Silesia <1– 708; average 10
- cultivated soils of Upper Silesia <1– 154; average 10

On the map, over a background of low Sr values (approximately 10 ppm) in soils of Upper Silesia, there can clearly be seen an area of anomalously high strontium concentration, which extends from Tarnowskie Góry and Rybnik in the west to Dąbrowa Górnicza and Jaworzno in the east. Within this area, the content of strontium in soils is usually greater than 20 ppm, and locally even greater than 80 ppm.The genesis of this anomaly is as yet poorly understood. It may be related to the leaching and redistribution of the fine fractions of mine waste-rock accumulations. High content of strontium in coal-mine waters may suggest that the Upper Carboniferous rocks are enriched with strontium and serve as its direct source for ground waters. Among various types of soils, urban soils are characterized by the highest strontium values. Here, the Sr values are two to three times higher than those recorded in cultivated soils in non-developed areas. Very low Sr values (4 ppm on the average) are noted in forest soils.

Water sediments: Plate 41, Table V; ppm = mg/kg = g/t

Basic values for Poland (47) and the study area:

- water sediments of Poland <1–7628; average 21
- alluvium of Vistula 5– 911; average 45
- alluvium of Odra 8– 166; average 45
- water sediments of Upper Silesia 1–1120; average 25

The distribution pattern of water sediments showing elevated content of strontium (>40 ppm) is in general similar to the pattern of Sr-enriched soils. Surface drainage may be of some importance in providing strontium to alluvial sediments. However, the main Sr source should be located in saline waters pumped out from coal mines. As a result of the mine water input, strontium enters the surface water system and concentrates in alluvial sediments, mostly in the Vistula and Odra rivers.

Surface waters: Plate 64, Table VI; ppb = µg/l

Approximate limit values (62):

- sea water 8000
- river waters 200

Basic values for Poland (47) and the study area:

- surface waters of Poland 4–26,078; average 263
- Vistula river 60– 3289; average 650
- Odra river 318– 2014; average 689
- surface waters of Upper Silesia 4–26,078; average 310

Over a background of moderate Sr values in surface waters of the study area, the waters of the Upper Silesian Coal Basin can clearly be distinguished by their strontium concentration. This distribution pattern reflects the input of Sr-rich mine waters to the surface water system. In rivers collecting strongly mineralized mine waters, the content of strontium may be greater than 1000 ppb. Small streams and water reservoirs show low Sr values, which usually fluctuate around the background value (approximately 300 ppb Sr). However, in the latter reservoirs there may locally develop water fields with high Sr content.

Review of published data suggests that the content of strontium in surface waters in Upper Silesia is greater than the Sr contents reported from other European countries. For instance, average Sr values of waters in Czech rivers are around 190 ppb, with maximum values of 300 ppb recorded in the Elbe river (J. Vesely, 1991). Exceptionally high concentration of strontium, attaining 35,600 ppb, was revealed in underground waters in a sulphur deposit located at Machów near Tarnobrzeg (A. Smuszkiewicz, 1969).

Ti TITANIUM

Soils: Plate 20, Table IV; ppm = mg/kg = g/t

Basic values for Poland (47) and the study area:

- soils of Poland <1–1542; average 26
- cultivated soils of Poland 2– 968; average 29
- soils of Upper Silesia 1– 396; average 27
- cultivated soils of Upper Silesia 7– 45; average 28

The content of HCl-soluble titanium in soils of Upper Silesia is similar to those noted in other regions of Poland. Slightly elevated Ti values were recorded in soils capping Carboniferous clastic rocks.

Water sediments: Plate 42, Table V; ppm = mg/kg = g/t

Basic values for Poland (47) and the study area:

- water sediments of Poland <1–5345; average 31
- alluvium of Vistula 7– 426; average 27
- alluvium of Odra 12– 174; average 46
- water sediments of Upper Silesia 3–3439; average 40

There are only slight variations in the content of HCl-soluble titanium in water sediments of Upper Silesia. It seems that direct rock substratum is the major source of titanium present in these sediments.

Surface waters: Table VI; ppb = µg/l

Basic values for Poland (47) and the study area:

- surface waters of Poland <5–89; average <5
- Vistula river <5–13; average <5
- Odra river <5–20; average 5
- surface waters of Upper Silesia <5–76; average 5

The content of titanium in surface waters of Upper Silesia is at or below the detection limit of the applied analytical methods. Therefore, geochemical map of titanium in the surface waters has not been developed.

V VANADIUM

Soils: Plate 21, Table IV; ppm = mg/kg = g/t

Approximate limit values (11, 27):

- cultivated soils ≤200
- soils in city parks, recreation fields and house building areas ≤200

Basic values for Poland (47) and the study area:

- soils of Poland <1–266; average 6
- cultivated soils of Poland <1– 58; average 7
- soils of Upper Silesia <1– 94; average 8
- cultivated soils of Upper Silesia <1– 45; average 10

The content of vanadium in soils of Upper Silesia is low, ranging from less than 1 ppm to 45 ppm. Slightly elevated V values were recorded in soils resting upon the Carboniferous clastic rocks.

Water sediments: Plate 43, Table V; ppm = mg/kg = g/t

Basic values for Poland (47) and the study area:

- water sediments of Poland <1–427; average 7
- alluvium of Vistula 2– 68; average 9
- alluvium of Odra 3– 30; average 13
- water sediments of Upper Silesia <1–155; average 11

The content of vanadium in water sediments of the study area is low. As in the case of soils, the observed

slight variations of the vanadium content can be related to the composition of rock substratum.

Surface waters: Table VI; ppb = µg/l

Classes of surface water purity (70):

I ≤1000
II ≤1000
III ≤1000

Basic values for Poland (47) and the study area:

– surface waters of Poland	<8–243; average <8
– Vistula river	average <8
– Odra river	average <8
– surface waters of Upper Silesia	<8– 72; average <8

Most of the analysed water samples contain vanadium in amounts below the detection limit of the applied analytical methods (1 ppb). Therefore, a geochemical map of vanadium in surface waters has not been developed.

Zn ZINC

Soils: Plate 22, Table IV; ppm = mg/kg = g/t

Approximate limit values (16, 27):

– cultivated soils	≤300; toxic level ≥600
– soils in children's play parks	≤300; toxic level ≥2000
– soils in city parks and recreation fields	≤1000; toxic level ≥3000
– soils in house building areas	≤300; toxic level ≥600
– soils in industrial building areas	<1000; toxic level ≥3000

Basic values for Poland (47) and the study area:

– soils of Poland	<1–91,110; average 40
– cultivated soils of Poland	<1– 2140; average 34
– soils of Upper Silesia	5–87,500; average 121
– cultivated soils of Upper Silesia	6– 2140; average 99

Area covered by limit values (for cultivated soils):

– within the tolerance range	(300–600 ppm)	888 km^2	14.1%
– above the toxic level	(>600 ppm)	747 km^2	11.9%

Soils with high content of zinc make dense areas in Upper Silesia. This widespread occurrence of Zn-rich soils is unique in Poland, and can be observed only in severely polluted parts of the region. The area covered by soils with Zn content above the limit value for agricultural soils (300 ppm) correlates with the area also showing lead and cadmium content above the limit values (Plates 7 and 17). This area extends from Tarnowskie Góry and Ruda Śląska in the north-western part of the map to Chrzanów and Olkusz in the south-eastern part. Fields showing maximum concentration of zinc in soils (>800 ppm) can clearly be seen at locations of mining, treatment and smelting of metal ores (Plate C).

The content of zinc in cultivated soils in Upper Silesia is almost three times greater than the content in other regions of Poland (average values are 99 ppm Zn and 34 ppm Zn, respectively).

In other regions of mining and treatment of Zn-Pb ores, anthropogenic input of zinc to soils also contributes to severe pollution of the natural environment. In soils of the Sipham area in Great Britain, the contents of zinc and lead are up to 45,900 ppm and 3,470 ppm, respectively (L. Xiangdong & I. Thornton, 1993). Soils surrounding old waste-rock accumulations in West Chiverton contain 14,790 ppm Zn and 37,000 ppm Pb, and those occurring near waste-rock accumulations in Wemyss – 3,800 ppm Zn and 19,900 ppm Pb (G. Merringtin & B. J. Alloway, 1994).

Water sediments: Plate 44, Table V; ppm = mg/kg = g/t

Basic values for Poland (47) and the study area:

– water sediments of Poland	<1–407,500; average 73
– alluvium of Vistula	10– 2759; average 235
– alluvium of Odra	32– 3755; average 426
– water sediments of Upper Silesia	<11–407,500; average 300

The area in which water sediments show high zinc values (>800 ppm) overlaps the area of high Zn values in soils. Maximum Zn values (>8000 ppm) were recorded in water sediments near locations of both old and modern zinc-smelting works. Conspicuous Zn anomalies can be seen near Miasteczko Śląskie and Bukowno. The highest measured value of more than 40% Zn was recorded in a water ditch near Bukowno railway station. The analysed sediment was composed of nearly pure zinc oxide with admixtures of lead (1,439 ppm), copper (1,432 ppm), cadmium (34.9 ppm), and sulphur (0.459%). An intriguing zinc anomaly in alluvial sediments of the upper Warta catchment area should be mentioned. This anomaly is observed in a belt extending in the NW-SE direction between Koziegłowy and Zawiercie. Small fields of Zn concentration are also noted near Kwaśniów and Dłużec along the same direction. In this belt, water sediments showing Zn concentration are usually surrounded by areas of slightly elevated Zn values in soils, suggesting a presence of metal-ore deposit in the rock substratum.

Surface waters: Plate 65, Table VI; ppb = µg/l

Classes of surface water purity (70):

I ≤200
II ≤200
III ≤200

Basic values for Poland (47) and the study area:

– surface waters of Poland	<5–16,414; average 36
– Vistula river	9– 948; average 44
– Odra river	17– 2167; average 87
– surface waters of Upper Silesia	5–13,198; average 96

The distribution pattern of zinc in surface waters of Upper Silesia is similar to that in water sediments. This suggests that the distribution of zinc in the two environments is controlled by the same set of geologic and anthropogenic factors. Elevated Zn background values in the study area can be related to the regional geological structure and composition of rock substratum. On the other hand, distinct zinc anomalies reflect anthropogenic contamination. Anthropogenic zinc anomalies, with values above 500 ppb Zn, were recorded in waters in the vicinity of Miasteczko Śląskie and Strzybnica, in Bytom and Katowice, in a belt between the Bukowno and the Katowice smelting works, and near Chrzanów. There is also a distinct Zn anomaly near Mierzęcice, whose origin is less clear and requires further study.

Hydrological and geochemical investigation of ground waters in the north-eastern part of Upper Silesia revealed Zn contents of up to 1,500 ppb in ground waters occurring near Pomorzany-Bukowno (J. Serafin-Radlicz, 1972). According to data published by this author, the concentration of zinc in waters, which is higher than 400 ppb, may be used as an indicator of the presence of metal-ore deposits in the rock substratum.

SUMMARY

The distribution patterns of elements in soils, water sediments, and surface waters presented in this Atlas point to a complex geochemical composition of surficial environments in Upper Silesia. Over a background of surficial environments in Poland, Upper Silesia is conspicuous due to its huge element variations and extent of geochemical anomalies, frequently straddling boundaries of the study area. The regional geology and the presence of many large Zn-Pb and coal deposits are basic factors affecting surficial geochemistry in Upper Silesia. The presence of economic deposits gave support to extensive urbanization of the region, which resulted in the development of Upper Silesian urban agglomeration, the greatest and most densely populated urban area in Poland.

A peculiar geochemical character of Upper Silesia must have already been pronounced in prehistoric times, when there was no or little human modification of the natural environment. In surficial environments of the region, there must have existed distinct natural anomalies of elements, such as lead, zinc and cadmium, resulting from subaerial weathering and redistribution of ore-bearing rocks. At present, it is difficult to approximate the intensity and extent of these anomalies, because their original nature was significantly modified by human influence, in particular during the last two centuries. An example of the scale of anthropogenic modification of natural environment in the region can be shown by results of comparative study of old and modern alluvium of the upper Vistula in the vicinity of Cracow (K. Klimek & M. Macklin, 1991). In these alluvium, the content of cadmium, zinc, and lead increased a few hundred times over the last 150–200 years.

At present, the geochemical composition of surficial environments in Upper Silesia, influenced by both the natural and anthropogenic factors, is widely defined by two peculiar element associations related to the two major types of industry present in the region: the Zn-Pb industry, including mining, treatment, and smelting of metal ores, and the coal industry, including mining of black coal and power engineering (coking and power plants).

The Zn-Pb industry is responsible for the pollution of surface waters and water sediments of big rivers with metals, in particular with lead, zinc, cadmium, silver, manganese, and sulphur. To a lesser extent, these environments are being polluted with arsenic, copper, barium, and strontium. The Zn-Pb industry also contributes to the pollution of soils with lead, zinc, cadmium, and sometimes silver. The distribution of polluted soils imprint the pattern of both old and modern metal plants and waste-rock accumulations.

The elevated metal background values in soils of Upper Silesia reflect metal concentration in the geological substratum. Local surface drainage can be considered a source of elements in small water reservoirs. Strong and localized sources aid the pollution of waters and water sediments in rivers and big streams of the Vistula and Odra catchments. As a consequence, waters and water sediments of Vistula and Odra themselves are also polluted, even over long distances from the pollution sources (J. Lis & A. Pasieczna, 1995).

Coal mining and the associated power industry pollute surface waters with sodium, potassium, sulphate, boron, barium, strontium, manganese, and iron. However, the influence of coal mining on the pollution of water sediments is less pronounced. A similar relationship can be observed for the metal-ore industry. Elevated metal contents in water are noted down the Vistula and Odra rivers over considerably long distances from the pollution sources. Upper Silesia also provides the main portion of sodium chloride transported to the Baltic Sea by the Vistula and Odra.

Other pollution sources in the region include municipal and industrial sludges, road and railway transport, and agriculture. In Upper Silesia and adjoining areas, there is a concentration of industry which, besides the indigenous deposits, also uses imported mineral materials, such as chromium, iron ores, and steel enrichment components. Wastes remaining after industrial use of these materials also affect the degradation of the natural environment. Modern agriculture contributes mainly to the pollution of surface waters with phosphorus. The phosphorus content in surface waters in Upper Silesia is high, frequently above the limit value of the second and even third class of water purity. Municipal and industrial sludges are local phosphorus sources.

A positive fact, in favour of respective services of local administration units, is the noticeably low content of toxic elements in artificial reservoirs of drinking water, and also in fish ponds. Phosphorus is here the only element present at elevated concentration, reflecting local drainage of soils.

Ecologically dangerous concentrations of elements (mostly zinc, lead and cadmium) in Upper Silesia are observed over an area of ca. 1,000 km^2. This Atlas provides a general insight into the complexity of surficial geochemistry in the region. It should be regarded as a base for detailed geochemical mapping and other activities aimed at protection of the environment and neutralization of pollution.

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Tabela I

Praktyczne granice oznaczalności pierwiastków i metody analityczne stosowane dla próbek gleb
Practical detection limits of elements and analytical methods used for soil samples

Pierwiastek Element	Metoda analityczna Analytical method	Długość fali (w nm) Wave length (in nm)	Jednostka Unit	Praktyczna granica oznaczalności Practical detection limit
pH	potencjometryczna potentiometric			
Ag	ICP-AES	328.068	ppm	1
As		193.695	ppm	5
Ba		455.403	ppm	1
Ca		315.887	%	0.01
Cd		226.502	ppm	0.5
Co		228.616	ppm	1
Cr		267.716	ppm	1
Cu		324.754	ppm	1
Fe		259.940	%	0.01
Hg	FAAS		ppm	0.05
Mg	ICP-AES	383.829	%	0.01
Mn		257.610	ppm	1
Ni		231.604	ppm	1
P		178.224	%	0.005
Pb		220.353	ppm	3
S		182.000	%	0.005
Sr		407.771	ppm	1
Ti		337.279	ppm	1
V		290.881	ppm	1
Zn		213.856	ppm	1

Tabela II

Praktyczne granice oznaczalności pierwiastków i metody analityczne stosowane dla próbek osadów wodnych
Practical detection limits of elements and analytical methods used for water sediment samples

Pierwiastek Element	Metoda analityczna Analytical method	Długość fali (w nm) Wave length (in nm)	Jednostka Unit	Praktyczna granica oznaczalności Practical detection limit
Ag	ICP-AES	328.068	ppm	1
As		189.042	ppm	5
Ba		233.527	ppm	1
Be		313.042	ppm	1
Ca		317.933	%	0.01
Cd		226.502	ppm	0.5
Co		228.616	ppm	1
Cr		267.716	ppm	1
Cu		324.754	ppm	1
Fe		259.940	%	0.01
Hg	FAAS		ppm	0.05
Mg	ICP-AES	279.079	%	0.01
Mn		257.610	ppm	1
Ni		231.604	ppm	1
P		178.225	%	0.005
Pb		220.353	ppm	5
S		181.974	%	0.005
Sr		407.771	ppm	1
Ti		337.279	ppm	1
V		310.230	ppm	1
Zn		213.856	ppm	1

ICP-AES – atomowa spektrometria emisyjna ze wzbudzeniem plazmowym
inductively coupled plasma atomic emission spectrometry
FAAS – atomowa spektrometria absorbcyjna z techniką zimnych par
cold vapour atomic absorption spectrometry

Tabela III

Praktyczne granice oznaczalności pierwiastków i metody analityczne stosowane dla próbek wód powierzchniowych

Practical detection limits of elements and analytical methods used for surface water samples

Pierwiastek Element	Metoda analityczna Analytical method	Długość fali (w nm) Wave length (in nm)	Jednostka Unit	Praktyczna granica wykrywalności Practical detection limit
Al	ICP-AES	308.215	ppm	0.1
As		193.695	ppm	0.04
B		208.893	ppm	0.02
Ba		455.403	ppb	1
Ca		315.887	ppm	1
Cd		226.502	ppb	3
Co		228.616	ppb	5
Cr		267.716	ppb	5
Cu		324.754	ppb	5
Fe		259.940	ppm	0.02
K		766.491	ppm	1
Li		670.776	ppm	0.02
Mg		383.829	ppm	0.1
Mn		257.610	ppb	1
Na		589.592	ppm	1
Ni		231.604	ppb	8
P		178.224	ppm	0.04
Pb		220.353	ppm	0.03
SiO_2		251.611	ppm	0.3
SO_4		182.000	ppm	1
Sr		407.771	ppb	1
Ti		337.279	ppb	5
V		290.881	ppb	8
Zn		213.856	ppb	5

ICP-AES – atomowa spektrometria emisyjna ze wzbudzeniem plazmowym
inductively coupled plasma atomic emission spectrometry

Parametry statystyczne pierwiastków chemicznych
(Ag, As, Ba, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb,
Statistical parameters of chemical elements
(Ag, As, Ba, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb,

		Ag	As	Ba	Ca	Cd	Co	Cr	Cu
Gleby Górnego Śląska	a	<1	<5	2	<0.01	<0.5	<1	<1	<1
Soils of Upper Silesia	b	13	238	1777	13.47	253.3	21	95	805
n = 1564	c	<1	7	81	0.58	3.1	3	6	13
	d	<1	<5	54	0.23	1.4	2	5	7
	e	<1	<5	54	0.22	1.3	3	5	7
Gleby uprawne	a	<1	<5	3	0.01	<0.5	<1	<1	<1
Cultivated soils	b	3	95	1404	10.40	16.7	21	67	96
n = 476	c	<1	<5	68	0.48	2.1	3	7	8
	d	<1	<5	54	0.24	1.4	3	6	7
	e	<1	<5	52	0.22	1.3	3	6	7
Gleby uprawne terenów bez zabu-	a	<1	<5	3	0.01	<0.5	<1	<1	<1
dowy	b	3	95	282	10.40	16.7	13	67	54
Cultivated soils in non-urbanized areas	c	<1	<5	60	0.52	2.0	3	7	8
n = 268	d	<1	<5	51	0.23	1.3	3	6	6
	e	<1	<5	49	0.20	1.2	3	6	6
Gleby uprawne terenów miejskich	a	<1	<5	5	0.03	<0.5	<1	<1	<1
i przemysłowych	b	13	238	1777	12.40	159.5	17	95	805
Cultivated soils in urban and industrial	c	<1	12	144	0.96	6.9	4	9	30
areas	d	<1	7	105	0.54	2.7	3	7	17
n = 228	e	<1	7	116	0.59	2.8	3	7	16
Gleby uprawne terenów bez zabu-	a	<1	<5	3	0.01	<0.5	<1	<1	<1
dowy (piaszczyste)	b	3	26	240	10.40	15.8	7	67	46
Cultivated soils in non-urbanized areas	c	<1	<5	49	0.61	2.0	3	6	6
(sandy)	d	<1	<5	42	0.21	1.2	2	5	5
n = 138	e	<1	<5	44	0.16	1.2	2	5	5
Gleby uprawne terenów bez zabu-	a	<1	<5	17	0.03	<0.5	1	3	2
dowy (gliniaste)	b	2	95	282	5.03	16.7	13	32	54
Cultivated soils in non-urbanized areas	c	<1	6	70	0.40	1.9	4	9	9
(clayey)	d	<1	<5	61	0.24	1.3	4	8	7
n = 127	e	<1	<5	56	0.22	1.2	4	8	7
Gleby łąk	a	<1	<5	7	0.02	<0.5	<1	<1	<1
Meadow soils	b	1	54	958	13.47	30.5	13	65	119
n = 293	c	<1	6	86	0.63	2.2	4	7	10
	d	<1	<5	64	0.29	1.4	3	6	7
	e	<1	<5	61	0.26	1.4	3	6	7
Gleby ugorów	a	<1	<5	3	0.01	<0.5	<1	<1	<1
Fallow soils	b	13	167	568	12.53	253.3	17	95	316
n = 226	c	<1	10	98	1.10	6.3	3	7	19
	d	<1	6	64	0.49	1.9	2	5	11
	e	<1	6	64	0.55	2.0	3	6	10
Gleby lasów	a	<1	<5	2	<0.01	<0.5	<1	<1	<1
Forest soils	b	5	45	1054	6.27	34.5	13	67	471
n = 401	c	<1	5	55	0.21	2.0	1	4	8
	d	<1	<5	33	0.08	1.0	<1	2	4
	e	<1	<5	31	0.06	1.0	<1	2	4
Gleby lasów z zabudową miejską	a	<1	<5	13	0.03	<0.5	<1	1	3
i przemysłową	b	<1	23	448	2.19	16.4	7	9	47
Forest soils in urban and industrial areas	c	<1	7	79	0.38	2.6	2	4	10
n = 17	d	<1	5	49	0.15	1.4	1	3	7
	e	<1	6	41	0.11	1.3	1	2	6
Gleby trawników przyulicznych	a	<1	<5	29	0.08	<0.5	<1	2	4
Roadside lawn soils	b	2	47	1777	5.72	54.6	11	74	805
n = 84	c	<1	9	153	1.02	5.2	4	11	45
	d	<1	6	115	0.74	2.7	3	9	21
	e	<1	7	119	0.74	2.7	4	8	16
Gleby parków miejskich	a	<1	<5	22	0.04	0.5	<1	2	4
City park soils	b	6	238	447	4.02	88.5	8	15	211
n = 28	c	<1	21	161	0.70	10.9	3	8	33
	d	<1	11	130	0.43	4.6	3	7	19
	e	<1	11	140	0.45	4.3	3	8	20
Gleby ogródków działkowych	a	<1	<5	18	0.06	<0.5	<1	2	3
Allotments soils	b	6	23	780	5.43	25.5	12	16	124
n = 56	c	<1	6	127	0.97	2.9	4	8	19
	d	<1	<5	94	0.53	1.4	3	7	14
	e	<1	<5	101	0.58	1.2	4	7	14
Gleby uprawne Polski	a	<1	<5	2	<0.01	<0.5	<1	<1	<1
Cultivated soils of Poland	b	12	168	1273	13.50	16.7	29	1873	2190
n = 3066	c	<1	<5	39	0.42	<0.5	3	6	8
	d	<1	<5	31	0.18	<0.5	2	5	5
	e	<1	<5	30	0.18	<0.5	2	5	5

a – minimum; minimum b – maksimum; maximum c – średnia arytmetyczna; arithmetic mean d – średnia geometryczna; geometric mean e – mediana; median n – liczba próbek; number of samples

Tabela IV

i kwasowość w glebach Górnego Śląska
Sr, Ti, V, Zn w ppm, Ca, Fe, Mg, P, S w %)
and acidity in soils of Upper Silesia
Sr, Ti, V, Zn in ppm, Ca, Fe, Mg, P, S in %)

Fe	Hg	Mg	Mn	Ni	P	Pb	S	Sr	Ti	V	Zn	pH
<0.01	<0.05	<0.01	2	<1	<0.005	<3	<0.005	<1	1	<1	5	2.2
5.06	4.00	4.90	7000	89	0.476	16972	0.516	708	396	94	87500	9.7
0.75	0.11	0.12	320	6	0.036	130	0.019	20	35	10	331	6.4
0.56	0.08	0.06	186	4	0.027	53	0.015	10	27	8	121	6.2
0.63	0.08	0.07	257	5	0.030	44	0.015	10	28	9	104	6.7
0.06	<0.05	<0.01	6	<1	<0.005	<3	<0.005	1	6	<1	6	3.5
5.06	1.04	1.75	2046	48	0.476	2113	0.121	246	194	54	2140	8.7
0.76	0.09	0.12	362	7	0.039	74	0.015	15	32	11	173	6.7
0.64	0.07	0.08	293	5	0.034	44	0.014	10	28	9	110	6.6
0.65	0.08	0.08	319	5	0.035	36	0.014	10	29	10	96	6.8
0.06	<0.05	0.01	6	<1	<0.005	<3	<0.005	1	7	<1	6	3.5
5.06	0.40	1.75	2016	48	0.476	1963	0.121	154	45	45	2140	8.7
0.81	0.09	0.12	371	7	0.039	64	0.015	13	32	11	157	6.6
0.67	0.08	0.08	296	5	0.033	39	0.014	10	28	10	99	6.5
0.69	0.08	0.08	319	6	0.034	34	0.015	10	31	10	87	6.7
0.09	<0.05	<0.01	6	<1	<0.005	5	<0.005	1	8	1	15	3.3
3.21	4.01	3.81	2229	89	0.254	16972	0.516	708	318	60	11899	8.6
0.98	0.20	0.21	440	10	0.044	320	0.026	43	63	12	719	7.3
0.83	0.13	0.13	314	7	0.035	110	0.019	26	49	10	306	7.2
0.87	0.14	0.13	338	8	0.035	102	0.019	27	49	11	317	7.6
0.06	<0.05	<0.01	6	<1	<0.005	<3	<0.005	1	7	<1	6	3.7
1.62	0.40	1.21	1832	20	0.123	1963	0.028	65	112	23	1758	8.7
0.60	0.09	0.10	310	5	0.034	72	0.014	12	30	9	147	6.6
0.52	0.07	0.06	240	4	0.030	38	0.013	8	26	8	92	6.6
0.58	0.08	0.06	269	4	0.032	33	0.014	8	29	9	79	6.7
0.24	<0.05	0.01	51	2	0.007	10	<0.005	3	7	3	20	3.9
5.06	0.33	1.75	1298	48	0.476	636	0.040	154	194	30	2140	8.3
1.02	0.09	0.14	427	9	0.043	54	0.016	14	34	13	163	6.5
0.88	0.07	0.11	370	7	0.036	39	0.015	11	30	12	106	6.4
0.83	0.08	0.10	372	7	0.038	34	0.016	11	33	12	91	6.7
0.08	<0.05	<0.01	8	<1	0.005	5	<0.005	1	6	1	17	3.3
4.08	1.10	1.25	3105	40	0.217	8751	0.135	180	120	40	9450	8.7
0.90	0.12	0.11	370	7	0.042	99	0.022	18	30	11	212	6.3
0.72	0.09	0.07	261	6	0.034	44	0.018	13	26	9	117	6.3
0.77	0.09	0.08	296	6	0.034	39	0.018	13	25	11	110	6.5
0.07	<0.05	<0.01	6	<1	<0.005	<3	<0.005	<1	4	<1	15	3.2
4.86	1.08	4.90	3507	89	0.254	8260	0.516	708	396	60	87500	8.8
0.86	0.12	0.22	392	8	0.040	248	0.024	36	47	11	970	7.3
0.64	0.09	0.10	249	6	0.029	74	0.016	17	35	8	210	7.2
0.67	0.08	0.10	278	6	0.032	63	0.016	18	33	9	179	7.5
<0.01	<0.05	<0.01	2	<1	<0.005	<3	<0.005	<1	1	<1	5	2.2
4.70	0.85	1.11	7000	28	0.310	4260	0.349	224	302	50	3116	9.7
0.48	0.09	0.05	154	3	0.021	102	0.017	9	25	6	163	5.3
0.30	0.07	0.02	56	2	0.015	50	0.011	4	19	4	73	5.1
0.28	0.07	0.02	51	2	0.015	49	0.011	4	18	4	61	5.1
0.11	<0.05	<0.01	12	<1	<0.005	14	<0.005	2	9	1	27	3.3
2.01	0.36	1.11	829	14	0.230	308	0.349	224	162	20	1736	7.8
0.66	0.14	0.11	234	5	0.032	89	0.036	27	48	7	225	5.9
0.43	0.10	0.03	108	3	0.018	72	0.015	10	32	5	113	5.8
0.48	0.08	0.02	114	3	0.019	78	0.015	9	27	4	98	6.1
0.27	<0.05	0.03	80	3	0.008	13	0.008	5	12	2	46	4.6
3.21	4.01	0.89	2229	38	0.117	1078	0.089	181	312	32	2903	8.7
0.99	0.24	0.20	424	10	0.045	193	0.022	41	71	13	580	7.5
0.90	0.14	0.16	348	9	0.039	111	0.020	30	58	11	340	7.5
0.89	0.14	0.16	343	8	0.039	103	0.018	32	55	11	336	7.6
0.17	0.05	0.02	44	2	0.006	8	0.007	4	12	3	31	3.8
2.33	0.95	1.75	1504	26	0.105	16972	0.113	108	178	27	4984	8.0
1.12	0.23	0.18	462	9	0.040	797	0.025	33	62	13	927	6.8
0.96	0.19	0.11	356	8	0.032	153	0.021	24	51	12	442	6.8
0.92	0.18	0.11	370	8	0.028	155	0.021	27	48	13	477	7.0
0.30	<0.05	0.02	48	2	0.011	6	<0.005	3	13	3	24	4.3
1.91	0.42	2.33	1933	28	0.276	518	0.107	438	379	94	1675	8.4
0.86	0.13	0.17	365	9	0.062	77	0.022	52	48	14	263	7.2
0.78	0.10	0.11	290	8	0.049	48	0.019	27	39	12	156	7.1
0.83	0.09	0.12	314	8	0.047	38	0.020	26	41	13	134	7.4
0.05	<0.05	<0.01	2	<1	<0.005	<3	<0.005	<1	2	<1	<1	2.8
5.99	4.75	1.75	24270	48	0.476	1963	0.177	654	968	58	2140	8.7
0.63	0.07	0.10	282	6	0.043	18	0.013	14	35	8	47	6.3
0.52	0.05	0.07	222	4	0.038	13	0.011	8	29	7	34	6.2
0.53	0.05	0.07	243	4	0.038	11	0.011	8	30	7	31	6.4

Parametry statystyczne pierwiastków chemicznych
(Ag, As, Ba, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb,
Statistical parameters of chemical elements
(Ag, As, Ba, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb,

		Ag	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe
Osady wodne Górnego Śląska Water sediments of Upper Silesia n = 1459	a	<1	<5	3	<0.5	0.02	<0.5	<1	<1	1	0.03
	b	117	901	1794	19.9	26.55	8735.9	164	12251	1886	26.43
	c	1	12	127	0.9	1.63	17.0	6	32	39	1.42
	d	<1	6	93	0.6	0.71	2.8	4	10	16	1.01
	e	1	6	98	0.6	0.71	2.5	4	9	15	1.07
ZLEWNIA THE VISTULA											
Wisła The Vistula river n = 13	a	1	<5	49	<0.5	0.13	2.3	4	24	30	1.09
	b	5	16	437	1.0	1.30	109.5	10	420	419	3.04
	c	2	7	219	0.6	0.64	37.1	7	161	138	2.08
	d	2	6	185	0.6	0.51	20.9	7	119	108	1.98
	e	2	6	191	0.6	0.60	24.4	7	131	106	2.05
Baba The Baba river n = 5	a	1	9	50	<0.5	2.77	4.8	3	6	13	0.49
	b	3	37	174	1.9	7.95	20.5	14	35	138	1.66
	c	2	18	100	0.8	4.85	10.1	7	17	60	1.03
	d	2	15	89	0.6	4.47	8.7	6	14	44	0.94
	e	2	14	67	0.5	5.15	9.4	5	14	59	1.20
Bachol The Bachol river n = 6	a	<1	<5	28	<0.5	0.16	<0.5	3	3	4	0.53
	b	<1	8	114	0.8	1.53	3.0	5	14	63	1.62
	c	<1	<5	74	<0.5	0.55	1.2	4	8	19	1.09
	d	<1	<5	65	<0.5	0.38	0.7	4	7	12	1.01
	e	<1	<5	74	<0.5	0.29	0.9	4	9	10	1.19
Biała Przemsza The Biała Przemsza river n = 11	a	<1	<5	27	<0.5	0.45	1.2	2	3	4	0.32
	b	2	77	226	1.2	12.53	65.0	20	1023	87	1.73
	c	1	28	123	0.7	4.80	24.0	8	133	35	1.00
	d	1	16	103	0.6	3.18	11.8	6	17	26	0.90
	e	1	31	110	0.6	4.63	18.1	7	10	32	1.16
Bobrek The Bobrek river n = 6	a	1	<5	77	<0.5	2.00	3.7	3	19	29	1.80
	b	3	32	342	3.9	4.18	17.4	57	629	164	6.67
	c	2	12	155	1.1	2.83	8.2	14	155	81	3.10
	d	2	9	135	0.7	2.75	7.3	8	73	71	2.79
	e	2	9	128	0.7	2.66	6.9	7	62	70	2.72
Brynica The Brynica river n = 16	a	<1	<5	34	<0.5	0.18	0.6	<1	2	3	0.23
	b	12	35	246	1.3	3.29	234.6	23	240	393	5.71
	c	3	12	116	0.8	1.89	33.9	9	32	76	1.91
	d	1	8	105	0.7	1.29	10.5	7	12	27	1.48
	e	2	9	115	0.9	2.44	9.1	9	23	55	1.96
Czarna Przemsza The Czarna Przemsza river n = 26	a	<1	<5	14	<0.5	0.09	<0.5	1	2	3	0.24
	b	6	19	650	2.2	8.66	18.8	46	522	590	2.94
	c	2	7	136	0.7	2.56	5.5	7	51	85	1.36
	d	1	5	99	0.5	1.56	3.3	4	23	27	1.09
	e	1	6	101	0.6	1.81	3.1	4	30	24	1.35
Chechło The Chechło river n = 5	a	1	10	90	<0.5	0.93	40.8	2	9	27	0.61
	b	25	39	159	2.5	15.74	130.1	15	55	667	2.53
	c	12	23	128	1.2	8.52	77.7	7	26	306	1.83
	d	7	21	125	0.9	5.66	70.8	6	22	197	1.64
	e	11	25	118	1.0	9.41	72.9	6	20	251	2.12
Dulówka The Dulówka river n = 5	a	1	<5	60	0.6	0.77	3.6	2	5	11	0.58
	b	1	5	115	3.8	3.00	8.1	5	9	47	0.87
	c	1	<5	80	2.0	1.66	5.8	4	7	25	0.71
	d	1	<5	77	1.6	1.49	5.5	3	7	22	0.70
	e	1	<5	69	1.7	1.25	5.4	4	8	24	0.64
Gostynia The Gostynia river n = 5	a	<1	7	62	0.7	0.25	2.2	6	16	11	1.02
	b	1	17	150	2.0	0.53	4.1	14	34	54	2.33
	c	<1	12	119	1.3	0.34	3.0	8	23	34	1.44
	d	<1	11	114	1.2	0.33	2.9	8	22	29	1.37
	e	1	9	128	1.2	0.30	2.9	7	18	35	1.32
Korzeniec The Korzeniec river n = 5	a	<1	<5	71	0.6	0.16	2.4	4	5	4	1.09
	b	<1	10	248	3.0	0.30	9.9	16	12	13	5.67
	c	<1	6	116	1.8	0.24	7.1	9	8	8	2.21
	d	<1	<5	103	1.6	0.24	6.4	8	8	8	1.78
	e	<1	5	90	1.8	0.27	7.8	7	8	8	1.40
Kozi Bród The Kozi Bród river n = 6	a	<1	<5	17	<0.5	0.13	2.0	<1	2	2	0.17
	b	4	10	158	3.4	7.41	11.7	14	12251	876	2.63
	c	2	5	78	1.6	3.69	6.3	6	2599	196	1.02
	d	1	<5	55	1.1	1.39	5.6	3	56	38	0.63
	e	2	<5	69	1.5	3.45	6.2	5	20	72	0.68
Mitręga The Mitręga river n = 8	a	<1	<5	44	<0.5	0.26	0.9	2	3	5	0.71
	b	1	<5	104	0.6	7.65	2.6	4	11	16	2.09
	c	<1	<5	58	<0.5	2.53	1.7	3	7	9	1.05
	d	<1	<5	56	<0.5	1.29	1.6	3	6	8	0.99
	e	<1	<5	51	<0.5	1.72	1.9	3	6	8	0.91

Tabela V

w osadach wodnych Górnego Śląska
Sr, Ti, V, Zn w ppm, Ca, Fe, Mg, P, S w %)
in water sediments of Upper Silesia
Sr, Ti, V, Zn in ppm, Ca, Fe, Mg, P, S in %)

Hg	Mg	Mn	Ni	P	Pb	S	Sr	Ti	V	Zn
<0.05	0.01	4	<1	<0.005	<5	<0.005	1	3	<1	11
10.50	5.87	21 295	795	3.961	43 878	2.193	1120	3439	155	407 500
0.15	0.25	558	16	0.107	328	0.150	43	54	14	1 250
<0.05	0.13	280	10	0.067	72	0.064	25	40	11	300
0.06	0.13	292	11	0.066	59	0.052	24	42	12	259
WISŁY RIVER CATCHMENT										
0.11	0.11	97	21	0.056	46	0.029	8	20	5	350
2.15	0.37	553	282	0.523	358	0.288	100	58	23	2 759
0.71	0.23	313	59	0.297	151	0.112	51	39	14	1 193
0.46	0.21	264	44	0.252	130	0.086	42	37	13	985
0.70	0.24	347	39	0.287	134	0.071	51	39	14	954
<0.05	0.44	186	7	0.021	183	0.020	23	70	7	414
0.12	1.31	475	57	0.122	1 544	0.254	94	208	26	2 199
0.06	0.76	319	24	0.051	566	0.079	50	115	13	1 162
0.05	0.69	300	17	0.042	408	0.049	44	106	11	974
<0.05	0.59	315	15	0.036	432	0.038	40	96	9	1 070
<0.05	0.05	183	5	0.032	10	0.006	5	21	6	31
0.09	0.25	608	11	0.239	92	0.321	36	61	15	853
0.06	0.15	406	9	0.127	33	0.078	18	41	11	220
<0.05	0.13	383	8	0.099	25	0.034	14	38	10	117
0.06	0.13	409	10	0.120	21	0.036	13	40	12	107
<0.05	0.07	174	3	0.017	37	0.010	9	26	4	126
<0.05	3.22	962	34	0.213	7 186	0.407	71	122	32	6 233
<0.05	1.32	470	15	0.056	1 762	0.194	39	73	15	2 450
<0.05	0.69	401	12	0.042	599	0.105	32	65	12	1 304
<0.05	1.65	389	15	0.035	1 336	0.073	38	77	12	2 083
<0.05	0.14	271	22	0.172	182	0.170	38	37	6	591
0.82	0.51	3 179	795	0.627	388	1.326	298	116	34	2 716
0.37	0.31	771	159	0.348	298	0.666	109	56	15	1 810
0.25	0.28	431	53	0.313	290	0.531	87	51	12	1 646
0.39	0.30	287	34	0.265	295	0.597	81	45	12	1 891
<0.05	0.03	99	2	0.009	20	0.007	4	14	2	134
0.99	0.64	2 416	181	0.632	1 289	1.462	123	103	32	63 157
0.18	0.32	815	33	0.188	348	0.507	56	50	16	9 333
0.08	0.21	601	17	0.098	161	0.167	32	41	12	1 896
<0.05	0.36	533	23	0.183	193	0.415	66	56	17	2 207
<0.05	0.03	22	2	0.011	9	0.006	2	9	2	34
1.01	0.63	14 701	395	0.445	1 014	1.154	159	173	35	2 190
0.25	0.27	1 352	31	0.140	206	0.339	50	53	13	768
0.14	0.19	468	11	0.093	109	0.167	29	42	9	481
0.15	0.21	401	11	0.111	95	0.159	29	44	10	494
<0.05	0.24	426	9	0.068	163	0.150	18	25	7	2 076
0.69	5.87	2 024	39	0.327	8 795	0.761	93	62	28	14 151
0.20	2.96	1 116	23	0.140	4 313	0.392	64	44	19	7 606
0.10	1.86	915	20	0.116	2 042	0.341	51	42	17	5 855
0.09	2.74	1 030	23	0.085	3 077	0.336	91	43	20	6 969
<0.05	0.19	169	6	0.040	134	0.024	20	55	8	441
0.07	0.59	196	11	0.062	412	0.141	39	118	14	1 365
0.05	0.35	181	8	0.049	244	0.055	30	79	11	895
0.05	0.31	181	8	0.048	224	0.044	29	76	11	825
0.06	0.29	176	7	0.045	213	0.036	33	74	12	934
0.09	0.07	64	15	0.085	24	0.057	26	29	11	249
0.29	0.15	287	23	0.243	82	0.495	64	46	155	524
0.21	0.10	152	18	0.136	51	0.265	49	37	49	352
0.20	0.09	130	18	0.127	47	0.192	45	36	31	339
0.24	0.08	101	17	0.124	51	0.330	59	36	28	317
<0.05	0.02	89	8	0.067	23	0.069	13	14	6	271
0.08	0.14	771	15	0.201	57	0.263	56	52	21	650
<0.05	0.06	305	12	0.130	35	0.132	27	30	10	441
<0.05	0.05	236	11	0.119	33	0.116	23	27	9	422
<0.05	0.05	219	11	0.105	33	0.104	18	29	9	434
<0.05	0.03	30	2	0.010	74	0.011	6	21	3	431
0.88	0.87	533	23	0.198	640	0.657	140	188	32	1 402
0.21	0.38	220	11	0.079	330	0.252	66	94	16	923
0.09	0.20	139	7	0.042	260	0.075	30	63	10	827
0.07	0.35	164	10	0.058	238	0.089	55	79	14	994
<0.05	0.04	60	3	0.042	22	0.024	6	14	4	146
0.15	0.22	633	10	0.131	85	0.417	59	107	12	362
<0.05	0.12	276	6	0.085	55	0.093	25	36	7	240
<0.05	0.10	226	5	0.079	50	0.058	19	28	6	227
<0.05	0.12	282	5	0.082	54	0.048	20	23	6	227

		Ag	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe
Mleczna The Mleczna river n = 5	a	<1	<5	25	<0.5	0.12	0.8	2	1	4	0.37
	b	1	53	268	1.0	0.69	6.3	9	43	33	2.66
	c	<1	16	169	0.8	0.36	2.8	6	19	20	1.22
	d	<1	8	132	0.7	0.30	2.1	5	12	16	0.94
	e	1	8	187	0.9	0.27	2.7	6	19	21	0.84
Pszczynka The Pszczynka river n = 11	a	<1	<5	26	<0.5	0.14	<0.5	2	5	4	0.68
	b	1	9	207	1.2	0.40	3.6	6	54	29	2.34
	c	<1	5	98	0.5	0.24	1.5	4	18	11	1.39
	d	<1	<5	88	<0.5	0.23	1.2	4	13	10	1.31
	e	<1	6	90	0.5	0.24	1.5	4	10	9	1.13
Sztoła The Sztoła river n = 5	a	1	<5	45	<0.5	1.61	1.3	1	2	3	0.41
	b	5	153	292	1.1	19.99	81.1	8	14	37	2.07
	c	2	53	124	0.7	7.69	27.7	4	8	19	0.98
	d	2	23	96	0.6	5.47	14.4	3	7	14	0.83
	e	2	19	102	0.7	4.36	21.8	3	7	18	0.76
Trzebyczka The Trzebyczka river n = 5	a	<1	<5	21	<0.5	0.31	1.2	1	3	4	0.29
	b	1	8	124	0.9	6.55	27.6	4	25	43	1.36
	c	<1	<5	85	0.5	2.91	8.6	2	13	21	0.76
	d	<1	<5	73	<0.5	1.91	5.0	2	10	16	0.66
	e	<1	<5	93	<0.5	1.81	4.5	2	12	16	0.63
											ZLEWNIA THE ODRA
Bierawka The Bierawka river n = 7	a	1	<5	68	<0.5	0.23	1.4	5	5	8	0.62
	b	4	16	218	1.4	1.69	7.9	34	29	273	2.81
	c	2	6	138	0.8	0.80	3.0	14	14	62	1.47
	d	1	5	126	0.7	0.63	2.5	11	11	29	1.34
	e	1	5	144	0.8	0.67	2.0	10	10	20	1.56
Brzeźnica The Brzeźnica river n = 5	a	<1	<5	49	<0.5	0.19	2.1	3	1	3	0.37
	b	2	13	206	1.0	2.37	7.6	7	11	18	2.27
	c	<1	5	110	0.5	1.01	3.9	4	4	8	1.02
	d	<1	<5	97	<0.5	0.62	3.5	4	3	6	0.82
	e	<1	<5	102	0.5	0.59	2.7	4	2	6	0.70
Bytomka The Bytomka river n = 7	a	3	9	111	0.5	2.04	9.3	5	19	96	1.71
	b	8	210	249	0.9	3.35	22.8	12	39	181	4.20
	c	6	51	180	0.7	2.84	15.3	7	30	128	2.55
	d	5	30	175	0.7	2.79	14.8	7	29	125	2.46
	e	6	24	174	0.7	2.84	15.9	6	31	123	2.32
Drama The Drama river n = 7	a	<1	<5	41	<0.5	0.28	0.9	1	4	8	0.30
	b	2	7	234	0.7	1.67	5.2	5	16	34	1.35
	c	<1	<5	134	<0.5	0.97	3.2	4	11	24	0.88
	d	<1	<5	119	<0.5	0.82	2.8	3	10	21	0.80
	e	<1	5	147	0.5	0.84	3.1	4	12	29	0.97
Kłodnica The Kłodnica river n = 11	a	<1	<5	107	<0.5	0.25	0.7	2	4	10	0.58
	b	3	10	474	0.7	3.35	19.1	12	29	70	3.53
	c	2	6	187	0.5	1.62	6.3	6	15	40	1.69
	d	1	6	168	<0.5	1.12	4.1	6	13	34	1.41
	e	2	6	146	0.5	1.04	3.4	5	13	44	1.57
Mała Panew The Mała Panew river n = 6	a	<1	<5	8	<0.5	0.05	<0.5	<1	<1	1	0.07
	b	1	25	590	2.0	0.73	303.1	20	28	65	2.68
	c	<1	12	243	0.9	0.30	75.7	8	11	25	1.14
	d	<1	8	103	0.6	0.21	8.3	4	5	12	0.70
	e	1	10	182	0.7	0.25	5.5	7	6	12	0.86
Nacyna The Nacyna river n = 5	a	<1	<5	85	0.6	0.28	0.8	4	8	17	1.34
	b	3	15	266	1.6	1.55	3.8	11	24	62	2.03
	c	2	7	170	1.0	0.81	2.0	7	16	42	1.66
	d	1	5	156	0.9	0.66	1.8	6	15	38	1.63
	e	2	6	143	0.9	0.50	1.6	6	18	43	1.77
Rokitnica The Rokitnica river n = 6	a	1	<5	102	<0.5	0.43	3.5	4	11	24	0.73
	b	2	16	247	0.9	2.22	7.6	30	37	432	1.55
	c	2	8	170	0.7	1.39	5.3	11	26	130	1.20
	d	1	7	161	0.7	1.21	5.1	8	24	84	1.16
	e	2	8	183	0.8	1.36	5.2	8	27	74	1.23
Ruda The Ruda river n = 6	a	<1	<5	51	<0.5	0.07	0.7	2	3	6	0.47
	b	1	21	304	1.2	0.58	16.3	21	44	35	1.93
	c	<1	6	133	<0.5	0.27	3.7	6	13	21	1.03
	d	<1	<5	113	<0.5	0.20	1.7	4	8	18	0.91
	e	1	<5	113	<0.5	0.19	1.2	3	7	19	1.00
Stoła The Stoła river n = 9	a	1	10	51	<0.5	0.51	6.3	2	15	21	0.75
	b	13	88	255	1.5	4.89	290.3	8	365	1 131	2.96
	c	5	43	144	0.8	2.10	59.6	5	140	408	1.74
	d	3	35	124	0.7	1.65	31.0	5	83	216	1.54
	e	6	35	141	0.7	1.55	28.8	6	72	279	1.97
Warta The Warta river n = 9	a	<1	<5	39	<0.5	0.57	1.2	2	14	18	1.20
	b	5	20	248	2.4	3.55	9.8	13	111	129	2.89
	c	2	12	122	1.0	1.83	5.2	6	46	70	1.90
	d	1	10	108	0.8	1.50	4.2	5	38	56	1.83
	e	2	13	119	0.9	1.56	4.4	6	43	85	1.94

Hg	Mg	Mn	Ni	P	Pb	S	Sr	Ti	V	Zn
<0.05	0.01	35	5	0.014	20	0.020	9	8	4	216
0.33	0.14	1 005	21	0.236	57	0.411	117	35	14	503
0.14	0.08	368	14	0.118	39	0.155	45	23	7	319
0.11	0.06	225	12	0.077	37	0.099	31	21	7	301
0.12	0.06	227	14	0.108	38	0.100	38	21	6	262
<0.05	0.06	81	6	0.012	9	0.008	7	22	3	28
0.10	0.19	766	15	0.433	53	0.350	31	58	17	472
0.05	0.09	322	9	0.141	25	0.063	16	40	10	166
<0.05	0.09	241	9	0.108	22	0.032	15	39	9	139
<0.05	0.07	244	8	0.129	21	0.024	15	43	9	138
<0.05	0.28	101	3	0.011	49	0.016	14	30	5	136
0.08	2.48	675	28	0.094	3 653	0.176	138	104	23	8 851
<0.05	1.20	313	12	0.039	1 109	0.082	52	66	12	3 550
<0.05	0.85	252	8	0.027	513	0.053	37	61	10	1 923
<0.05	1.04	260	10	0.020	571	0.038	44	66	9	3 268
<0.05	0.08	132	3	0.010	144	0.013	6	13	4	116
0.97	3.72	787	17	0.054	1 737	0.067	59	121	14	1 638
0.24	1.15	530	8	0.034	509	0.039	30	48	8	615
0.08	0.52	457	7	0.030	305	0.034	24	37	7	430
<0.05	0.35	589	6	0.037	207	0.035	29	33	7	410
ODRY RIVER CATCHMENT										
<0.05	0.06	49	10	0.049	31	0.023	17	19	4	251
0.50	0.29	693	83	0.264	144	0.791	139	61	17	1 364
0.12	0.15	282	27	0.144	78	0.345	51	44	10	523
0.07	0.12	223	21	0.128	70	0.177	40	41	9	446
0.06	0.09	268	20	0.140	66	0.298	30	48	9	402
<0.05	0.03	122	3	0.034	<5	0.024	6	14	4	153
0.05	0.45	1 182	11	0.322	350	0.149	55	91	12	1 018
<0.05	0.14	535	6	0.120	93	0.091	28	36	7	492
<0.05	0.08	411	6	0.090	32	0.077	20	28	7	400
<0.05	0.06	417	6	0.084	25	0.109	21	24	6	430
0.56	0.44	436	17	0.111	297	0.200	73	56	10	1 411
1.99	1.26	1 847	26	0.451	1 413	0.761	122	87	19	4 272
1.06	0.64	837	20	0.254	763	0.487	103	73	15	3 163
0.99	0.60	755	20	0.230	698	0.441	101	72	14	2 985
1.02	0.50	681	20	0.245	769	0.470	111	77	15	3 449
<0.05	0.05	71	3	0.039	25	0.035	12	22	3	137
0.18	0.32	492	14	0.206	307	0.402	69	102	17	779
0.10	0.19	278	9	0.106	154	0.150	40	63	11	497
0.08	0.16	241	8	0.092	126	0.113	33	56	10	449
0.10	0.18	303	11	0.106	163	0.114	36	64	12	526
<0.05	0.06	81	7	0.046	15	0.041	24	21	6	183
0.77	1.44	817	21	0.353	242	0.341	123	51	25	1 424
0.35	0.56	453	14	0.147	135	0.161	69	36	13	708
0.23	0.30	346	13	0.119	110	0.126	58	35	12	586
0.30	0.16	433	14	0.113	124	0.117	42	32	12	728
<0.05	0.01	19	<1	<0.005	6	<0.005	2	9	1	36
0.10	0.21	3 760	18	0.157	338	0.405	41	70	15	2 793
<0.05	0.06	866	9	0.079	137	0.133	19	26	7	1 124
<0.05	0.03	214	6	0.047	77	0.053	12	21	5	448
<0.05	0.03	196	9	0.077	124	0.097	14	19	6	668
0.08	0.11	212	9	0.067	30	0.017	31	50	13	100
0.30	0.32	637	22	0.267	123	0.559	144	89	21	677
0.20	0.22	325	16	0.129	75	0.209	88	75	18	348
0.18	0.21	297	16	0.113	68	0.123	77	73	17	269
0.22	0.20	257	18	0.090	74	0.110	85	82	19	419
0.12	0.11	110	10	0.038	158	0.040	35	38	11	373
0.38	0.48	2 218	24	0.421	260	0.805	127	100	32	1 276
0.29	0.26	805	17	0.158	210	0.298	73	63	19	762
0.27	0.23	431	16	0.120	206	0.185	65	60	18	708
0.33	0.21	334	18	0.107	211	0.191	64	65	18	710
<0.05	0.03	73	4	0.050	10	0.025	5	16	3	61
0.15	0.11	737	37	0.273	126	0.200	48	111	19	570
0.09	0.07	243	11	0.117	41	0.095	26	45	9	214
0.07	0.06	179	8	0.100	29	0.080	21	37	8	167
0.08	0.07	171	7	0.099	29	0.089	23	34	8	172
0.08	0.03	143	15	0.036	127	0.080	11	15	3	1 040
1.26	1.08	939	140	0.363	2 956	1.800	160	106	26	12 148
0.43	0.33	486	60	0.192	987	0.888	85	66	13	5 528
0.28	0.23	405	42	0.161	668	0.642	63	58	11	3 984
0.31	0.32	476	39	0.175	946	0.728	100	63	13	4 322
0.05	0.04	141	8	0.041	55	0.115	13	19	4	352
0.63	0.37	900	293	0.561	860	2.193	72	182	23	3 859
0.25	0.19	382	52	0.214	391	0.749	40	80	14	1 575
0.19	0.16	326	26	0.162	272	0.508	35	68	12	1 204
0.25	0.17	306	23	0.179	325	0.512	43	68	15	1 042

		Ag	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe
											ZLEWNIA WISŁY THE VISTULA AND ODRA
Strumienie, rowy i cieki bez nazwy Unnamed streams, ditches and rivulets n = 782	a	<1	<5	6	<0.5	0.02	<0.5	<1	<1	1	0.03
	b	27	901	1794	19.9	24.34	8735.9	164	968	1 432	26.43
	c	<1	12	132	1.0	1.23	17.2	6	14	28	1.49
	d	<1	6	97	0.7	0.57	2.6	4	9	15	1.04
	e	<1	6	102	0.7	0.54	2.4	5	9	14	1.06
Sztuczne zbiorniki (zalewy) Artificial lakes n = 19	a	<1	<5	12	<0.5	0.03	<0.5	1	1	1	0.10
	b	1	10	775	1.0	1.44	5.7	6	19	20	1.49
	c	<1	<5	119	<0.5	0.34	1.7	2	5	7	0.55
	d	<1	<5	58	<0.5	0.19	1.2	2	4	6	0.45
	e	<1	<5	40	<0.5	0.23	1.5	2	3	6	0.46
Małe zbiorniki wodne bez nazwy (sadzawki, jeziorka, stawy) Unnamed small reservoirs (pools, lakes, ponds) n = 105	a	<1	<5	3	<0.5	0.02	<0.5	<1	1	1	0.05
	b	24	250	783	6.2	16.92	253.8	32	110	1 200	14.54
	c	2	17	152	1.0	2.45	12.1	7	15	54	1.60
	d	<1	9	114	0.8	0.97	3.4	5	11	23	1.14
	e	1	8	135	0.8	1.05	3.3	5	10	22	1.31
Stawy rybne Fish ponds n = 16	a	<1	<5	11	<0.5	0.06	<0.5	<1	2	2	0.09
	b	2	8	196	1.2	16.22	8.0	7	24	17	2.74
	c	<1	<5	72	0.6	1.27	2.2	3	10	10	0.94
	d	<1	<5	60	<0.5	0.26	1.4	2	7	8	0.65
	e	<1	<5	62	<0.5	0.22	1.2	3	8	10	0.72
Osady wodne Polski Water sediments of Poland n = 12778	a	<1	<5	<1	<0.5	<0.01	<0.5	<1	<1	<1	<0.01
	b	117	6215	1794	21.0	43.15	8736.0	357	12 251	15 460	31.14
	c	<1	7	80	<0.5	1.67	2.8	4	18	21	1.18
	d	<1	<5	52	<0.5	0.84	0.6	3	6	8	0.75
	e	<1	<5	54	<0.5	0.86	<0.5	3	5	7	0.80

a – minimum; minimum b – maksimum; maximum c – średnia arytmetyczna; arithmetic mean d – średnia geometryczna; geometric mean e – mediana; median n – liczba próbek; number of samples

Parametry statystyczne pierwiastków chemicznych
(Al, As, B, Ca, Fe, K, Li, Mg, Na, P, Pb, SiO_2, SO_4 w ppm (mg/l),
Statistical parameters of chemical elements
(Al, As, B, Ca, Fe, K, Li, Mg, Na, P, Pb, SiO_2, SO_4 w ppm (mg/l),

		Al	As	B	Ba	Ca	Cd	Co	Cr	Cu	Fe	K	Li
Wody powierzchniowe Górnego Śląska Surface waters of Upper Silesia n = 1188	a	<0.1	<0.04	<0.02	2	3	<3	<5	<5	<5	<0.02	<1	<0.02
	b	1.2	1.71	7.92	3470	6400	238	136	4445	994	93.44	473	2.78
	c	0.3	<0.04	0.24	117	104	<3	<5	8	10	1.79	15	0.05
	d	0.2	<0.04	0.09	87	83	<3	<5	<5	5	1.01	8	<0.02
	e	0.2	<0.04	0.09	82	85	<3	<5	<5	5	1.00	8	<0.02
													ZLEWNIA THE VISTULA
Wisła The Vistula river n = 15	a	0.2	<0.04	0.03	61	36	<3	<5	<5	<5	0.68	3	<0.02
	b	0.7	<0.04	0.63	1254	167	14	<5	44	84	3.09	34	0.15
	c	0.3	<0.04	0.40	314	128	5	<5	12	13	1.76	21	0.10
	d	0.3	<0.04	0.31	223	119	3	<5	8	8	1.61	17	0.07
	e	0.3	<0.04	0.50	202	142	3	<5	6	7	1.89	25	0.11
Baba The Baba river n = 4	a	0.2	<0.04	0.03	46	48	<3	<5	<5	<5	0.41	1	<0.02
	b	0.5	<0.04	0.07	81	122	4	<5	<5	97	0.58	2	<0.02
	c	0.4	<0.04	0.05	56	84	<3	<5	<5	43	0.51	2	<0.02
	d	0.3	<0.04	0.05	54	79	<3	<5	<5	22	0.51	2	<0.02
	e	0.4	<0.04	0.05	48	82	<3	<5	<5	36	0.53	2	<0.02
Bachol The Bachol river n = 8	a	<0.1	<0.04	0.06	43	34	<3	<5	<5	<5	0.89	9	<0.02
	b	1.0	<0.04	1.64	74	64	<3	<5	<5	38	3.02	24	<0.02
	c	0.4	<0.04	0.27	55	54	<3	<5	<5	10	1.97	13	<0.02
	d	0.3	<0.04	0.10	54	53	<3	<5	<5	5	1.84	12	<0.02
	e	0.4	<0.04	0.07	54	55	<3	<5	<5	<5	1.92	11	<0.02
Biała Przemsza The Biała Przemsza river n = 7	a	<0.1	<0.04	0.02	59	75	<3	<5	<5	<5	0.39	2	<0.02
	b	0.6	<0.04	0.44	308	149	13	<5	374	8	2.81	14	<0.02
	c	0.3	<0.04	0.13	160	118	6	<5	56	<5	1.36	6	<0.02
	d	0.2	<0.04	0.09	136	115	4	<5	5	<5	1.04	5	<0.02
	e	0.2	<0.04	0.09	127	112	5	<5	<5	<5	0.69	5	<0.02
Bobrek The Bobrek river n = 4	a	0.2	<0.04	0.08	99	101	<3	<5	<5	<5	1.10	4	<0.02
	b	0.5	<0.04	0.26	150	116	<3	<5	18	8	1.67	28	0.03
	c	0.3	<0.04	0.20	127	111	<3	<5	7	6	1.46	21	0.03
	d	0.3	<0.04	0.18	125	110	<3	<5	5	6	1.44	16	0.02
	e	0.3	<0.04	0.23	130	113	<3	<5	<5	8	1.53	26	0.03
Brynica The Brynica river n = 13	a	<0.1	<0.04	<0.02	37	65	<3	<5	<5	<5	0.37	2	<0.02
	b	0.8	<0.04	0.62	206	262	63	<5	18	27	2.83	23	0.07
	c	0.3	<0.04	0.21	103	124	6	<5	<5	7	1.17	11	0.02
	d	0.2	<0.04	0.10	94	113	<3	<5	<5	5	1.01	9	<0.02
	e	0.2	<0.04	0.07	84	101	<3	<5	<5	5	1.14	7	<0.02

c.d. tab. V

Hg	Mg	Mn	Ni	P	Pb	S	Sr	Ti	V	Zn
I ODRY RIVER CATCHMENT										
<0.05	0.01	4	<1	<0.005	<5	<0.005	1	6	1	17
8.62	5.54	21 295	583	3.961	43 878	1.519	760	3439	67	407 501
0.13	0.22	551	14	0.111	312	0.124	38	54	14	1 277
<0.05	0.12	269	10	0.069	66	0.059	23	39	12	269
0.06	0.12	293	11	0.068	55	0.048	22	41	13	236
<0.05	0.01	22	2	0.005	8	0.006	4	10	2	25
0.07	0.34	1 377	19	0.116	268	0.112	39	189	28	454
<0.05	0.08	254	5	0.027	64	0.039	13	41	7	174
<0.05	0.06	131	4	0.019	40	0.032	11	30	6	124
<0.05	0.05	123	4	0.018	51	0.036	11	30	5	170
<0.05	0.01	6	1	<0.005	<5	<0.005	1	7	<1	11
10.50	5.60	21 023	64	0.562	20 296	1.605	510	266	64	24 555
0.20	0.34	945	17	0.075	578	0.202	58	67	19	1 710
0.07	0.18	341	13	0.051	130	0.088	33	53	16	445
0.07	0.19	364	15	0.054	121	0.086	40	57	17	416
<0.05	0.01	14	1	0.011	6	0.009	3	8	2	21
0.09	0.48	874	24	0.079	669	0.075	153	90	29	915
<0.05	0.14	193	10	0.042	77	0.032	19	24	12	153
<0.05	0.09	119	7	0.037	35	0.025	11	19	10	87
<0.05	0.10	144	7	0.039	34	0.020	11	17	11	87
<0.05	<0.01	<1	<1	<0.005	<5	<0.005	<1	<1	<1	<1
11.00	10.62	63 719	1298	5.866	43 878	8.610	7628	5345	427	407 500
0.12	0.17	506	11	0.102	68	0.113	40	42	9	247
<0.05	0.11	255	6	0.064	15	0.047	21	31	7	73
0.05	0.11	274	6	0.059	13	0.040	20	30	7	62

Tabela VI

w wodach powierzchniowych Górnego Śląska
Ba, Cd, Co, Cr, Cu, Mn, Ni, Sr, Ti, V, Zn w ppb (µg/l)
in surface waters of Upper Silesia
Ba, Cd, Co, Cr, Cu, Mn, Ni, Sr, Ti, V, Zn in ppb (µg/l)

Mg	Mn	Na	Ni	P	Pb	SiO_2	SO_4	Sr	Ti	V	Zn
0.2	1	1	<8	<0.04	<0.03	0.3	3	4	<5	<8	5
833.8	16 829	5723	194	45.12	1.87	82.5	7085	26 078	76	72	13 198
25.8	481	138	<8	1.09	0.08	12.2	162	621	7	<8	208
14.1	186	28	<8	0.31	0.04	10.2	85	310	5	<8	96
12.7	213	21	<8	0.26	<0.03	11.7	81	253	6	<8	86
WISŁY RIVER CATCHMENT											
4.0	59	11	<8	0.08	<0.03	0.7	36	154	<5	<8	30
106.5	494	1210	30	1.41	0.29	11.4	271	3 289	13	<8	948
64.7	379	736	16	0.81	0.06	8.3	174	1 913	6	<8	184
47.2	341	439	15	0.67	0.03	7.1	139	1 459	5	<8	127
77.9	426	869	15	0.74	<0.03	9.1	214	2 124	6	<8	106
8.1	22	7	<8	0.14	0.06	6.8	43	67	8	<8	140
21.0	37	13	<8	0.51	0.14	8.4	222	164	20	<8	619
15.9	29	9	<8	0.27	0.09	7.8	105	100	15	<8	271
14.8	29	9	<8	0.24	0.08	7.7	84	94	14	<8	218
17.2	29	8	<8	0.21	0.08	7.9	78	84	15	<8	162
7.2	256	12	<8	0.21	<0.03	12.2	22	102	<5	<8	34
9.9	1 490	125	13	24.28	0.18	44.3	37	217	16	<8	1 204
8.8	615	30	<8	3.37	0.06	19.9	28	169	9	<8	273
8.8	529	20	<8	0.60	0.04	18.1	28	164	8	<8	109
9.2	470	17	<8	0.38	0.03	14.9	28	175	8	<8	72
2.6	32	3	<8	<0.04	<0.03	7.4	50	95	<5	<8	37
51.4	221	26	12	1.15	0.57	12.8	355	259	35	9	1 823
29.1	116	20	<8	0.37	0.22	10.3	192	190	13	<8	802
18.8	91	17	<8	0.19	0.12	10.1	137	181	7	<8	311
34.5	82	22	<8	0.27	0.06	11.3	169	223	5	<8	144
28.6	242	62	<8	0.19	0.05	8.2	131	934	<5	<8	176
33.2	577	230	194	4.17	0.25	10.7	247	1 274	5	<8	252
31.5	336	187	55	1.87	0.12	8.9	204	1 067	<5	<8	224
31.5	313	165	17	1.18	0.10	8.8	198	1 059	<5	<8	221
32.1	262	227	11	1.57	0.09	8.4	219	1 029	<5	<8	233
4.7	15	8	<8	<0.04	<0.03	6.0	72	127	<5	<8	55
111.7	998	476	20	4.73	0.40	12.1	804	1 344	15	<8	6 147
36.5	279	138	<8	1.17	0.09	8.9	256	525	6	<8	740
20.7	155	51	<8	0.26	0.06	8.6	171	347	<5	<8	258
20.6	139	17	<8	0.14	0.07	8.3	112	194	<5	<8	182

		Al	As	B	Ba	Ca	Cd	Co	Cr	Cu	Fe	K	Li
Chechło	a	0.1	<0.04	0.08	71	50	<3	<5	<5	<5	0.47	4	<0.02
The Chechło river	b	0.4	<0.04	0.18	98	135	10	<5	<5	15	2.10	8	<0.02
n = 5	c	0.2	<0.04	0.14	86	111	<3	<5	<5	6	1.11	6	<0.02
	d	0.2	<0.04	0.13	85	105	<3	<5	<5	<5	0.88	6	<0.02
	e	0.1	<0.04	0.15	92	126	<3	<5	<5	<5	0.60	6	<0.02
Czarna Przemsza	a	<0.1	<0.04	0.04	42	33	<3	<5	<5	<5	0.42	3	<0.02
The Czarna Przemsza river	b	1.0	<0.04	0.51	444	170	<3	<5	31	50	6.57	14	0.04
n = 23	c	0.3	<0.04	0.19	120	92	<3	<5	<5	11	1.46	9	<0.02
	d	0.2	<0.04	0.13	106	88	<3	<5	<5	7	1.10	8	<0.02
	e	0.1	<0.04	0.17	99	88	<3	<5	<5	8	1.09	10	<0.02
Dulówka	a	0.2	<0.04	0.05	110	76	<3	<5	<5	<5	0.50	4	<0.02
The Dulówka river	b	1.0	<0.04	0.12	138	121	<3	<5	<5	<5	1.01	8	<0.02
n = 5	c	0.5	<0.04	0.08	125	100	<3	<5	<5	<5	0.65	5	<0.02
	d	0.4	<0.04	0.08	124	98	<3	<5	<5	<5	0.63	5	<0.02
	e	0.3	<0.04	0.08	123	106	<3	<5	<5	<5	0.55	5	<0.02
Gostynia	a	<0.1	<0.04	0.56	42	99	<3	<5	<5	5	0.86	21	0.11
The Gostynia river	b	0.5	<0.04	1.55	153	373	<3	9	<5	219	2.71	92	0.67
n = 5	c	0.2	<0.04	1.03	89	186	<3	<5	<5	50	1.73	53	0.37
	d	0.2	<0.04	0.94	76	163	<3	<5	<5	15	1.58	45	0.30
	e	0.2	<0.04	1.02	56	151	<3	<5	<5	7	1.71	47	0.39
Korzeniec	a	<0.1	<0.04	0.06	50	38	<3	<5	<5	<5	0.54	4	<0.02
The Korzeniec river	b	0.7	<0.04	0.08	66	53	<3	8	<5	<5	93.44	11	<0.02
n = 5	c	0.3	<0.04	0.07	57	44	<3	<5	<5	<5	19.48	6	<0.02
	d	0.2	<0.04	0.07	57	44	<3	<5	<5	<5	2.24	6	<0.02
	e	0.2	<0.04	0.08	55	44	<3	<5	<5	<5	0.85	5	<0.02
Kozi Bród	a	<0.1	<0.04	0.04	45	62	<3	<5	<5	<5	0.13	2	<0.02
The Kozi Bród river	b	0.5	<0.04	3.63	195	153	7	<5	4445	20	0.88	16	0.13
n = 9	c	0.2	<0.04	1.43	87	118	<3	<5	559	9	0.42	12	0.06
	d	0.2	<0.04	0.70	78	113	<3	<5	10	7	0.33	10	0.05
	e	0.1	<0.04	0.80	79	118	<3	<5	<5	8	0.27	15	0.06
Mitręga	a	<0.1	<0.04	0.03	45	88	<3	<5	<5	<5	0.50	2	<0.02
The Mitręga river	b	0.4	<0.04	0.19	592	113	<3	<5	<5	10	5.35	11	<0.02
n = 8	c	0.2	<0.04	0.14	135	99	<3	<5	<5	<5	1.58	8	<0.02
	d	0.1	<0.04	0.12	88	99	<3	<5	<5	<5	1.11	7	<0.02
	e	0.2	<0.04	0.15	73	101	<3	<5	<5	<5	0.87	9	<0.02
Mleczna	a	0.2	<0.04	0.26	82	70	<3	<5	<5	<5	0.75	14	<0.02
The Mleczna river	b	0.6	<0.04	0.99	1431	158	4	<5	6	13	2.10	30	0.18
n = 6	c	0.3	<0.04	0.62	637	97	<3	<5	<5	8	1.39	20	0.08
	d	0.3	<0.04	0.56	425	93	<3	<5	<5	7	1.29	19	0.05
	e	0.3	<0.04	0.67	390	80	<3	<5	<5	9	1.45	18	0.08
Pszczynka	a	0.1	<0.04	0.05	61	44	<3	<5	<5	<5	0.95	8	<0.02
The Pszczynka river	b	0.7	<0.04	0.13	112	118	<3	<5	<5	33	3.32	23	0.32
n = 9	c	0.4	<0.04	0.07	88	65	<3	<5	<5	7	1.94	13	0.05
	d	0.3	<0.04	0.07	87	62	<3	<5	<5	<5	1.79	12	<0.02
	e	0.3	<0.04	0.06	92	57	<3	<5	<5	<5	2.23	11	<0.02
Sztoła	a	<0.1	<0.04	<0.02	51	57	<3	<5	<5	<5	0.11	<1	<0.02
The Sztoła river	b	0.8	<0.04	0.04	199	121	20	<5	<5	<5	2.80	2	<0.02
n = 5	c	0.4	<0.04	0.02	102	90	7	<5	<5	<5	1.03	1	<0.02
	d	0.3	<0.04	0.02	92	86	4	<5	<5	<5	0.64	1	<0.02
	e	0.4	<0.04	0.03	94	93	4	<5	<5	<5	0.61	1	<0.02
Trzebyczka	a	<0.1	<0.04	0.07	114	97	<3	<5	<5	5	0.12	3	<0.02
The Trzebyczka river	b	0.1	<0.04	0.18	153	106	<3	<5	<5	266	0.23	6	<0.02
n = 4	c	<0.1	<0.04	0.13	136	102	<3	<5	<5	71	0.18	5	<0.02
	d	<0.1	<0.04	0.12	135	101	<3	<5	<5	16	0.17	5	<0.02
	e	0.1	<0.04	0.13	139	102	<3	<5	<5	7	0.18	6	<0.02
													ZLEWNIA THE ODRA
Bierawka	a	<0.1	<0.04	0.19	35	83	<3	<5	<5	<5	0.94	13	0.02
The Bierawka river	b	0.4	<0.04	1.18	186	227	<3	7	12	13	2.32	91	0.63
n = 9	c	0.2	<0.04	0.62	100	137	<3	<5	<5	7	1.57	49	0.31
	d	0.2	<0.04	0.49	85	128	<3	<5	<5	7	1.52	38	0.15
	e	0.2	<0.04	0.72	92	119	<3	<5	<5	6	1.66	46	0.28
Brzeźnica	a	<0.1	<0.04	0.06	54	67	<3	<5	<5	<5	0.49	7	<0.02
The Brzeźnica river	b	0.1	<0.04	0.12	90	86	<3	<5	<5	302	1.21	22	<0.02
n = 5	c	<0.1	<0.04	0.07	72	74	<3	<5	<5	62	0.80	14	<0.02
	d	<0.1	<0.04	0.07	71	74	<3	<5	<5	7	0.77	13	<0.02
	e	<0.1	<0.04	0.06	78	71	<3	<5	<5	<5	0.76	14	<0.02
Bytomka	a	0.1	<0.04	0.47	51	138	<3	<5	<5	<5	1.04	24	0.09
The Bytomka river	b	0.4	<0.04	0.86	153	207	<3	<5	31	22	2.02	33	0.15
n = 7	c	0.3	<0.04	0.63	120	159	<3	<5	7	13	1.43	28	0.11
	d	0.3	<0.04	0.62	115	158	<3	<5	<5	11	1.39	28	0.11
	e	0.3	<0.04	0.59	126	153	<3	<5	<5	14	1.35	30	0.11

Mg	Mn	Na	Ni	P	Pb	SiO_2	SO_4	Sr	Ti	V	Zn
5.9	166	10	<8	0.04	<0.03	9.7	70	159	<5	<8	169
73.9	365	40	10	1.15	0.70	11.9	388	385	9	<8	1720
48.0	235	31	<8	0.59	0.21	10.5	243	302	<5	<8	740
36.4	224	28	<8	0.34	0.10	10.5	211	290	<5	<8	503
52.0	193	39	9	0.56	0.07	10.2	250	320	<5	<8	446
2.0	40	3	<8	0.05	<0.03	2.2	28	59	<5	<8	26
36.9	434	313	10	3.52	0.25	14.5	219	994	27	<8	897
20.8	233	52	<8	1.07	0.08	9.1	111	356	6	<8	155
18.2	203	33	<8	0.52	0.05	8.6	100	274	<5	<8	104
18.8	236	39	<8	0.64	0.04	9.2	82	218	<5	<8	88
16.5	32	8	<8	0.16	<0.03	12.1	73	250	7	<8	55
24.2	166	11	<8	0.56	0.13	15.3	138	964	31	<8	836
20.9	85	9	<8	0.30	0.04	14.1	99	505	14	<8	250
20.7	74	9	<8	0.27	0.03	14.0	96	434	12	<8	145
21.8	82	9	<8	0.30	<0.03	14.2	83	358	10	<8	105
12.4	428	146	<8	0.40	<0.03	7.5	197	718	<5	<8	58
364.1	1032	1718	20	2.29	0.03	12.2	885	7782	8	24	198
91.1	704	573	11	1.25	<0.03	9.4	514	2668	<5	8	107
36.9	669	385	9	1.05	<0.03	9.3	456	1859	<5	<8	98
20.8	595	356	13	1.10	<0.03	9.0	564	1614	<5	<8	94
6.6	27	23	<8	<0.04	<0.03	5.6	41	178	<5	<8	38
9.4	840	36	<8	0.43	<0.03	16.6	75	403	6	<8	83
7.6	364	30	<8	0.23	<0.03	8.9	52	279	<5	<8	64
7.5	190	30	<8	0.15	<0.03	8.3	50	269	<5	<8	62
7.2	309	31	<8	0.29	<0.03	7.1	45	263	<5	<8	62
12.0	10	6	<8	0.07	0.08	9.2	73	199	<5	<8	26
84.2	89	71	<8	0.53	0.23	13.1	599	704	17	<8	323
57.4	43	29	<8	0.30	0.12	12.2	436	507	8	<8	119
47.3	32	23	<8	0.26	0.11	12.1	349	484	6	<8	85
65.7	46	28	<8	0.25	0.10	12.5	525	542	6	<8	91
4.3	60	7	<8	0.12	<0.03	8.0	65	112	<5	<8	20
19.1	342	29	<8	1.02	0.04	13.4	97	315	11	<8	1743
14.3	135	21	<8	0.34	<0.03	10.7	87	259	5	<8	334
13.3	116	19	<8	0.26	<0.03	10.5	86	249	<5	<8	150
15.8	97	23	<8	0.21	<0.03	11.2	91	274	<5	<8	143
16.3	331	47	<8	0.49	<0.03	8.4	72	343	<5	<8	39
91.2	522	993	9	4.32	0.41	12.9	248	3940	10	<8	199
45.4	383	489	<8	1.60	0.15	10.6	148	1679	7	<8	100
37.2	378	325	<8	1.17	0.06	10.5	136	1161	6	<8	83
39.6	357	496	<8	0.89	0.04	10.6	126	1221	8	<8	74
6.6	138	12	<8	0.24	<0.03	8.1	51	192	<5	<8	29
47.5	843	1062	<8	3.04	0.06	15.8	679	1282	18	<8	162
14.6	482	168	<8	0.74	0.03	11.7	148	393	8	<8	86
12.1	418	64	<8	0.51	0.03	11.5	100	326	6	<8	73
11.0	433	58	<8	0.42	<0.03	10.6	81	310	5	<8	89
18.6	20	1	<8	<0.04	<0.03	6.7	54	54	<5	<8	39
24.5	127	9	<8	0.44	0.60	11.9	114	121	47	<8	2342
22.0	49	5	<8	0.13	0.20	8.6	82	98	17	<8	780
21.8	38	4	<8	0.07	0.11	8.4	79	95	11	<8	374
23.1	34	7	<8	0.06	0.09	8.1	88	109	13	<8	518
31.3	10	22	<8	0.06	<0.03	3.5	102	532	<5	<8	57
33.1	285	52	<8	0.14	0.06	8.0	136	605	<5	<8	185
32.6	107	38	<8	0.09	0.03	6.1	117	573	<5	<8	108
32.6	49	36	<8	0.09	<0.03	5.8	117	572	<5	<8	98
33.0	66	38	<8	0.09	<0.03	6.5	116	578	<5	<8	94
ODRY RIVER CATCHMENT											
24.2	299	55	<8	0.48	<0.03	9.9	208	279	<5	<8	45
182.9	789	3170	15	4.33	0.14	12.1	696	4839	7	<8	337
89.4	522	1486	9	1.89	0.06	11.2	428	2254	<5	<8	120
66.9	498	517	<8	1.46	0.04	11.1	381	1223	<5	<8	101
80.3	567	1721	11	2.11	<0.03	11.3	470	2181	<5	<8	99
11.4	77	12	<8	0.25	0.06	3.4	48	191	<5	<8	31
29.2	403	20	<8	2.47	0.09	14.9	62	374	<5	<8	246
16.7	202	15	<8	0.80	0.07	7.5	58	263	<5	<8	87
15.6	171	15	<8	0.52	0.07	6.7	57	256	<5	<8	64
14.5	206	14	<8	0.39	0.07	6.5	59	246	<5	<8	52
56.9	298	302	<8	1.19	0.07	11.7	390	1078	<5	<8	96
104.6	1015	653	8	3.43	0.23	14.0	844	1694	11	<8	299
72.9	442	484	<8	2.67	0.15	13.2	535	1332	8	<8	234
71.5	403	472	<8	2.53	0.14	13.2	520	1315	7	<8	221
69.2	353	441	<8	2.96	0.13	13.2	516	1265	9	<8	251

		Al	As	B	Ba	Ca	Cd	Co	Cr	Cu	Fe	K	Li
Drama	a	0.1	<0.04	0.05	40	69	<3	<5	<5	<5	0.27	6	<0.02
The Drama river	b	0.6	<0.04	0.34	89	118	<3	<5	<5	8	0.89	20	0.03
n = 6	c	0.3	<0.04	0.23	61	91	<3	<5	<5	6	0.57	14	<0.02
	d	0.2	<0.04	0.19	59	89	<3	<5	<5	<5	0.53	13	<0.02
	e	0.2	<0.04	0.29	61	83	<3	<5	<5	7	0.61	15	<0.02
Kłodnica	a	0.3	<0.04	0.15	95	82	<3	<5	<5	6	1.52	13	<0.02
The Kłodnica river	b	0.7	<0.04	0.61	213	206	4	<5	17	21	7.58	51	0.24
n = 9	c	0.4	<0.04	0.41	138	138	<3	<5	6	11	3.03	31	0.13
	d	0.4	<0.04	0.38	133	133	<3	<5	<5	10	2.67	28	0.10
	e	0.3	<0.04	0.38	137	151	<3	<5	5	10	2.34	33	0.16
Mała Panew	a	<0.1	<0.04	0.05	120	46	<3	<5	<5	<5	0.63	5	<0.02
The Mała Panew river	b	0.5	<0.04	0.43	435	90	35	8	<5	41	22.50	13	<0.02
n = 6	c	0.3	<0.04	0.21	247	62	15	<5	<5	19	5.36	7	<0.02
	d	0.3	<0.04	0.14	217	61	7	<5	<5	11	2.66	7	<0.02
	e	0.4	<0.04	0.17	225	62	12	<5	<5	18	2.15	6	<0.02
Rokitnica	a	0.1	<0.04	0.13	70	134	<3	<5	<5	5	0.46	11	0.03
The Rokitnica river	b	0.3	<0.04	0.75	128	272	<3	11	<5	34	0.85	72	1.05
n = 5	c	0.2	<0.04	0.52	98	169	<3	<5	<5	15	0.66	59	0.83
	d	0.2	<0.04	0.45	96	162	<3	<5	<5	12	0.64	49	0.51
	e	0.2	<0.04	0.58	98	139	<3	<5	<5	8	0.67	71	1.02
Ruda	a	0.1	<0.04	0.04	75	54	<3	<5	<5	<5	0.47	11	<0.02
The Ruda river	b	0.4	<0.04	0.86	233	126	<3	<5	<5	22	9.61	24	0.14
n = 5	c	0.3	<0.04	0.39	125	81	<3	<5	<5	12	2.91	18	0.06
	d	0.2	<0.04	0.23	115	76	<3	<5	<5	8	1.70	17	0.03
	e	0.3	<0.04	0.34	101	67	<3	<5	<5	14	1.49	18	0.03
Stoła	a	<0.1	<0.04	0.18	107	71	<3	<5	<5	7	0.92	9	<0.02
The Stoła river	b	0.2	<0.04	3.23	577	116	33	<5	23	47	2.14	18	<0.02
n = 9	c	0.1	<0.04	1.79	408	95	7	<5	6	27	1.29	12	<0.02
	d	0.1	<0.04	1.33	362	94	4	<5	<5	23	1.26	11	<0.02
	e	0.1	<0.04	1.64	453	99	3	<5	<5	28	1.26	10	<0.02
Warta	a	<0.1	<0.04	0.09	57	61	<3	<5	<5	<5	0.40	6	<0.02
The Warta river	b	0.9	<0.04	0.20	213	86	<3	<5	13	11	5.04	11	<0.02
n = 10	c	0.3	<0.04	0.15	103	77	<3	<5	<5	6	1.41	9	<0.02
	d	0.2	<0.04	0.14	95	76	<3	<5	<5	5	1.08	9	<0.02
	e	0.2	<0.04	0.14	91	81	<3	<5	<5	7	0.95	9	<0.02
ZLEWNIA WISŁY THE VISTULA AND ODRA													
Strumienie, rowy i cieki	a	<0.1	<0.04	<0.02	2	3	<3	<5	<5	<5	<0.02	<1	<0.02
bez nazwy	b	1.2	0.07	5.37	3470	6400	238	85	92	441	71.39	256	2.11
Unnamed streams, ditches	c	0.3	<0.04	0.23	118	110	<3	<5	<5	9	2.23	17	0.05
and rivulets	d	0.2	<0.04	0.10	87	81	<3	<5	<5	5	1.19	9	<0.02
n = 546	e	0.3	<0.04	0.10	83	82	<3	<5	<5	5	1.14	9	<0.02
Sztuczne zbiorniki (zalewy)	a	<0.1	<0.04	0.03	37	25	<3	<5	<5	<5	0.13	3	<0.02
Artificial lakes	b	1.0	<0.04	1.32	337	178	8	<5	55	12	4.56	40	0.21
n = 19	c	0.3	<0.04	0.20	93	62	<3	<5	5	6	1.11	9	0.03
	d	0.2	<0.04	0.11	80	55	<3	<5	<5	5	0.80	7	<0.02
	e	0.2	<0.04	0.09	75	54	<3	<5	<5	6	0.75	6	<0.02
Małe zbiorniki wodne bez naz-	a	<0.1	<0.04	<0.02	28	20	<3	<5	<5	<5	0.13	1	<0.02
wy (sadzawki, jeziorka, stawy)	b	0.9	1.71	7.92	1723	739	23	136	67	178	13.70	473	2.78
Unnamed small reservoirs (pools,	c	0.3	0.04	0.34	142	101	<3	<5	<5	8	1.35	23	0.06
lakes, ponds)	d	0.2	<0.04	0.13	105	76	<3	<5	<5	<5	0.87	11	<0.02
n = 81	e	0.2	<0.04	0.13	99	64	<3	<5	<5	<5	0.89	9	<0.02
Stawy rybne	a	0.1	<0.04	<0.02	29	11	<3	<5	<5	<5	0.48	<1	<0.02
Fish ponds	b	1.0	<0.04	0.19	213	71	<3	<5	18	76	4.04	16	<0.02
n = 13	c	0.4	<0.04	0.06	89	46	<3	<5	<5	10	1.81	6	<0.02
	d	0.3	<0.04	0.05	78	41	<3	<5	<5	<5	1.52	4	<0.02
	e	0.4	<0.04	0.04	76	40	<3	<5	<5	<5	1.55	6	<0.02
Wody powierzchniowe Polski	a	<0.1	<0.04	<0.02	<1	3	<3	<5	<5	<5	<0.02	<1	<0.02
Surface waters of Poland	b	1.2	6.77	12.87	3470	6400	238	136	4445	3732	438.72	473	2.78
n = 12 955	c	0.2	<0.04	0.08	66	92	<3	<5	<5	7	1.00	9	<0.02
	d	0.1	<0.04	0.04	55	79	<3	<5	<5	<5	0.52	5	<0.02
	e	0.1	<0.04	0.04	54	83	<3	<5	<5	<5	0.52	5	<0.02

a – minimum; minimum b – maksimum; maximum c – średnia arytmetyczna; arithmetic mean d – średnia geometryczna; geometric mean e – mediana; median n – liczba próbek; number of samples

Mg	Mn	Na	Ni	P	Pb	SiO_2	SO_4	Sr	Ti	V	Zn
19.9	23	20	<8	0.36	<0.03	7.7	79	247	<5	<8	81
25.6	86	72	<8	4.74	<0.05	16.2	147	817	15	10	448
23.2	57	53	<8	2.47	0.04	12.6	101	433	7	<8	178
23.1	52	48	<8	1.79	0.04	12.3	98	380	5	<8	147
23.5	58	61	<8	2.08	0.05	12.6	91	284	6	<8	131
13.9	422	62	<8	1.79	0.04	7.5	86	270	6	<8	72
95.7	2582	1734	10	2.99	0.43	21.2	493	3261	17	<8	290
61.8	816	753	<8	2.39	0.24	12.5	303	1617	10	<8	178
53.0	662	564	<8	2.36	0.18	12.0	262	1350	9	<8	159
78.4	471	806	<8	2.34	0.25	12.5	320	1731	8	<8	187
5.0	133	11	<8	<0.04	0.08	8.6	71	214	<5	<8	78
14.6	830	70	20	0.86	0.15	18.0	99	623	8	<8	579
10.8	318	33	9	0.48	0.11	13.5	84	406	<5	<8	381
10.2	260	28	<8	0.31	0.11	13.2	84	378	<5	<8	309
11.5	242	28	<8	0.54	0.11	14.0	85	400	<5	<8	466
29.7	166	217	<8	0.18	0.11	14.5	217	915	<5	<8	61
281.8	413	353	<8	3.65	0.27	16.0	1723	1875	8	31	125
85.3	266	307	<8	2.05	0.20	15.2	674	1201	5	14	91
53.8	255	302	<8	1.14	0.19	15.2	526	1155	<5	10	88
34.1	248	315	<8	2.97	0.24	15.1	476	963	6	13	94
12.2	179	19	<8	0.55	<0.03	1.6	53	200	<5	<8	41
53.0	1760	729	10	1.53	0.14	19.4	446	1793	11	<8	122
27.3	569	325	<8	1.05	0.06	9.4	205	882	6	<8	72
22.3	383	170	<8	0.99	0.04	7.1	142	647	5	<8	66
15.9	277	170	8	1.08	<0.03	7.1	122	562	7	<8	57
15.2	153	41	<8	3.32	0.07	14.2	87	395	<5	<8	183
25.7	287	264	20	7.07	0.14	17.7	147	932	10	<8	1040
21.4	213	140	9	4.23	0.10	15.4	112	567	<5	<8	518
21.2	210	110	<8	4.13	0.09	15.3	109	551	<5	<8	450
21.1	213	144	9	3.96	0.09	14.9	105	556	<5	<8	463
8.3	47	25	<8	0.10	<0.03	2.9	83	129	<5	<8	36
24.8	509	59	23	2.96	0.13	11.5	101	257	15	<8	2017
17.7	227	39	<8	1.33	0.04	9.0	92	180	6	<8	333
16.9	178	38	<8	0.79	0.03	8.5	92	177	<5	<8	168
18.9	196	38	<8	1.21	0.03	10.4	93	171	<5	<8	149
I ODRY RIVER CATCHMENT											
0.2	1	1	<8	<0.04	<0.03	0.7	4	4	<5	<8	5
833.8	120956	5723	100	45.12	1.87	82.5	7085	26078	76	72	13198
26.5	658	130	<8	1.41	0.07	14.1	174	665	8	<8	222
13.6	220	28	<8	0.37	0.04	12.4	91	302	6	<8	106
12.4	252	22	<8	0.30	<0.03	13.5	88	257	6	<8	97
4.0	21	6	<8	<0.04	<0.03	1.1	39	140	<5	<8	22
85.1	540	907	8	3.16	0.42	12.8	503	2033	15	<8	390
18.6	233	97	<8	0.40	0.10	4.5	125	383	7	<8	93
12.5	182	23	<8	0.16	0.06	3.4	95	257	6	<8	69
12.0	218	15	<8	0.13	0.05	2.8	89	196	8	<8	56
1.1	10	3	<8	<0.04	<0.03	0.4	3	50	<5	<8	29
267.2	16829	3571	94	6.77	0.75	21.3	3747	25998	30	15	6512
32.2	604	137	<8	0.60	0.12	6.6	217	724	8	<8	229
16.2	252	28	<8	0.20	0.07	4.3	84	295	6	<8	103
12.7	281	21	<8	0.16	0.07	4.5	73	235	6	<8	84
3.4	44	3	<8	0.07	<0.03	0.6	11	50	<5	<8	29
22.6	471	21	<8	0.45	0.14	12.8	119	363	21	<8	279
8.2	174	11	<8	0.24	0.05	3.7	39	179	8	<8	98
7.2	149	9	<8	0.21	<0.04	2.4	31	158	6	<8	72
6.1	164	11	<8	0.22	<0.03	2.2	25	157	6	<8	53
0.2	<1	<1	<8	<0.04	<0.03	<0.3	2	4	<5	<8	<5
833.8	34500	5723	1326	45.12	1.87	83.1	7085	26078	89	243	16414
14.8	247	40	<8	0.59	0.04	13.1	86	374	<5	<8	67
11.5	107	16	<8	0.19	<0.03	10.2	58	263	<5	<8	36
11.6	102	14	<8	0.16	<0.03	12.5	56	243	<5	<8	33

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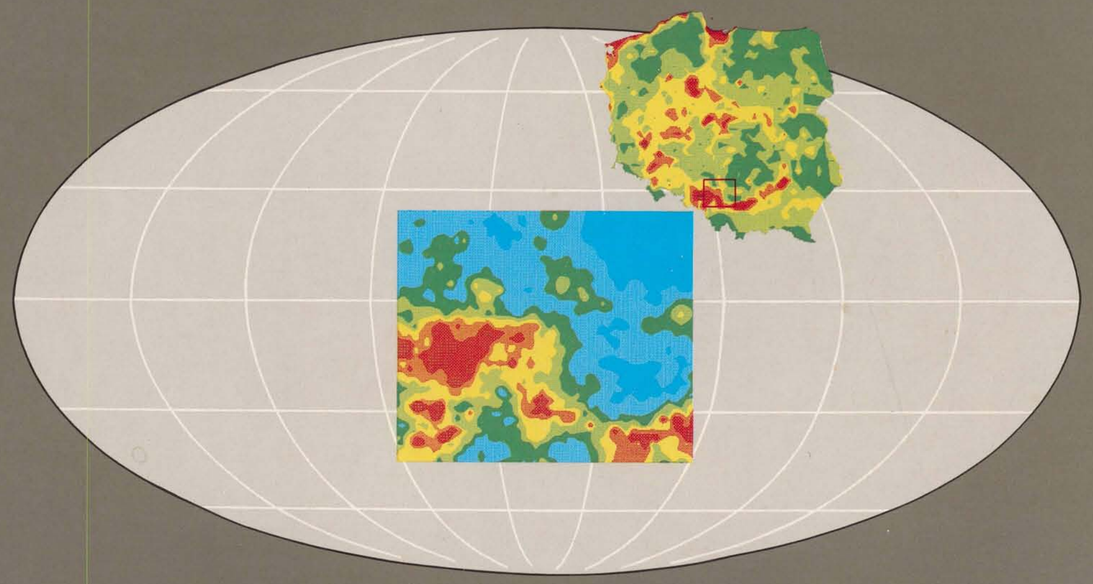
ATLAS GEOCHEMICZNY GÓRNEGO ŚLĄSKA

GEOCHEMICAL ATLAS OF UPPER SILESIA

1:200 000

Józef Lis, Anna Pasieczna



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GEOCHEMIA
GEOCHEMISTRY
Józef LIS, Anna PASIECZNA

OPRÓBOWANIE
SAMPLING
Henryk BIERNAT
(kierownik – manager)

ANALIZY CHEMICZNE
CHEMICAL ANALYSES
Piotr PASŁAWSKI
(kierownik – manager)

GEOLOGIA I ZŁOŻA
GEOLOGY AND DEPOSITS
Stanisław PRZENIOSŁO

PRZETWARZANIE DANYCH
DATA PROCESSING
Grzegorz PRZENIOSŁO, Tomasz GLIWICZ

Praca wykonana na zamówienie
Ministra Ochrony Środowiska, Zasobów Naturalnych i Leśnictwa

Redaktor mgr Barbara SŁOWAŃSKA

Akceptował do druku 10.02.1995 r.
dyrektor Państwowego Instytutu Geologicznego
prof. dr hab. Stanisław SPECZIK

SPIS TABLIC
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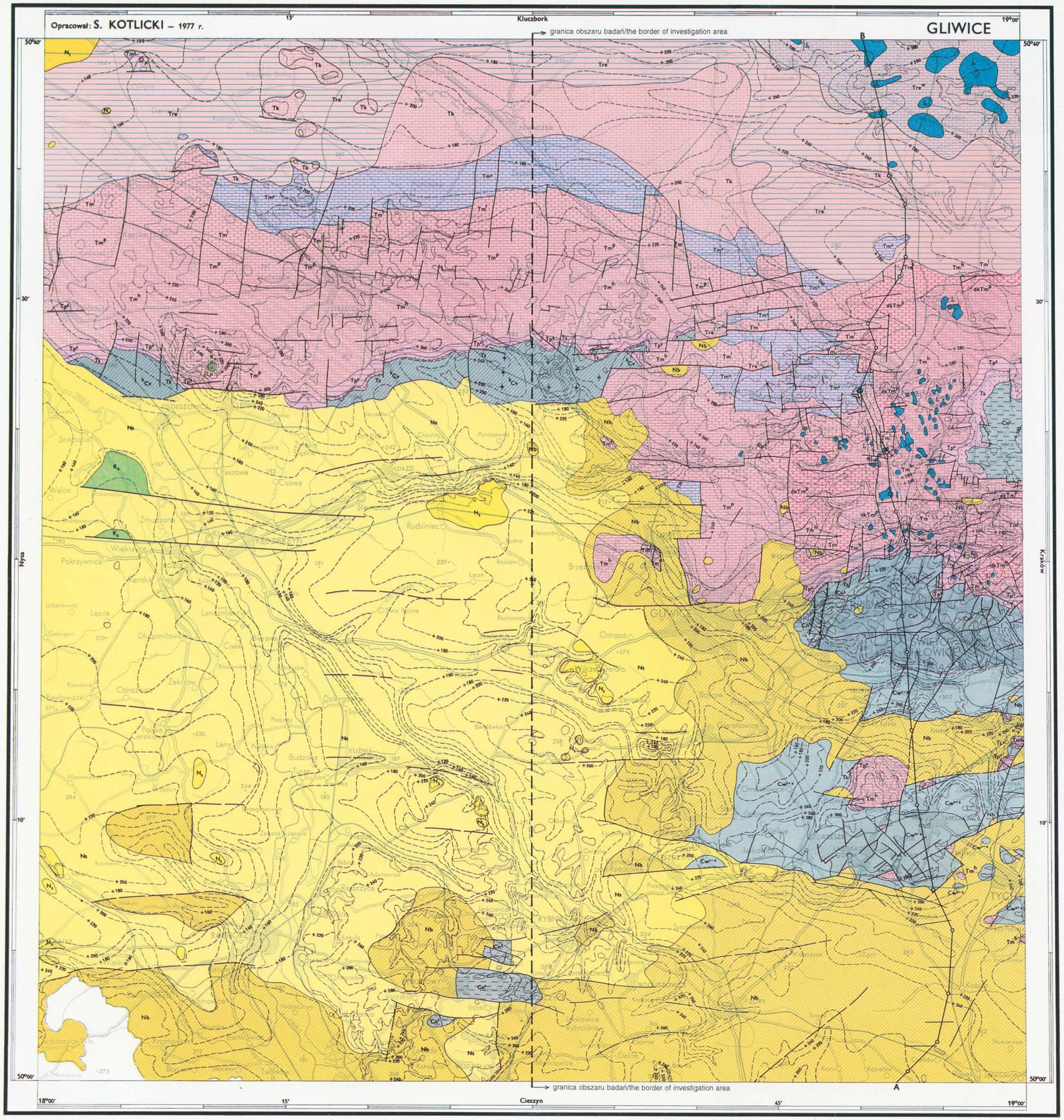
Druk ZPP Polskiej Agencji Ekologicznej S.A. Zlec. D-3.



PAŃSTWOWY
INSTYTUT GEOLOGICZNY

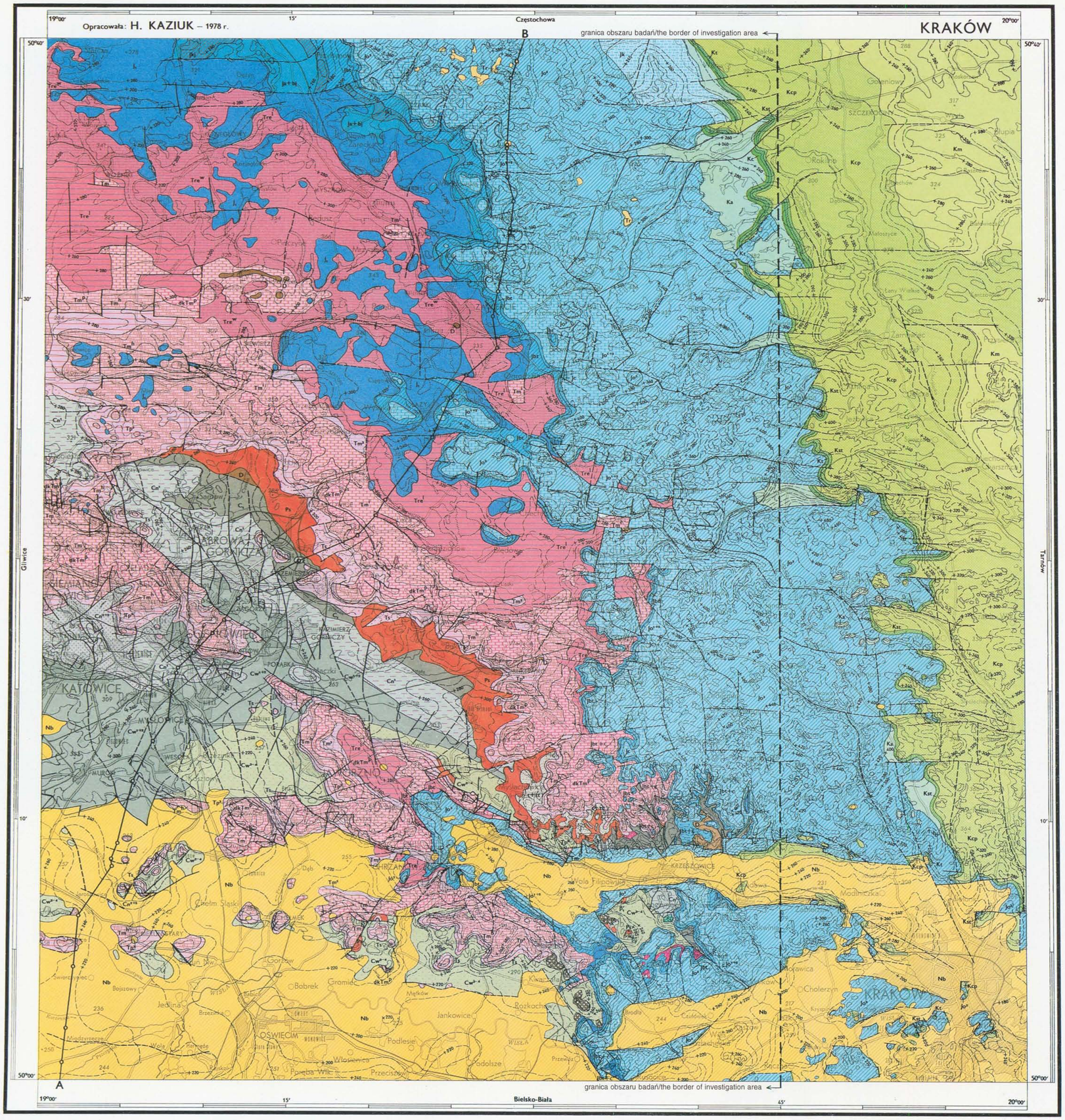
TABLICA
PLATE **A**

MAPA GEOLOGICZNA POLSKI

B – MAPA BEZ UTWORÓW CZWARTORZĘDOWYCH

1 : 200 000

TRZECIORZĘD	NEOGEN	N_3	Żwiry i piaski		PLIOCEN
		N_1	Iły i piaski z lignitem		MIOCEN
		Ns	Iły i piaski z syderytami, miejscami z węglem brunatnym warstw kędzierzyńskich	SARMAT	
		Nb	Iły piaszczyste i margliste, piaski, żwiry i łupki ilaste z gipsem i anhydrytem oraz sole kamienne warstw skawińskich, wielickich i grabowieckich	BADEN	
KREDA	KREDA GÓRNA	K_2	Margle i piaskowce		
JURA	JURA DOLNA	J_1	Żwiry, zlepieńce, piaski, iły i glinki ogniotrwałe		
TRIAS	TRIAS GÓRNY	Tre^w	Iłowce pstre z wapieniami woźnickimi, piaskowce i mułowce		RETYK
		Tre^l	Iłowce pstre z brekcją lisowską		
		Tk	Iłowce i margle z ewaporytami, piaskowce, mułowce i dolomity		KAJPER
	TRIAS ŚRODKOWY	Tm^s	Łupki, dolomity, wapienie i piaskowce warstw rybniańskich, boruszowickich i miedarskich		LADYN
		Tm	Dolomity warstw jemielnickich oraz dolomity margliste, miejscami z ewaporytami, warstw tarnowickich		ANIZYK
		Tm^p	Wapienie i margle warstw gorażdżańskich, terebratulowych i karchowickich		
		$dkTm^p$	Dolomity epigenetyczne — kruszconośne		
		Tm^h	Wapienie, margle i dolomity warstw błotnickich i gogolińskich		
	TRIAS DOLNY	Tp^s	Dolomity, margle i wapienie w części północno-zachodniej z ewaporytami (ret)		
		Ts	Piaskowce, mułowce i iłowce czerwono-brunatne warstw świerklanieckich		
KARBON	KARBON GÓRNY	Cw^{3-2}	Zlepieńce, piaskowce, mułowce i węgiel kamienny warstw łaziskich	ŚRODKOWY I GÓRNY	WESTFAL
		Cw^{1-2}	Iłowce, mułowce i węgiel kamienny warstw załęskich i orzeskich (seria mułowcowa)	DOLNY I ŚRODKOWY	
		Cn^3	Piaskowce, mułowce i węgiel kamienny warstw rudzkich	GÓRNY	NAMUR
		Cn^2	Piaskowce, zlepieńce i węgiel kamienny warstw siodłowych	ŚRODKOWY	
		Cn^1	Iłowce, mułowce, piaskowce i węgiel kamienny warstw pietrzkowickich, gruszowskich, jaklowieckich i porębskich	DOLNY	
		k_{Cv}	Szarogłazy, zlepieńce i łupki kulmu, miejscami łupki i wapienie		WIZEN
		ν	Nefelinity		



PAŃSTWOWY
INSTYTUT GEOLOGICZNY

TABLICA
PLATE **B**

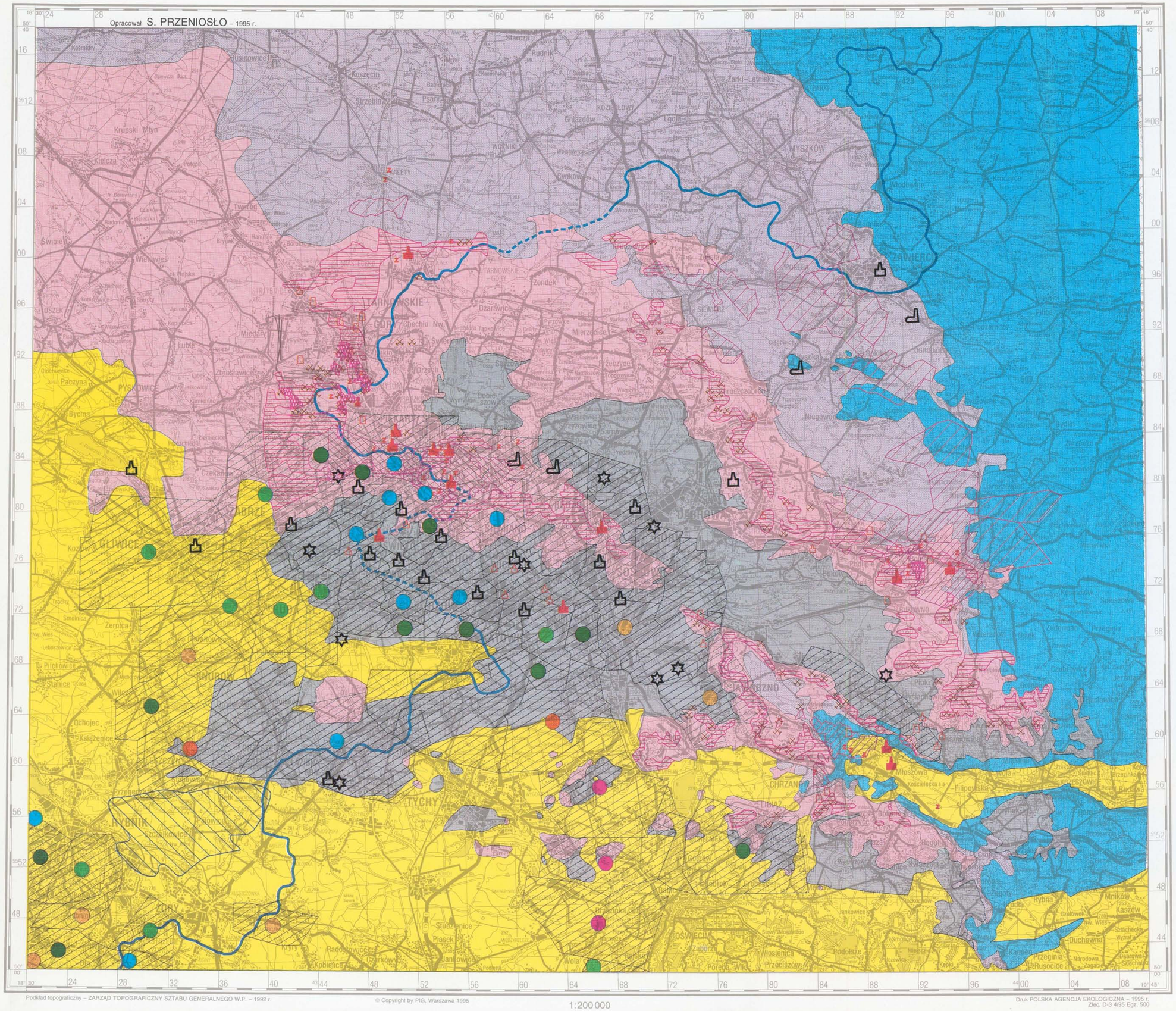
MAPA GEOLOGICZNA POLSKI

B – MAPA BEZ UTWORÓW CZWARTORZĘDOWYCH

1 : 200 000

TRZECIORZĘD	NEOGEN	Tr	Piaski i iły		
		Nb	Iły, mułki, piaski i piaskowce (warstwy skawińskie wielickie i grabowieckie)	BADEN	MIOCEN
KREDA	KREDA GÓRNA	Km	Margle, opoki i gezy		MASTRYCHT
		Kcp	Margle z czertami i wapienie		KAMPAN
		Kst	Margle glaukonitowe		SANTON
		Kt	Wapienie margliste i margle glaukonitowe		TURON
		Kc	Piaski glaukonitowe z fosforytami, piaskowce i zlepieńce		CENOMAN
	KREDA DOLNA	Ka	Piaski kwarcowe słabo glaukonitowe		ALB
JURA	JURA GÓRNA	Jk	Wapienie płytowe i margle		KIMERYD
		Jo^{3}	Wapienie płytowe, skaliste, pylaste i kredowate	GÓRNY	OKSFORD
		Jo^{1-2}	Wapienie płytowe, skaliste i oolitowe oraz margle piaszczyste	DOLNY I ŚRODKOWY	
	JURA ŚRODKOWA	Jc	Margle glaukonitowe i wapienie margliste		KELOWEJ
		Jbt	Iły z wkładkami łupków, mułowców i syderytami oraz zlepieńce		BATON
		Jkj	Iłowce i zlepieńce		KUJAW
		Ja+bj	Piaskowce, iły, zlepieńce i syderyty (warstwy kościeliskie)		AALEN I BAJOS
	JURA DOLNA	Jr	Piaski, piaskowce, żwiry, iły i glinki ogniotrwałe		
TRIAS	TRIAS GÓRNY	Tre^{w}	Iły, iłowce i mułowce z wkładkami wapieni woźnickich		RETYK
		Tre^{l}	Iłowce z brekcją lisowską		
	TRIAS ŚRODKOWY	Tm^{3}	Łupki, dolomity i piaskowce (głównie warstwy boruszowickie)		LADYN
		Tm^{2}	Dolomity margliste (warstwy tarnowickie) i dolomity diploporowe		ANIZYK
		Tm^{p}	Dolomity, wapienie i margle (warstwy górażdżańskie, terebratulowe i karchowickie)		
		$dkTm^{p}$	Dolomity epigenetyczne – kruszconośne		
		Tm^{b}	Wapienie, margle i dolomity (warstwy błotnickie i gogolińskie)		
	TRIAS DOLNY	Tp^{1}	Dolomity i margle		
		Ts	Piaskowce, mułowce i iłowce (warstwy świerklanieckie)		
PERM	CZERWONY SPĄGOWIEC	Ps	Zlepieńce myślachowickie, piaskowce, mułowce, iłowce, arkozy i martwica karniowicka		
KARBON	KARBON GÓRNY	Cw^{3-4}	Piaskowce, zlepieńce, iłowce, mułowce i węgiel kamienny (warstwy łaziskie i libiążskie) oraz piaskowce i piaski arkozowe – krakowska seria piaskowcowa	ŚRODKOWY I GÓRNY	WESTFAL
		Cw^{1+2}	Iłowce, mułowce, piaskowce i węgiel kamienny (warstwy załęskie – seria mułowcowa)	DOLNY I ŚRODKOWY	
		Cn^{2+3}	Piaskowce, mułowce, zlepieńce i węgiel kamienny (warstwy rudzkie i siodłowe – górnośląska seria piaskowcowa)	ŚRODKOWY I GÓRNY	NAMUR
		Cn^{1}	Iłowce, mułowce, piaskowce i węgiel kamienny (warstwy malinowickie, sarnowskie, florowskie i grodzieckie)	DOLNY	
	KARBON DOLNY	C_1	Wapienie przewarstwione marglami i wapienie krystaliczne w facji wapienia węglowego oraz iłowce, mułowce i piaskowce w facji kulmowej		
DEWON		D	Wapienie, dolomity, mułowce, piaskowce i łupki		
		Q	Ryodacyty		
			Diabazy hiperstenowe (doleryty)		
			Melafiry		
		t+tt	Tufy filipowickie i tufity		

Opracował S. PRZENIOSŁO – 1995 r.



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

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ZŁOŻA DEPOSITS TABLICA PLATE **C**

GŁÓWNE ZŁOŻA KOPALIN I PRZERÓBKA SUROWCÓW
PRINCIPAL DEPOSITS, MINES AND TREATEMENT OF RAW MATERIALS

SZKIC GEOLOGICZNY WYCHODNI GŁÓWNYCH FORMACJI PRZEDCZWARTORZĘDOWYCH
GEOLOGICAL SKETCH OF OUTCROPS OF PRINCIPAL FORMATIONS (WITHOUT QUATERNARY)

- Osady trzeciorzędowe / Tertiary sediments
- Węglanowe osady jury (i kredy) / Jurassic (and Cretaceous) carbonate sediments
- Ilaste osady triasu górnego (i jury dolnej) / Upper Triassic (and Lower Jurassic) clay sediments
- Dolomity kruszconośne / Ore-bearing dolomites
- Węglanowe osady triasu środkowego / Middle Triassic carbonate sediments
- Ilasto-piaskowcowe osady karbonu / Carboniferous sediments

WĘGIEL KAMIENNY HARD COAL

Złoża kopalń czynnych / Mines exploited

Solanki i zasolone wody kopalniane z kopalń węgla (średnia z lat 1991-1993) w przeliczeniu na eq. NaCl w tys. t/rok

Brines and saline waters exhausted of coal mines (average of 1991-1993) in equivalent of NaCl in 1000 tons/year

5-10 | 10-25 | 25-50 | 50-100 | 100-200 | 200-400 | 400-800 eq. NaCl

a b — Wododział Odry i Wisły: a - pewny, b - niepewny
Oder and Vistula Water-parting: a - sure, b - fluctuating

Elektrownie / Power stations

Cementownie / Cement factories

Huty, Siderurgies

CYNK I OŁÓW ZINC AND LEAD

Złoża i przeróbka rud w ostatnich 50 latach
Deposits and treatement in the period of last 50 years

a b — Złoża eksploatowane: a - kopalnie czynne, b - nieczynne
Exploited deposits: a - active mines, b - abandoned mines

Złoża udokumentowane Zn-Pb proved fields

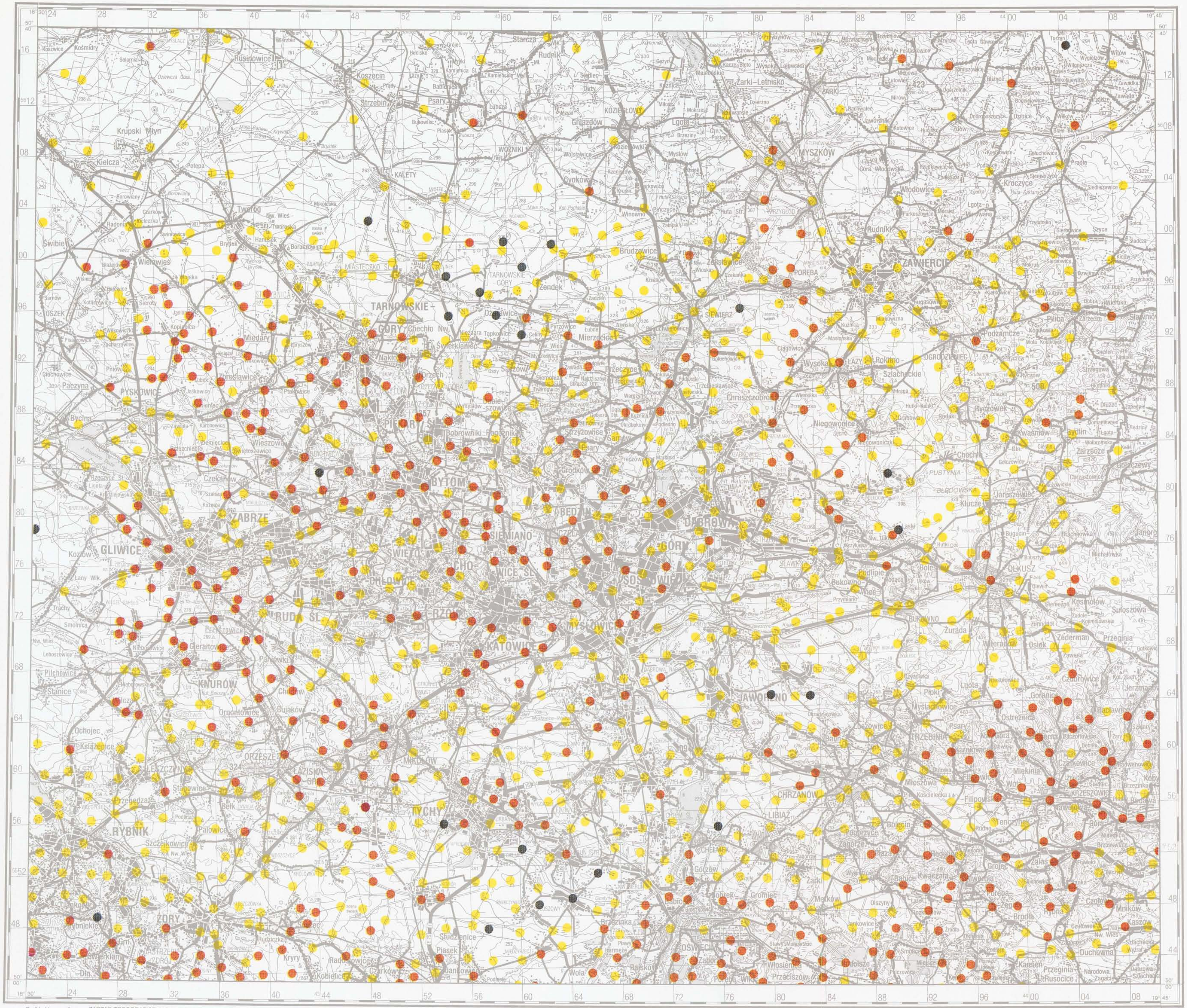
Zakłady przeróbki, metalurgiczne lub huty / Treatement or metallurgical plants

Miejsca historycznej eksploatacji i przeróbki rud
Sites of historical exploitation and treatement of ores

- Miejsca eksploatacji — Sites of exploitation
- Sztolnie odwadniające — Drainage addits
- Stare huty — Old metallurgical factories
- z Hałdy, zwały — Dumps

SÓL KAMIENNA ROCK SALT

Udokumentowane złoże soli kamiennej
Rock salt proved field



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GLEBY SOILS

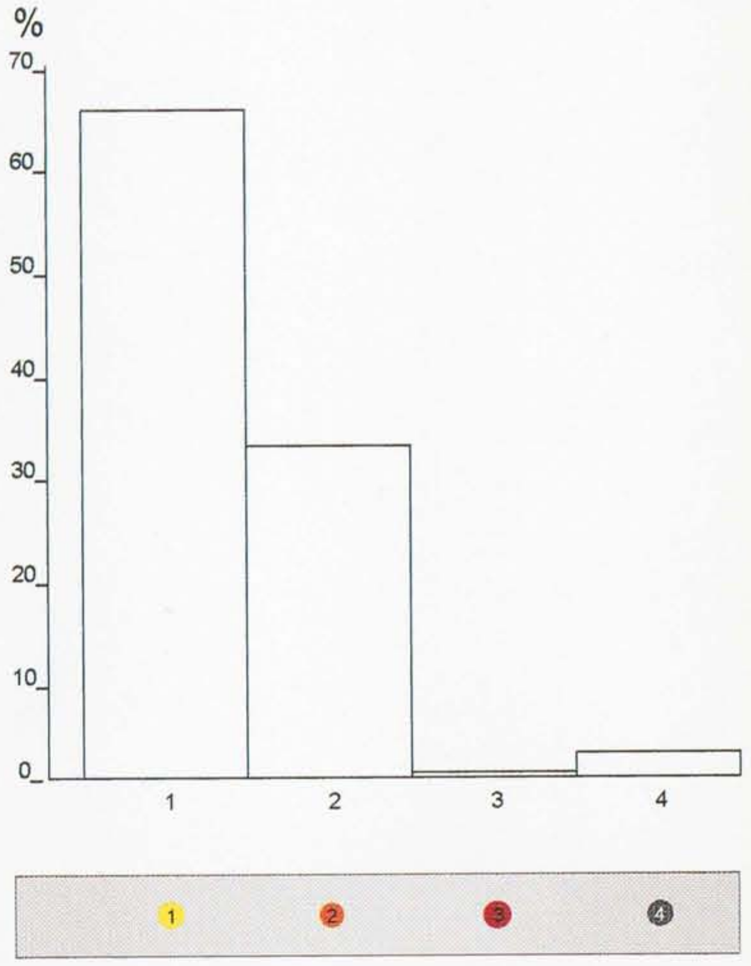
TABLICA
PLATE
1

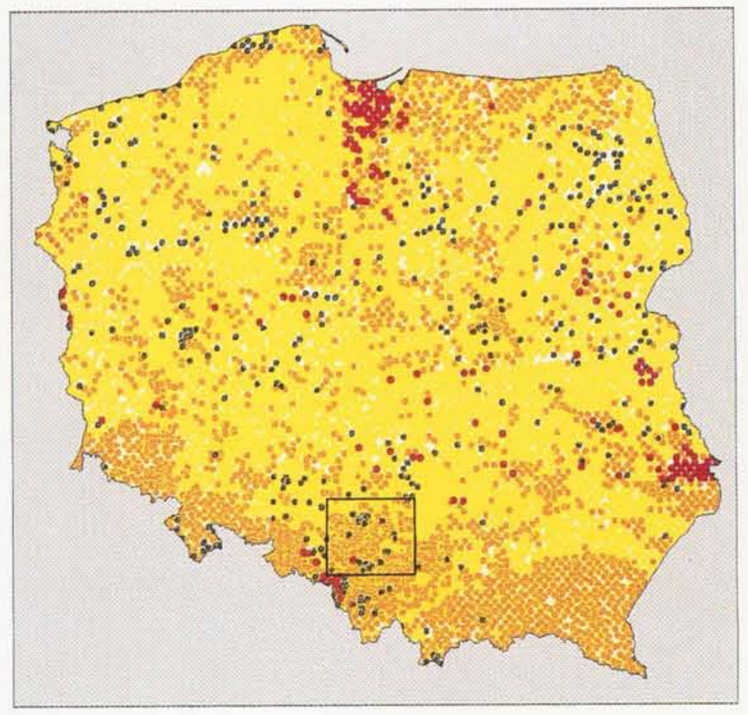
OPRÓBOWANIE
SAMPLING

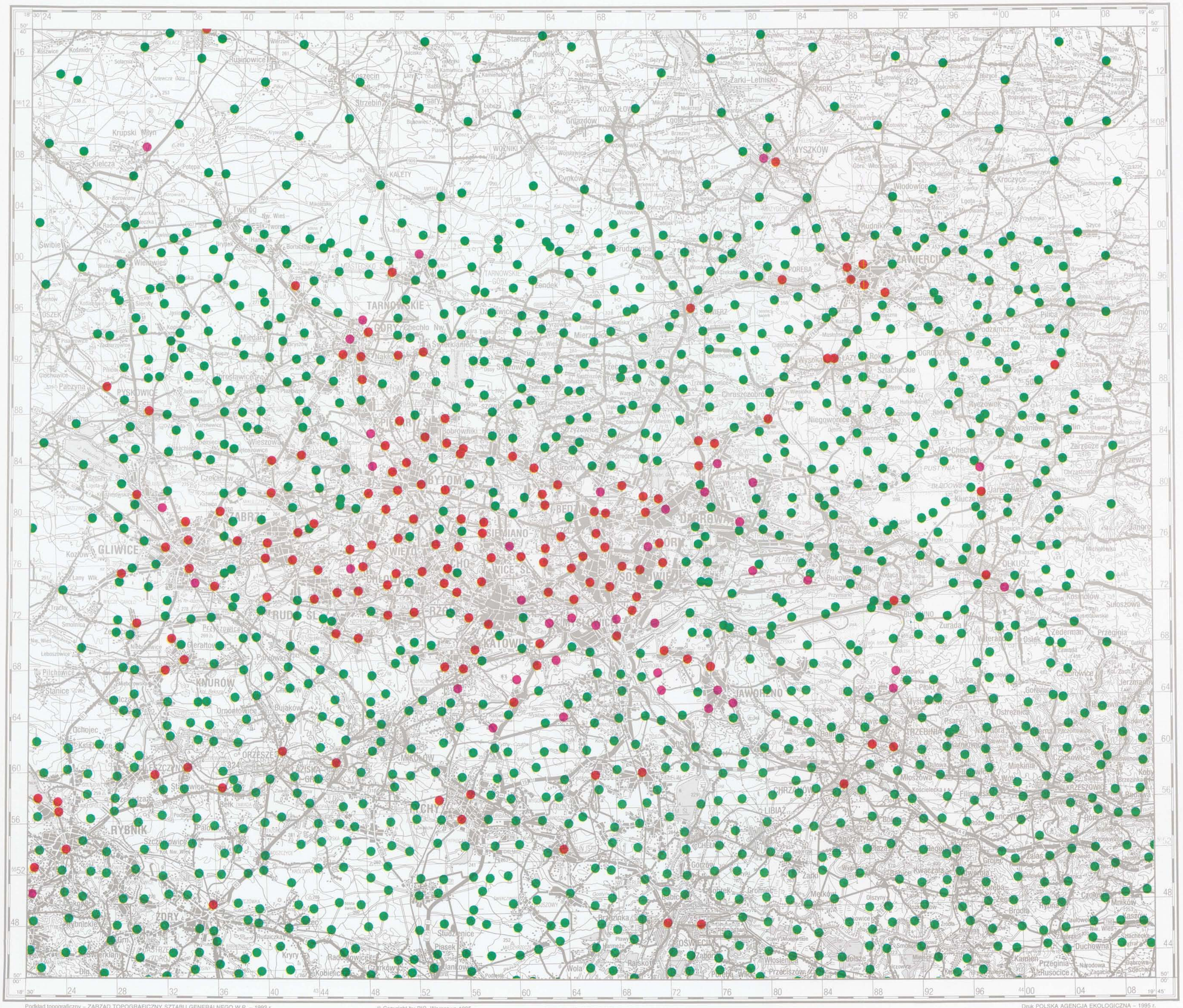
Rodzaje gleb Kinds of soils

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
Liczba próbek
Number of samples

① Gleby piaszczyste	1016	① Sandy soils
② Gleby gliniaste	506	② Loam soils
③ Gleby pylase	5	③ Silty soils
④ Gleby torfiaste	37	④ Peaty soils







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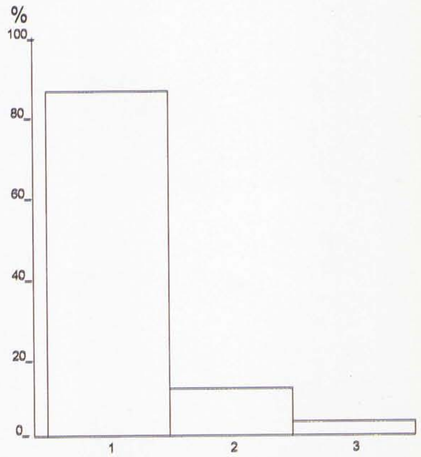
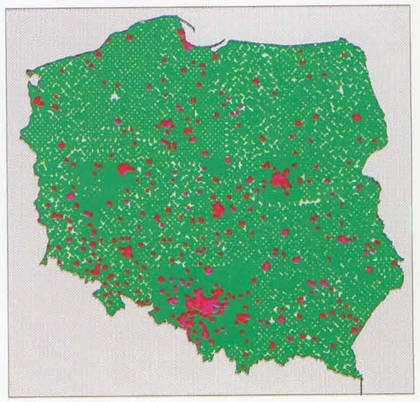
OPRÓBOWANIE SAMPLING

Zabudowa Land development

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
Liczba próbek
Number of samples

Tereny:		Areas:
1 niezabudowane	1336	1 non-development
2 miejskie	180	2 urban
3 przemysłowe	48	3 Industrial



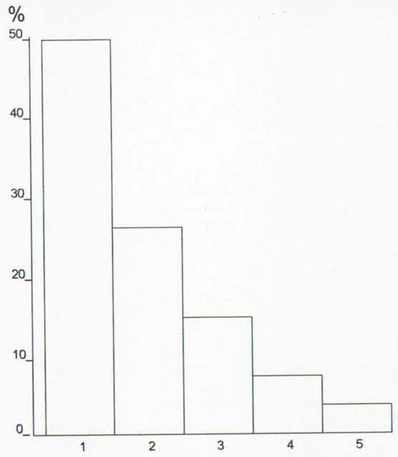


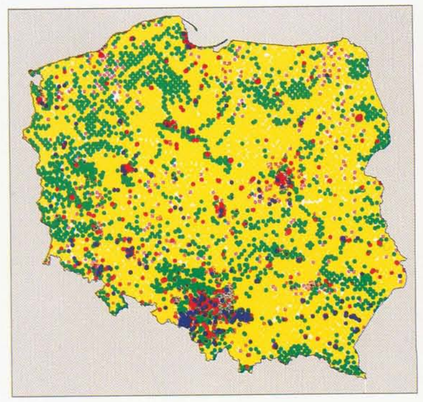
OPRÓBOWANIE SAMPLING

Użytkowanie gleb / Soils employment

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
Liczba próbek
Number of samples

1 Pola uprawne i łąki	768	1 Cultivated fields and meadows	
2 Lasy	402	2 Forests	
3 Ugory	226	3 Fallows	
4 Parki i trawniki	112	4 City parks and lawns	
5 Ogródki działkowe	56	5 Allotments	

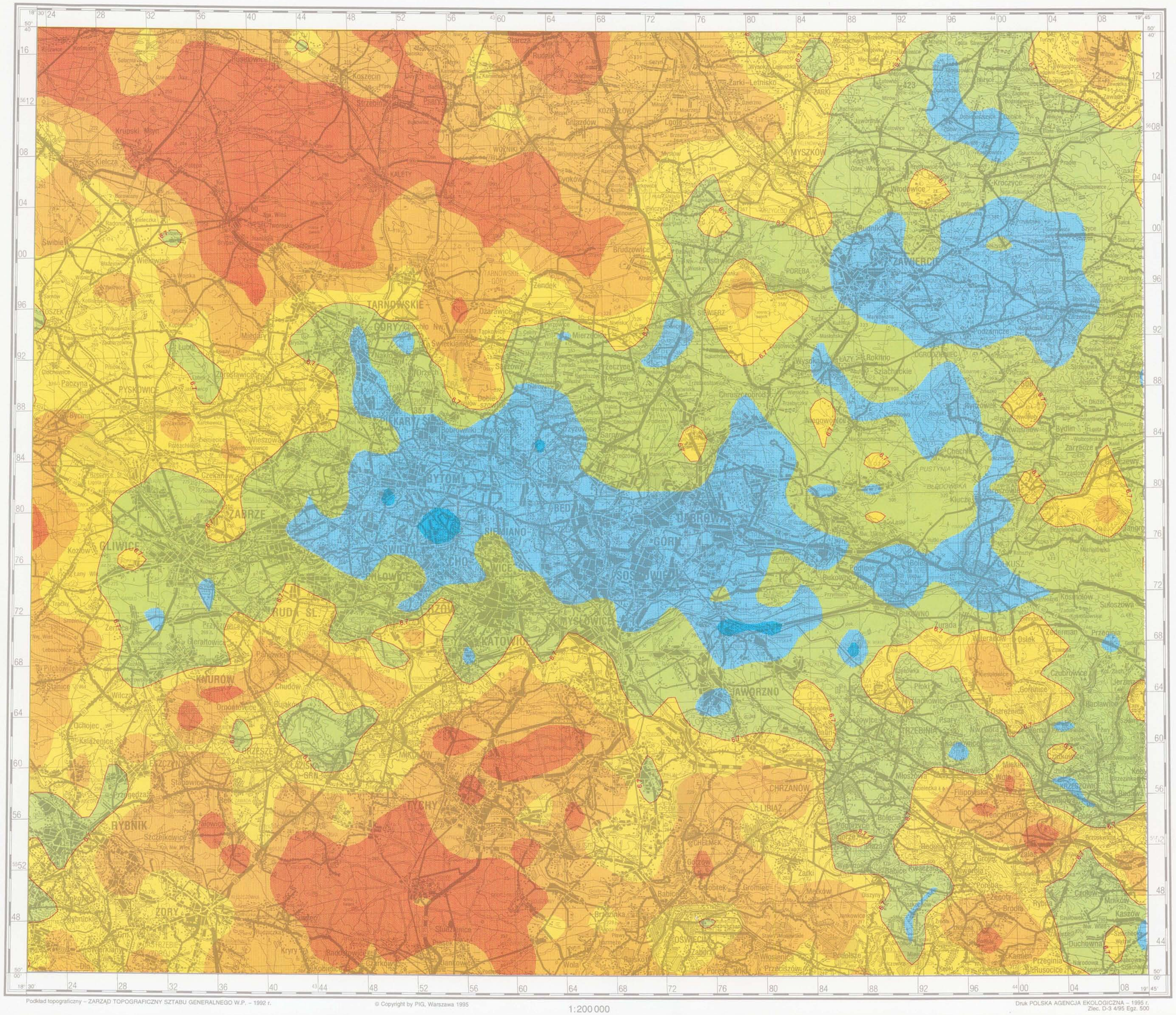




Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000
Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

pH KWASOWOŚĆ ACIDITY



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000

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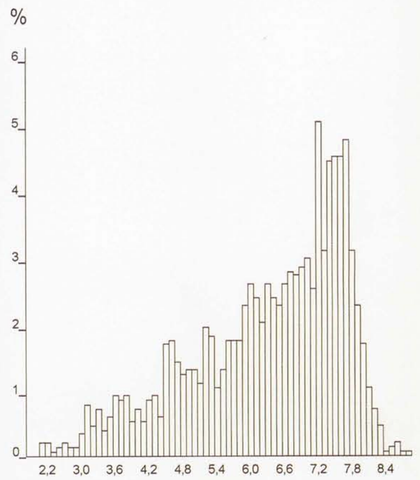
Zlec. D-3 4/95 Egz. 500

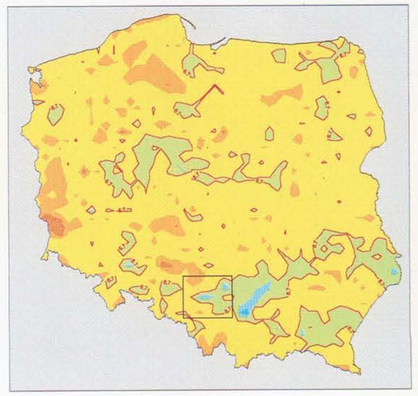
PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
pH

Liczba próbek	1564	Number of samples
Minimum	2.2	Minimum
Maksimum	9.7	Maximum
Średnia arytm.	6.4	Arithmetic mean
Średnia geom.	6.2	Geometric mean
Mediana	6.7	Median



4.0 5.0 6.7 7.4 8.0

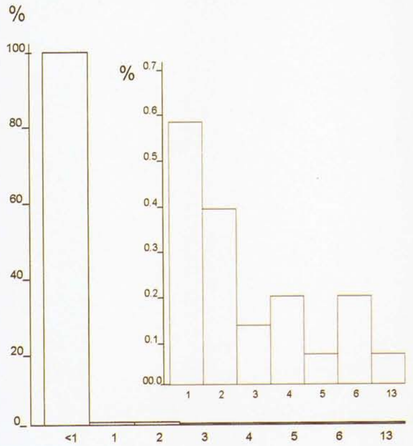
6.7 Wartość graniczna dla gleb kwaśnych
Limit value for acid soil



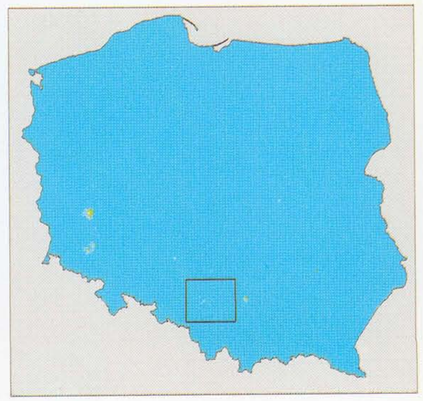
Ag SREBRO SILVER

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/kg = g/t

Liczba próbek	1564	Number of samples
Minimum	< 1	Minimum
Maksimum	13	Maximum
Średnia arytm.	< 1	Arithmetic mean
Średnia geom.	< 1	Geometric mean
Mediana	< 1	Median
Granica wykrywalności	1	Detection limit



<1 Wartość graniczna tła w glebach Polski
Limit value for background in soil of Poland



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000
Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

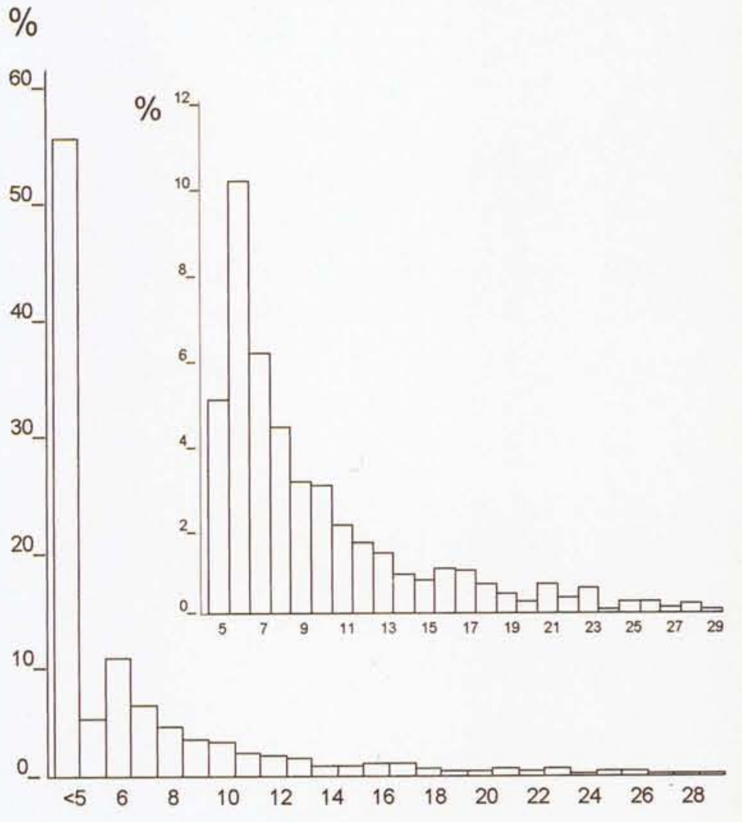
GLEBY SOILS

TABLICA
PLATE **4**

As ARSEN ARSENIC

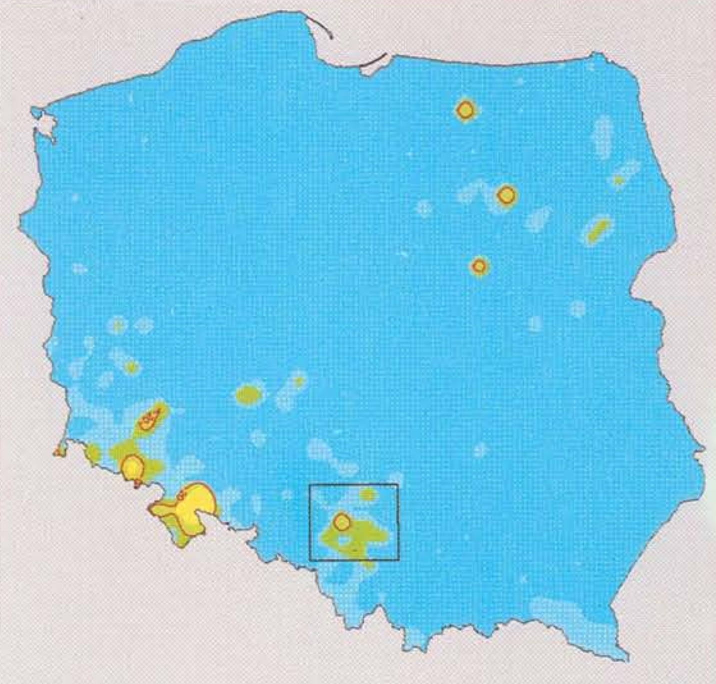
PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/kg = g/t

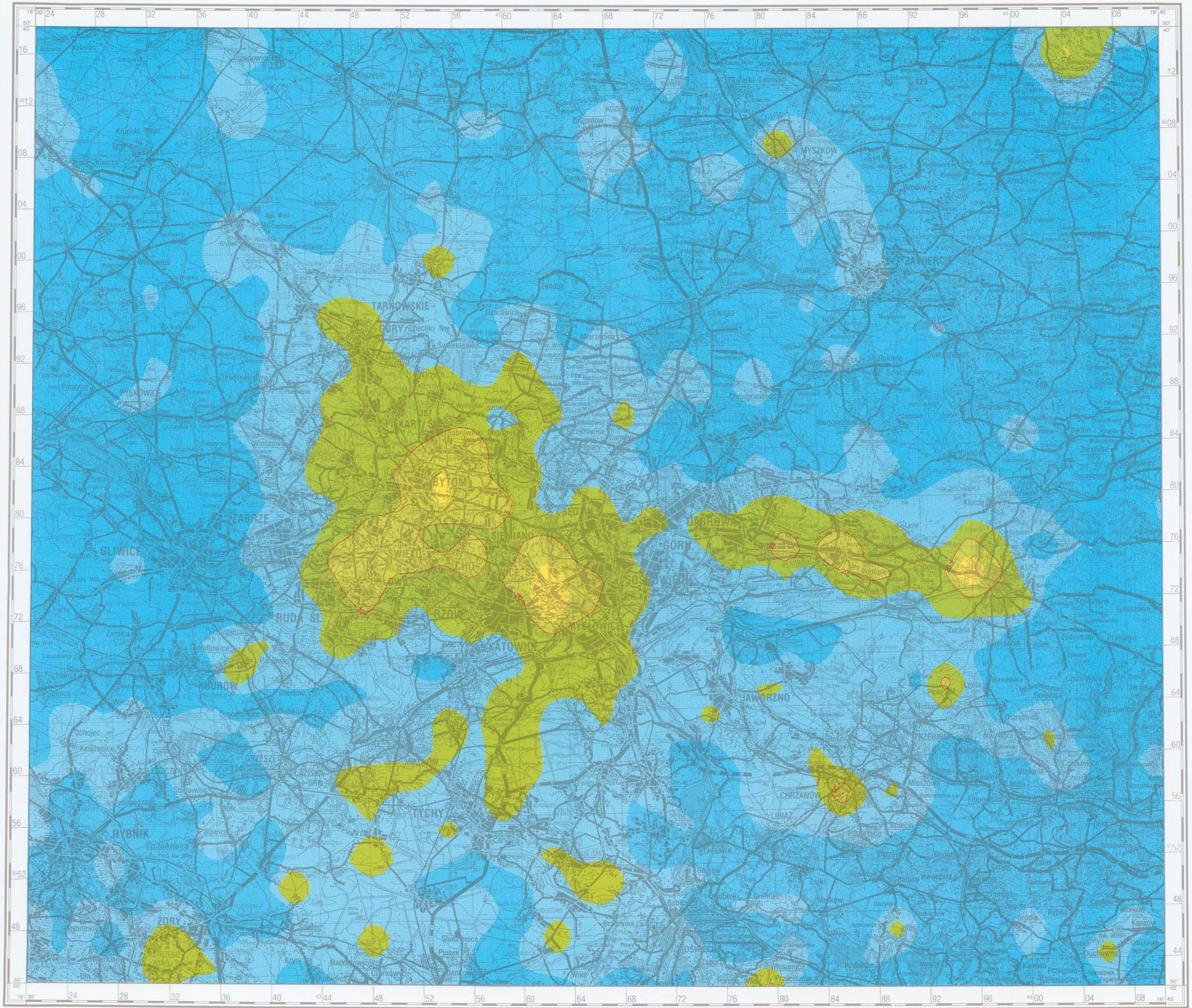
Liczba próbek	1564	Number of samples
Minimum	< 5	Minimum
Maksimum	238	Maximum
Średnia arytm.	7	Arithmetic mean
Średnia geom.	< 5	Geometric mean
Mediana	< 5	Median
Granica wykrywalności	5	Detection limit



5 10 20 40

20 Wartość graniczna w glebach
Limit value in soil

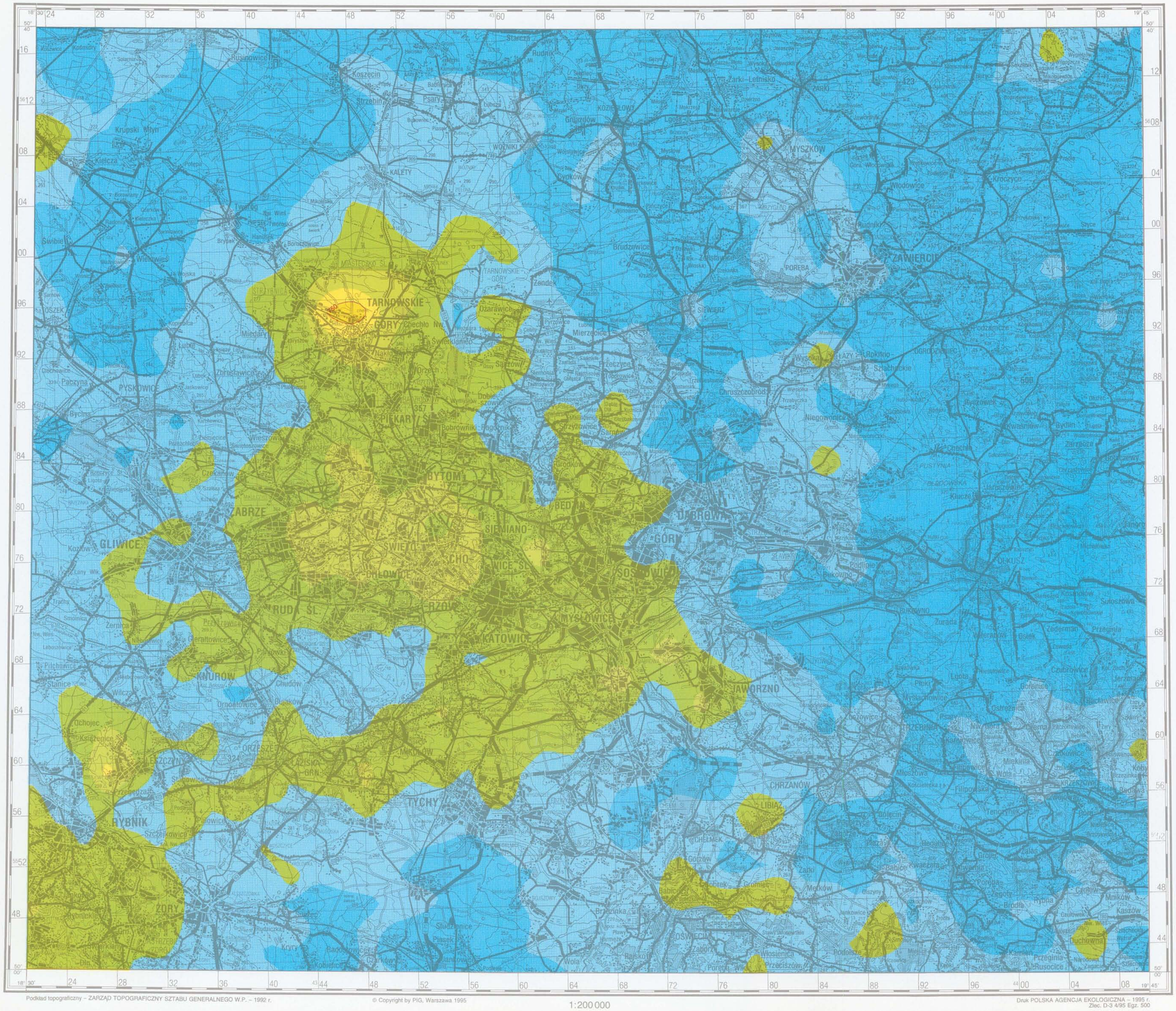




Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000

Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

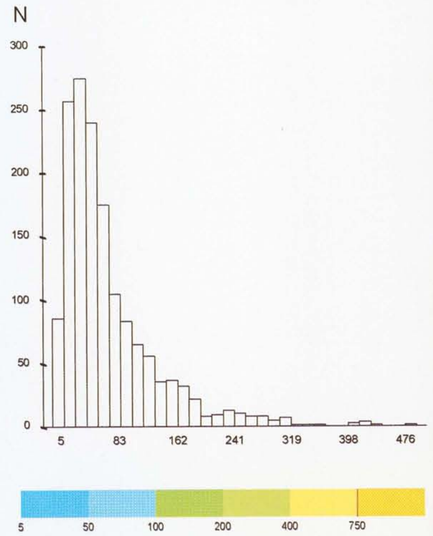
1:200 000

Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

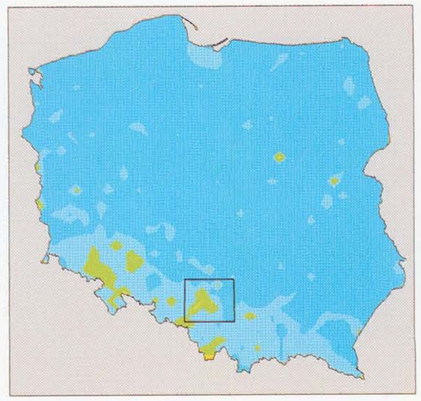
Ba BAR BARIUM

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/kg = g/t

Liczba próbek	1564	Number of samples
Minimum	2	Minimum
Maksimum	1777	Maximum
Średnia arytm.	81	Arithmetic mean
Średnia geom.	54	Geometric mean
Mediana	54	Median
Granica wykrywalności	1	Detection limit



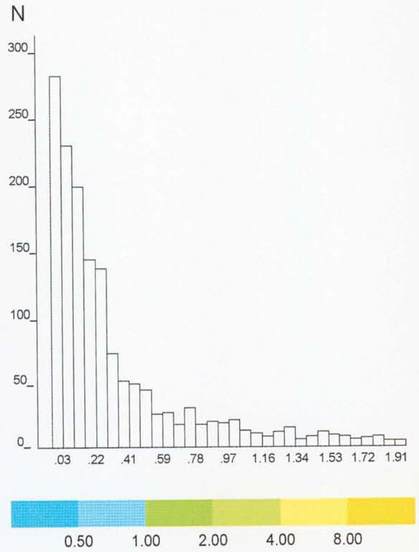
750 Wartość graniczna w glebach
Limit value in soil



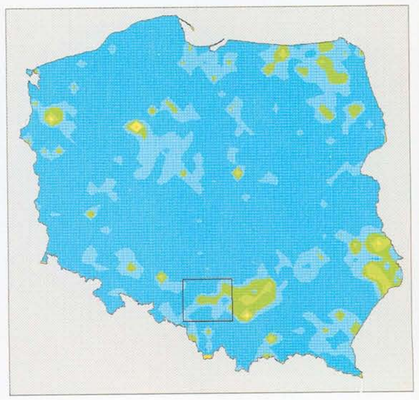
Ca WAPŃ CALCIUM

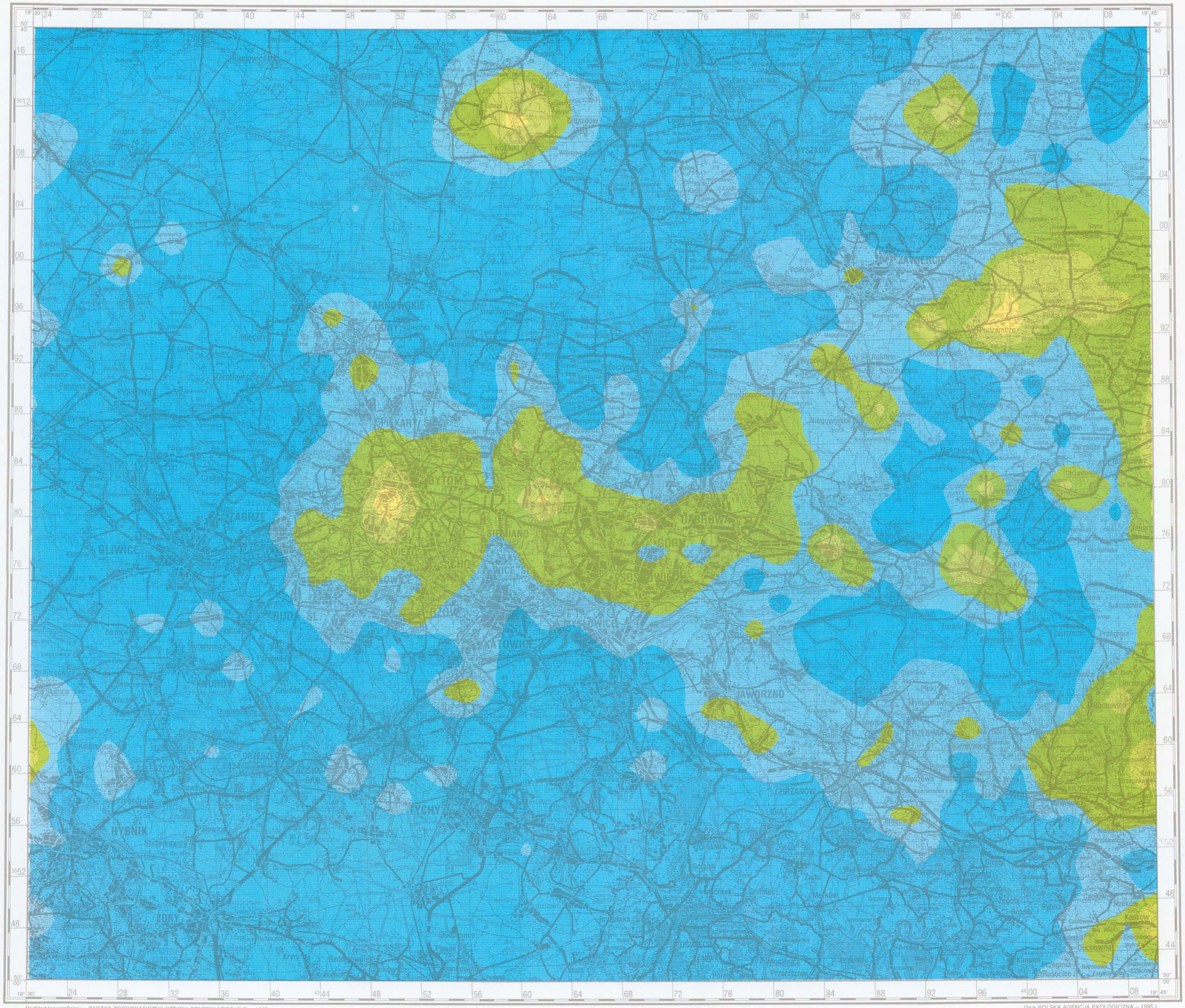
PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
% = procent = percent

Liczba próbek	1564	Number of samples
Minimum	< 0.01	Minimum
Maksimum	13.47	Maximum
Średnia arytm.	0.58	Arithmetic mean
Średnia geom.	0.23	Geometric mean
Mediana	0.22	Median
Granica wykrywalności	0.01	Detection limit



0.50 Wartość graniczna dla tła w glebach Polski
Limit value for background in soil of Poland

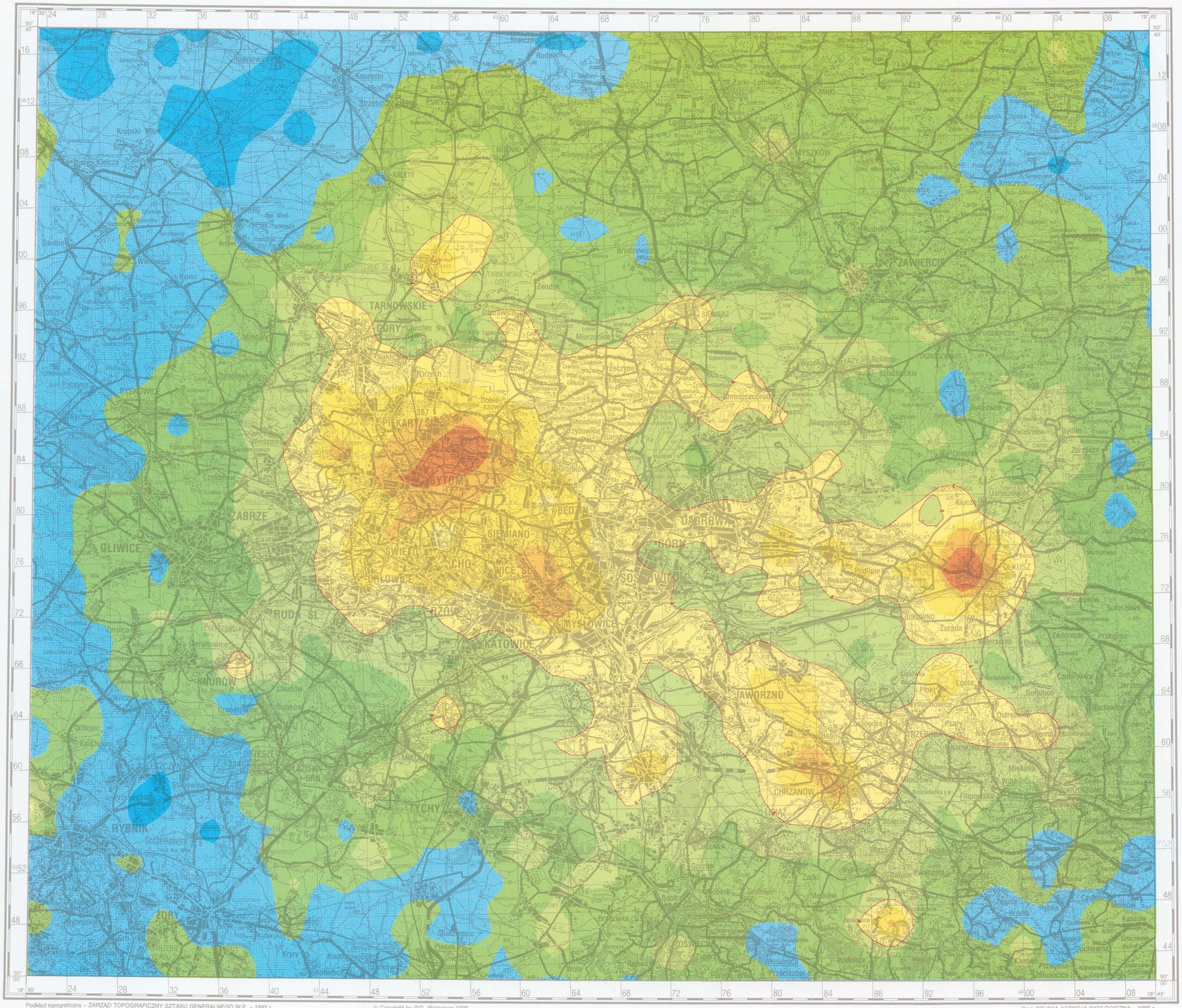




Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000

Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000

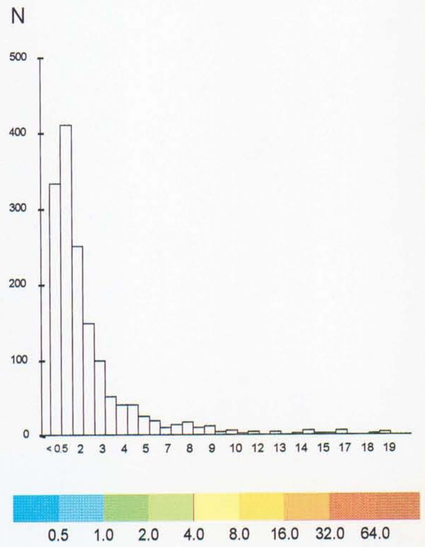
Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

GLEBY SOILS TABLICA PLATE **7**

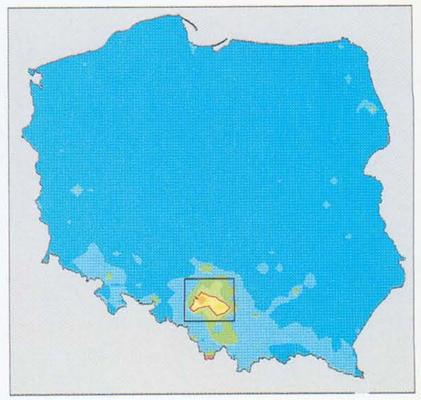
Cd KADM CADMIUM

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/kg = g/t

Liczba próbek	1564	Number of samples
Minimum	< 0.5	Minimum
Maksimum	253.3	Maximum
Średnia arytm.	3.1	Arithmetic mean
Średnia geom.	1.4	Geometric mean
Mediana	1.3	Median
Granica wykrywalności	0.5	Detection limit



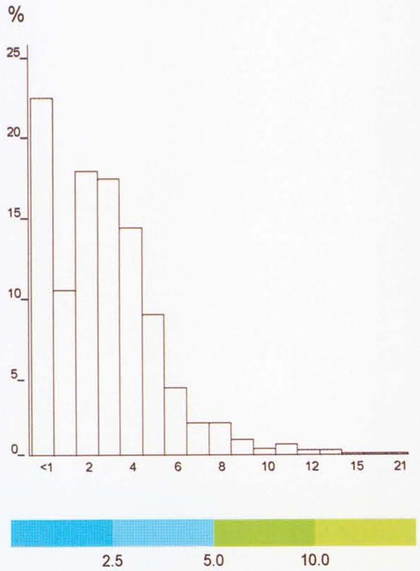
4 Wartość graniczna w glebach
Limit value in soil



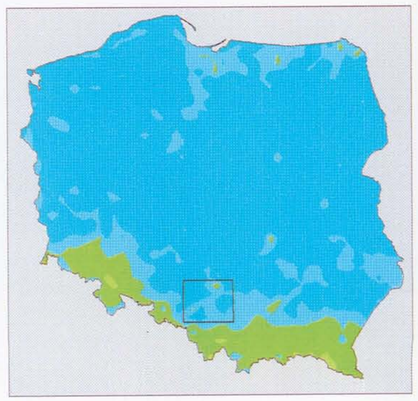
Co KOBALT COBALT

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/kg = g/t

Liczba próbek	1564	Number of samples
Minimum	< 1	Minimum
Maksimum	21	Maximum
Średnia arytm.	3	Arithmetic mean
Średnia geom.	2	Geometric mean
Mediana	3	Median
Granica wykrywalności	1	Detection limit



6 Wartość graniczna dla tła w glebach Polski
Limit value for background in soil of Poland



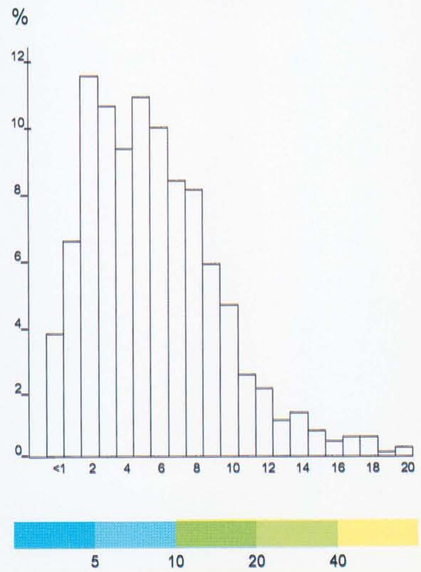
Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000
Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

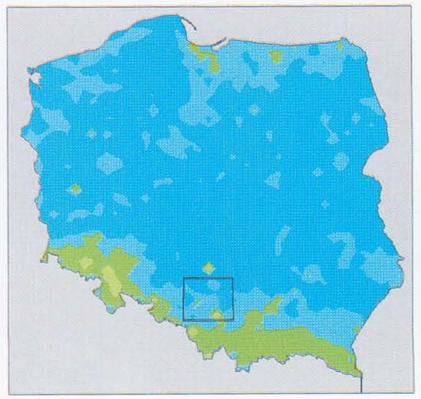
Cr CHROM CHROMIUM

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/kg = g/t

Liczba próbek	1564	Number of samples
Minimum	< 1	Minimum
Maksimum	95	Maximum
Średnia arytm.	6	Arithmetic mean
Średnia geom.	5	Geometric mean
Mediana	5	Median
Granica wykrywalności	1	Detection limit



12 Wartość graniczna dla tła w glebach Polski
Limit value for background in soil of Poland



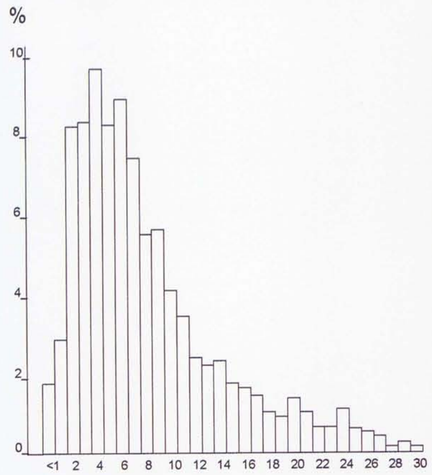
Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000
Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

Cu MIEDŹ COPPER

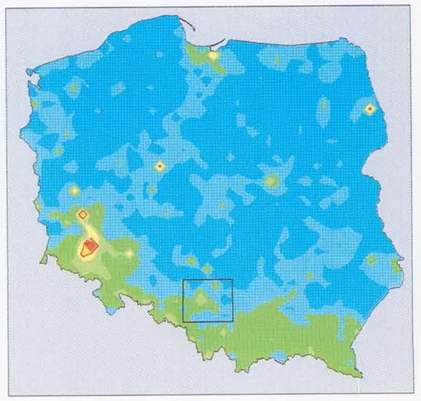
PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/kg = g/t

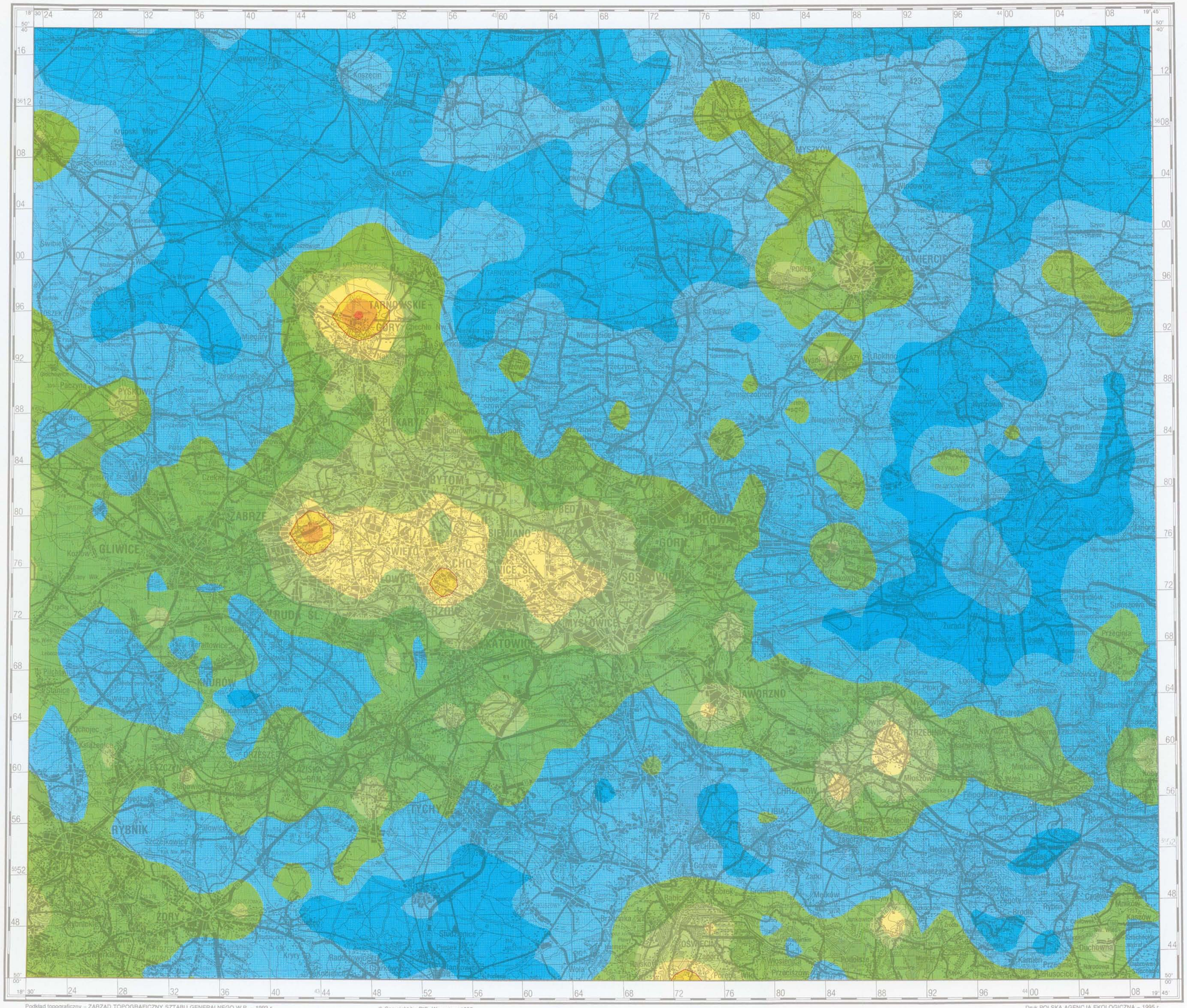
Liczba próbek	1564	Number of samples
Minimum	< 1	Minimum
Maksimum	805	Maximum
Średnia arytm.	13	Arithmetic mean
Średnia geom.	7	Geometric mean
Mediana	7	Median
Granica wykrywalności	1	Detection limit



5 10 20 40 80 160 320 640

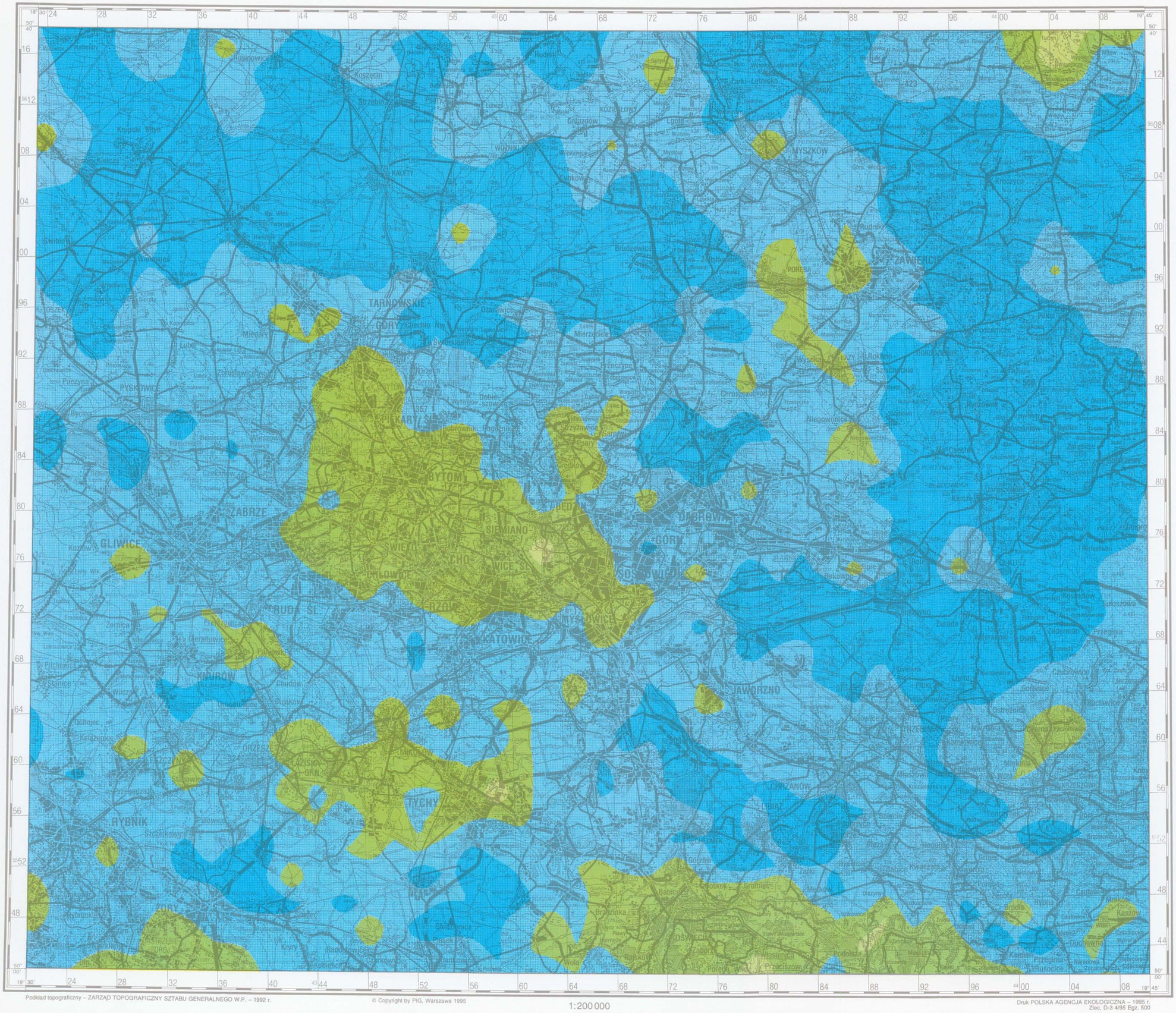
80 Wartość graniczna w glebach
Limit value in soil





Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000
Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

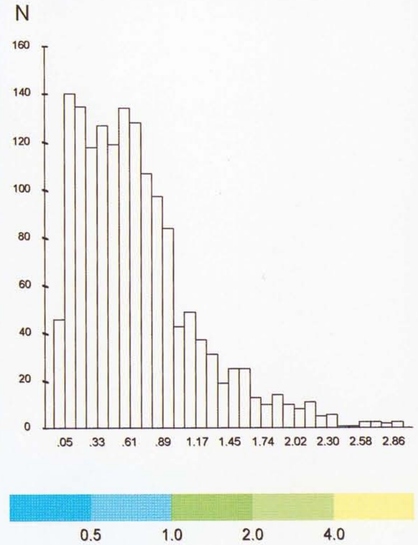
1:200 000

Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

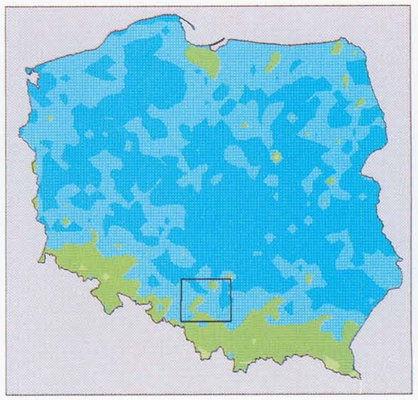
Fe ŻELAZO IRON

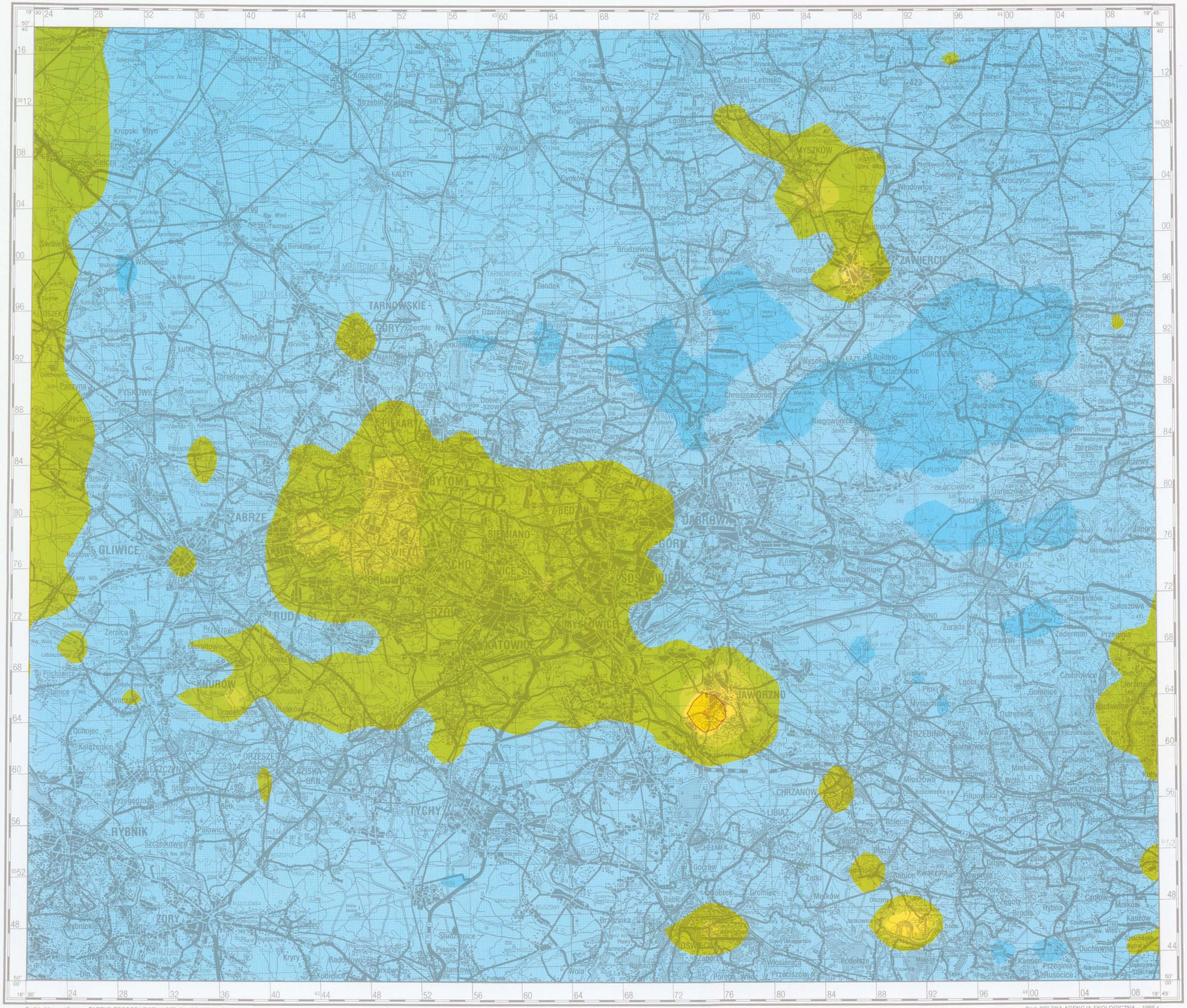
PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
% = procent = percent

Liczba próbek	1564	Number of samples
Minimum	< 0.01	Minimum
Maksimum	5.06	Maximum
Średnia arytm.	0.75	Arithmetic mean
Średnia geom.	0.56	Geometric mean
Mediana	0.63	Median
Granica wykrywalności	0.01	Detection limit



1.90 Wartość graniczna dla tła w glebach Polski
Limit value for background in soil of Poland

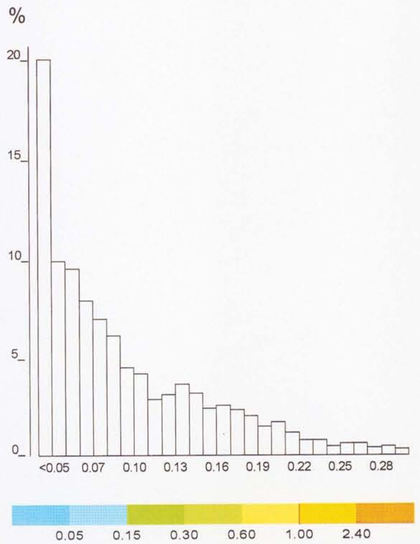




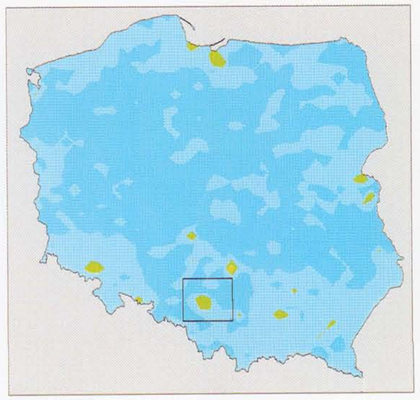
Hg RTĘĆ MERCURY

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/kg = g/t

Liczba próbek	1564	Number of samples
Minimum	< 0.05	Minimum
Maksimum	4.00	Maximum
Średnia arytm.	0.11	Arithmetic mean
Średnia geom.	0.08	Geometric mean
Mediana	0.08	Median
Granica wykrywalności	0.05	Detection limit



1 Wartość graniczna w glebach
Limit value in soil



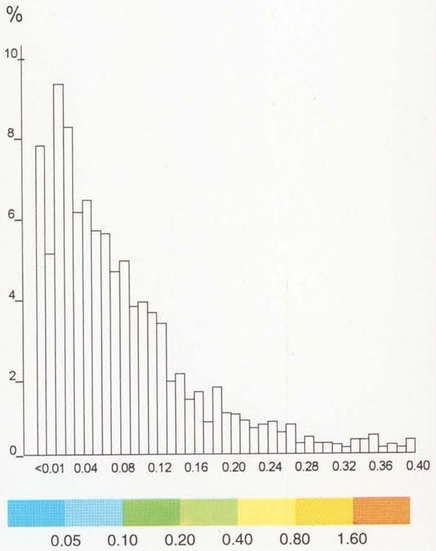
Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000
Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

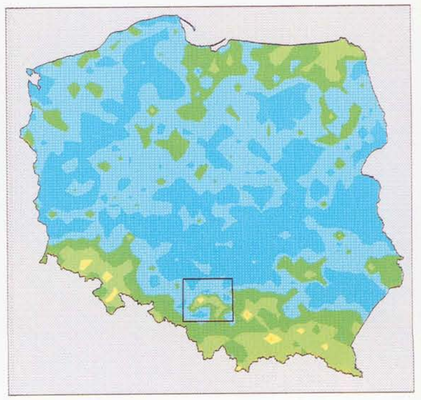
Mg MAGNEZ MAGNESIUM

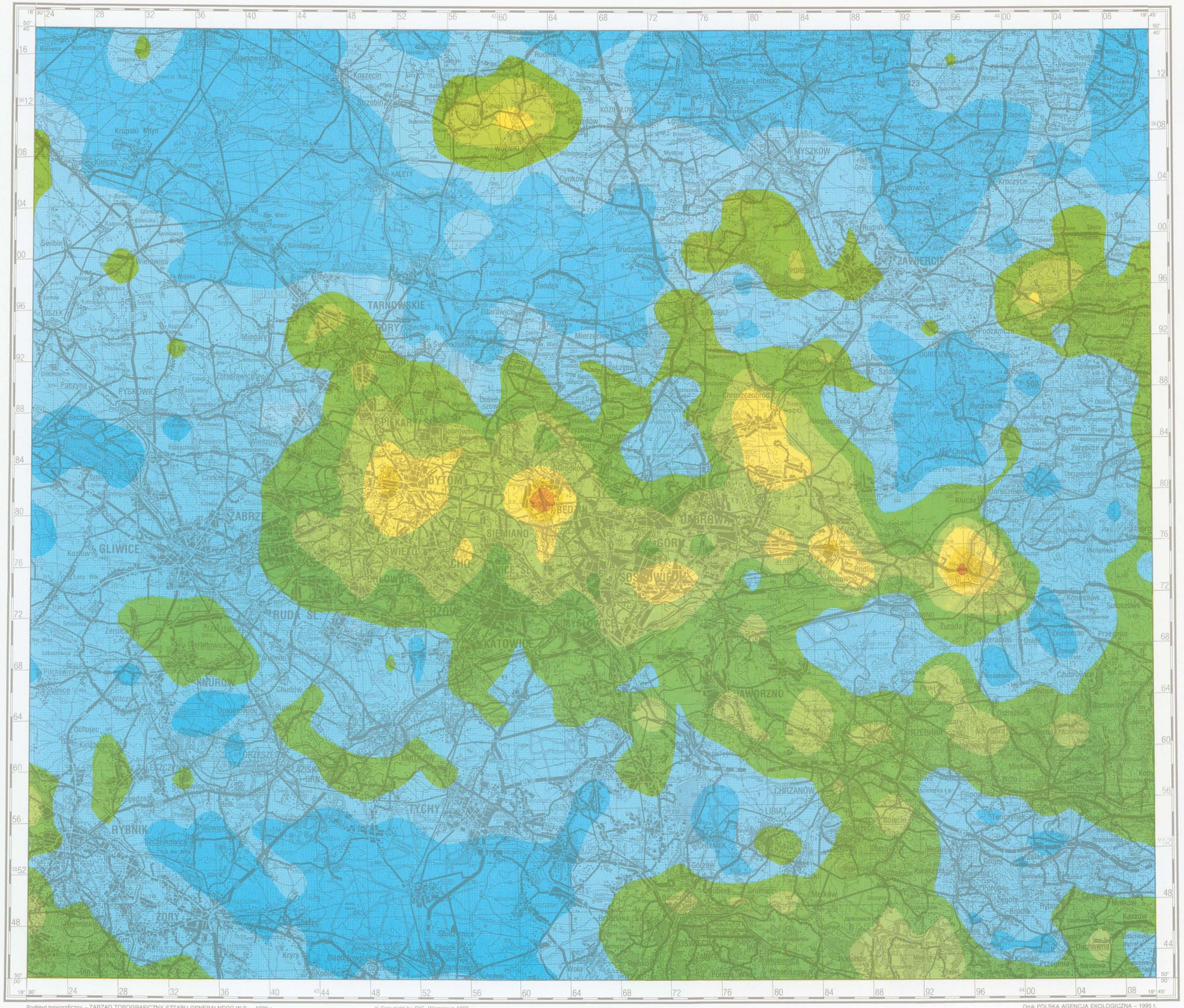
PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
% = procent = percent

Liczba próbek	1564	Number of samples
Minimum	< 0.01	Minimum
Maksimum	4.90	Maximum
Średnia arytm.	0.12	Arithmetic mean
Średnia geom.	0.06	Geometric mean
Mediana	0.07	Median
Granica wykrywalności	0.01	Detection limit



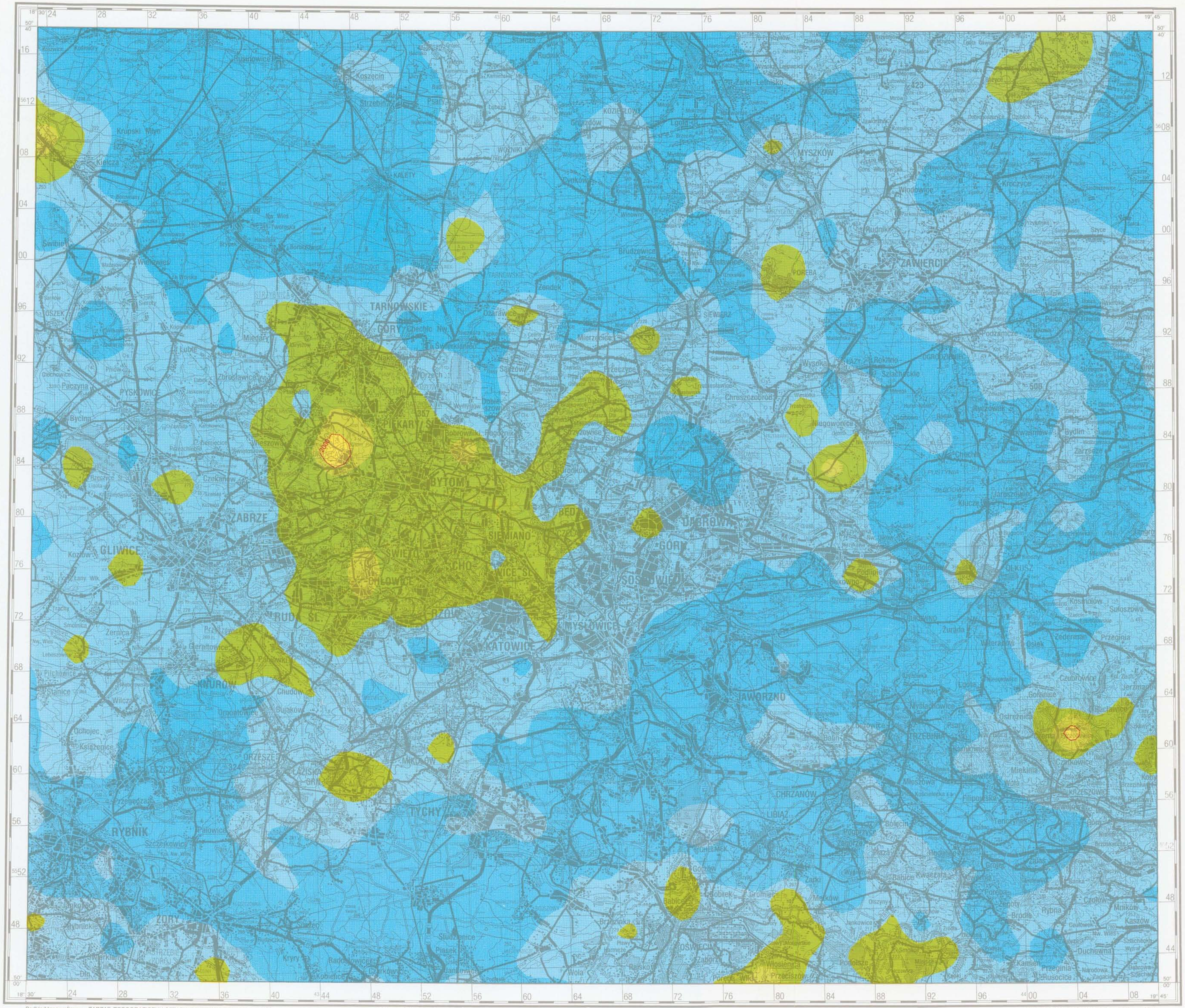
0.20 Wartość graniczna dla tła w glebach Polski
Limit value for background in soil of Poland





Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000
Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

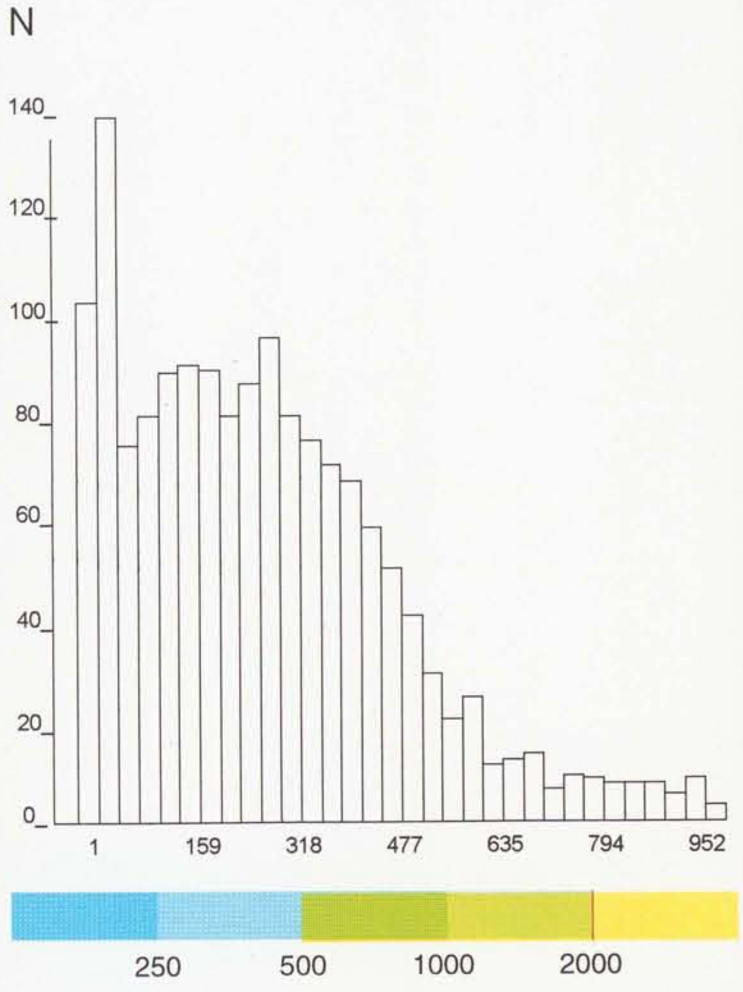


GLEBY SOILS TABLICA PLATE **14**

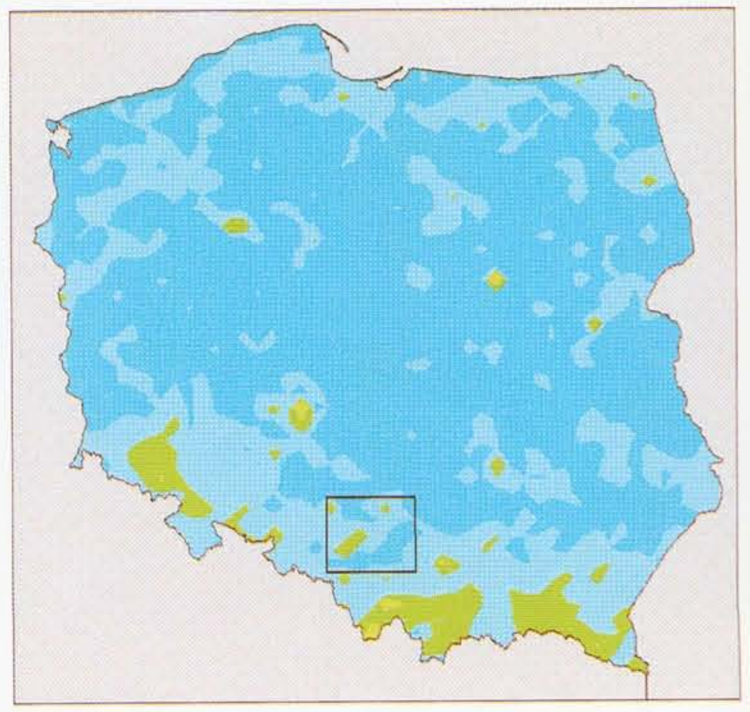
Mn MANGAN MANGANESE

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/kg = g/t

Liczba próbek	1564	Number of samples
Minimum	2	Minimum
Maksimum	7000	Maximum
Średnia arytm.	320	Arithmetic mean
Średnia geom.	186	Geometric mean
Mediana	257	Median
Granica wykrywalności	1	Detection limit



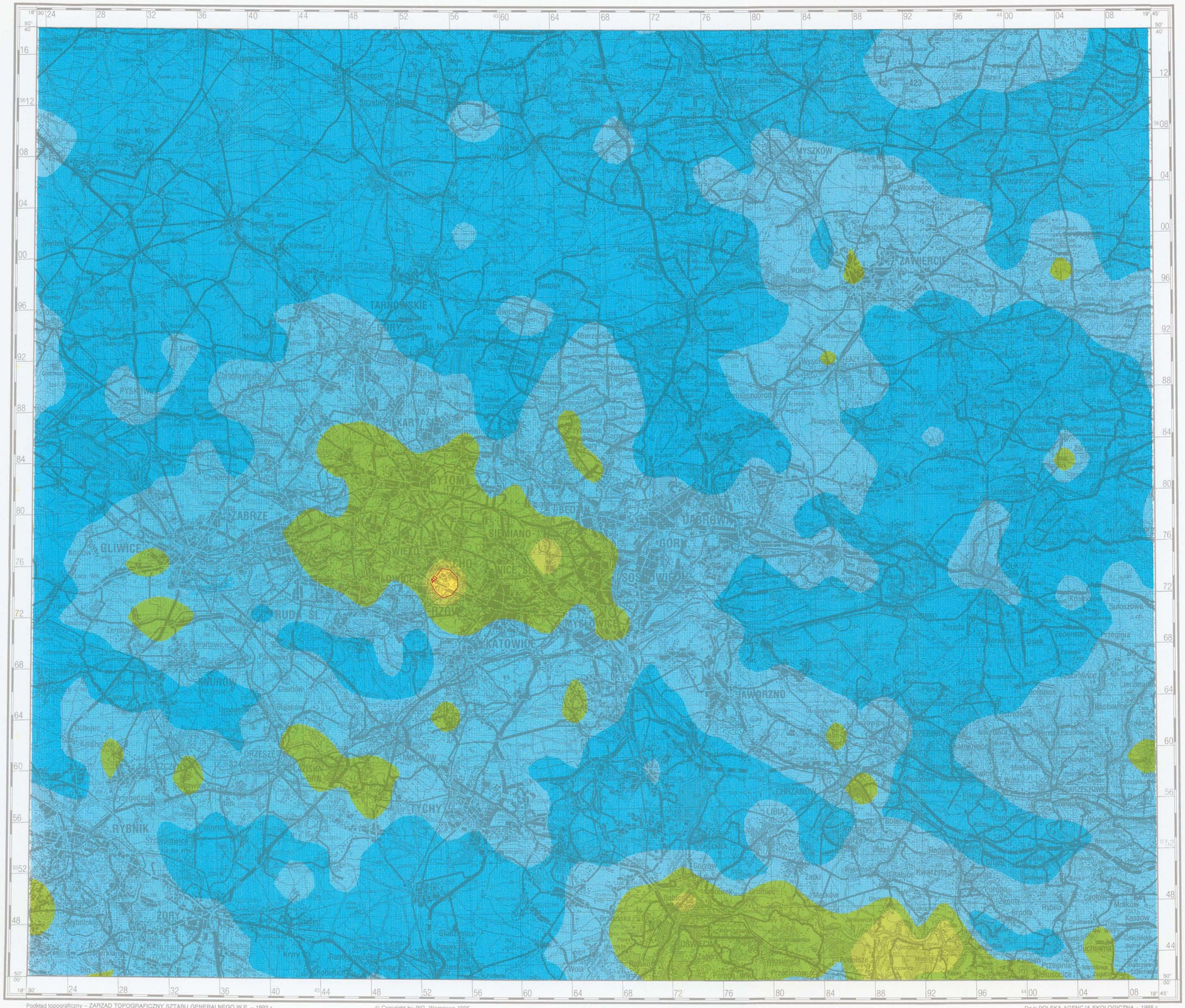
2000 Wartość graniczna w glebach
Limit value in soil



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000

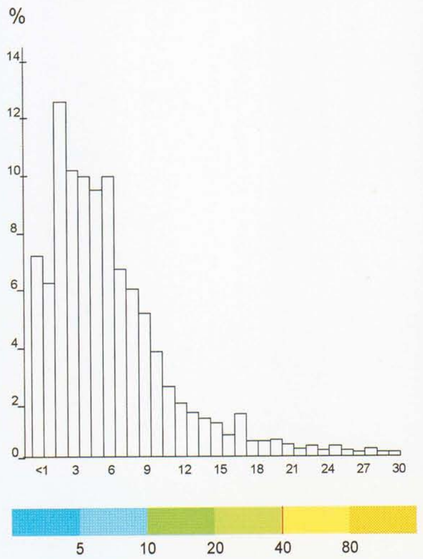
Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500



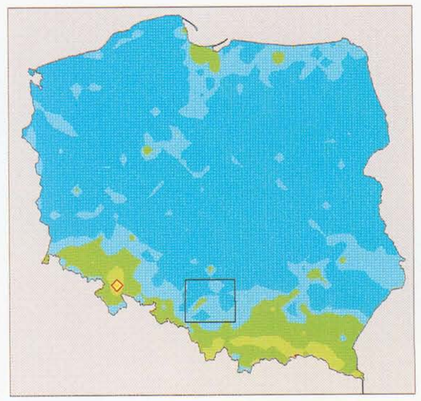
Ni NIKIEL NICKEL

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/kg = g/t

Liczba próbek	1564	Number of samples
Minimum	< 1	Minimum
Maksimum	89	Maximum
Średnia arytm.	6	Arithmetic mean
Średnia geom.	4	Geometric mean
Mediana	5	Median
Granica wykrywalności	1	Detection limit



40 Wartość graniczna w glebach
Limit value in soil



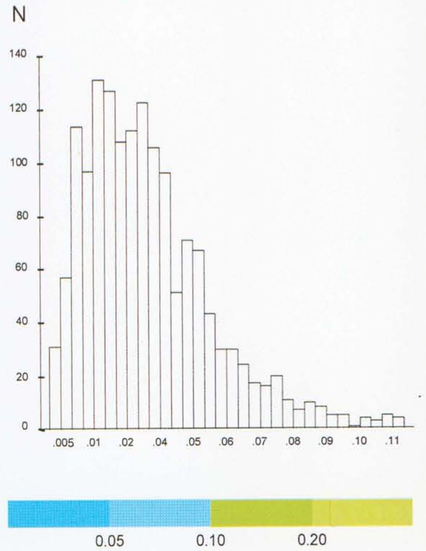
Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000
Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

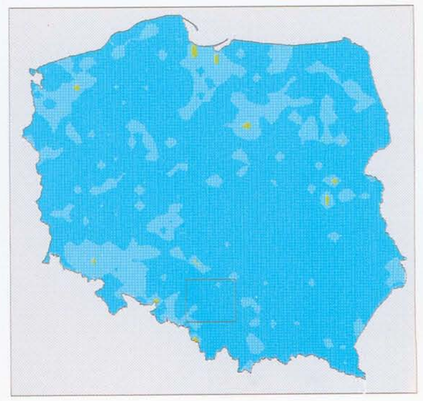
P FOSFOR PHOSPHORUS

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
% = procent = percent

Liczba próbek	1564	Number of samples
Minimum	< 0.005	Minimum
Maksimum	0.476	Maximum
Średnia arytm.	0.036	Arithmetic mean
Średnia geom.	0.027	Geometric mean
Mediana	0.030	Median
Granica wykrywalności	0.005	Detection limit



0.080 Wartość graniczna dla tła w glebach Polski
Limit value for background in soil of Poland



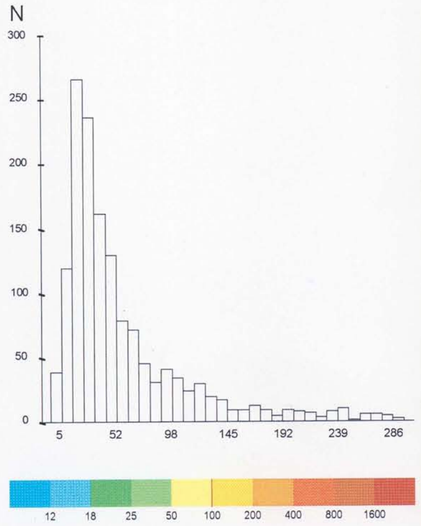
Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000
Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

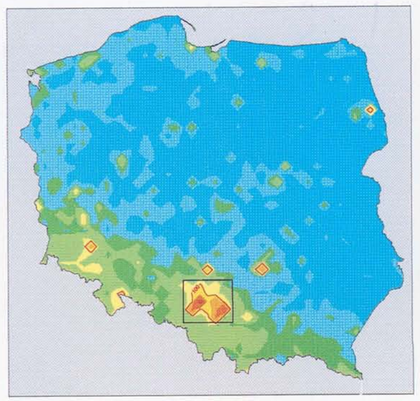
Pb OŁÓW LEAD

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/kg = g/t

Liczba próbek	1564	Number of samples
Minimum	< 3	Minimum
Maksimum	16972	Maximum
Średnia arytm.	130	Arithmetic mean
Średnia geom.	53	Geometric mean
Mediana	44	Median
Granica wykrywalności	3	Detection limit

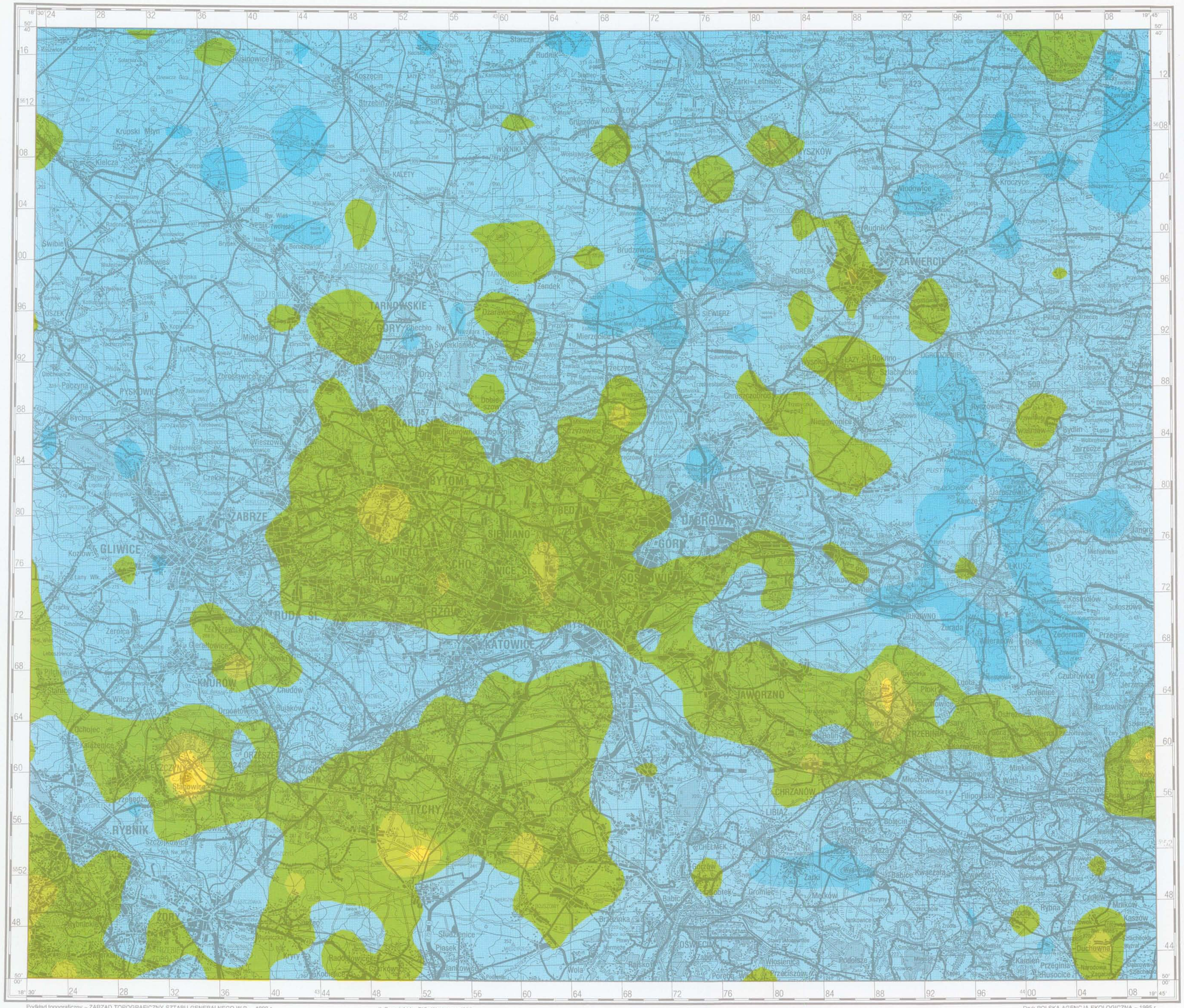


100 Wartość graniczna w glebach
Limit value in soil



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000
Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

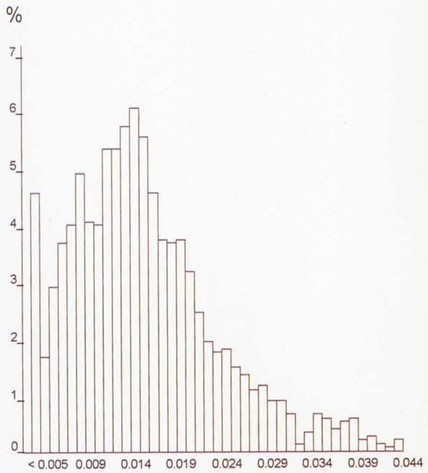
1:200 000

Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

S SIARKA SULPHUR

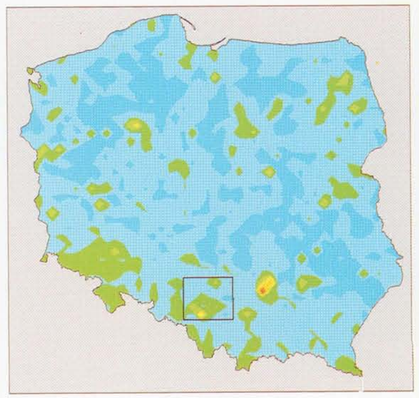
PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
% = procent = percent

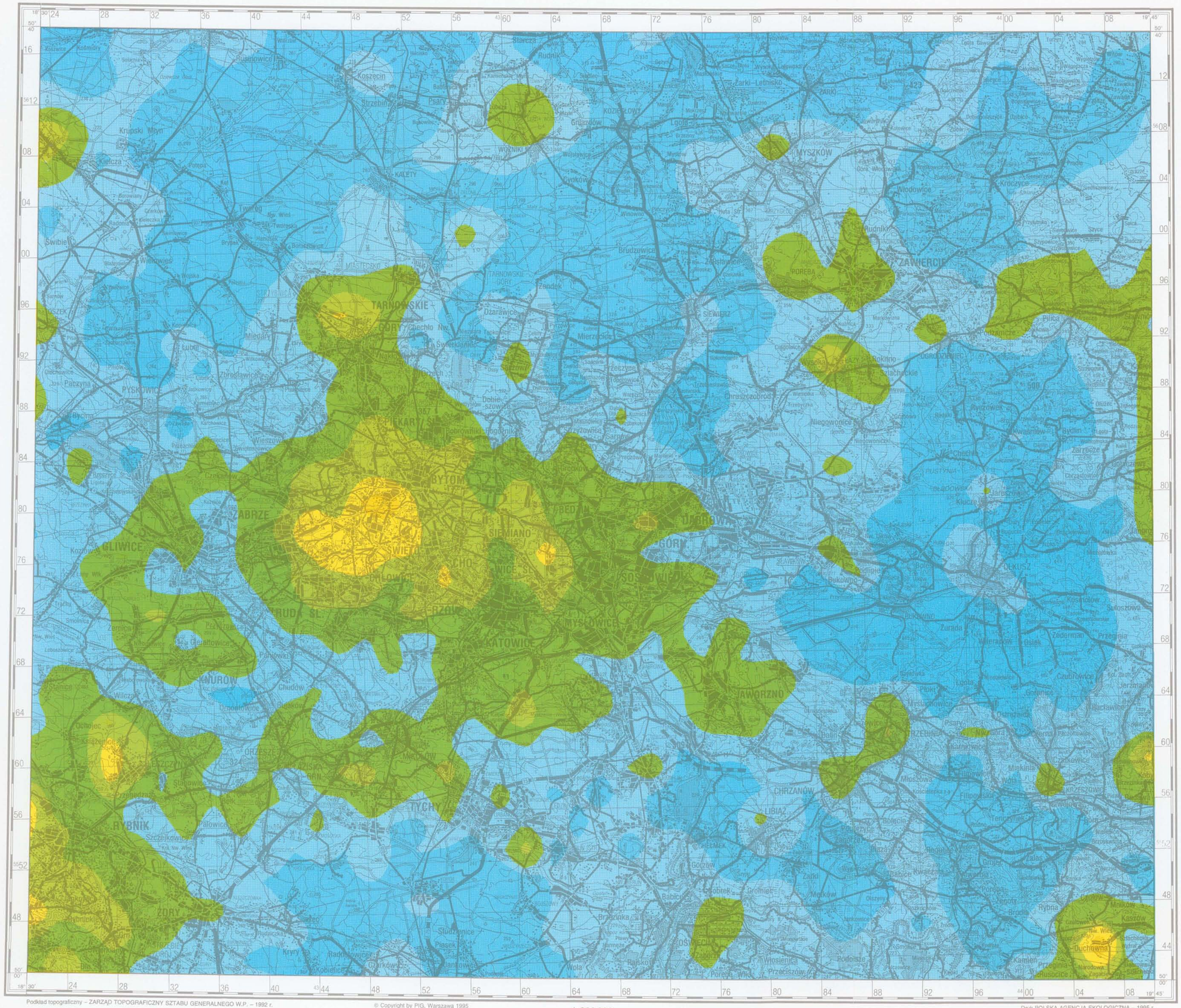
Liczba próbek	1564	Number of samples
Minimum	< 0.005	Minimum
Maksimum	0.516	Maximum
Średnia arytm.	0.019	Arithmetic mean
Średnia geom.	0.015	Geometric mean
Mediana	0.015	Median
Granica wykrywalności	0.005	Detection limit



0.01 0.02 0.04 0.08 0.16 0.32

0.04 Wartość graniczna dla tła w glebach Polski
Limit value for background in soil of Poland

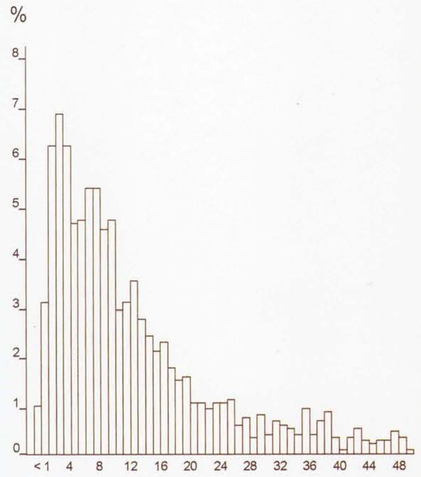




Sr STRONT STRONTIUM

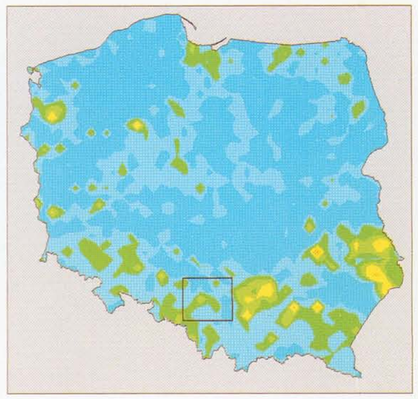
PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/kg = g/t

Liczba próbek	1564	Number of samples
Minimum	< 1	Minimum
Maksimum	708	Maximum
Średnia arytm.	20	Arithmetic mean
Średnia geom.	10	Geometric mean
Mediana	10	Median
Granica wykrywalności	1	Detection limit



10 20 40 80 160 320

30 Wartość graniczna dla tła w glebach Polski
Limit value for background in soil of Poland



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

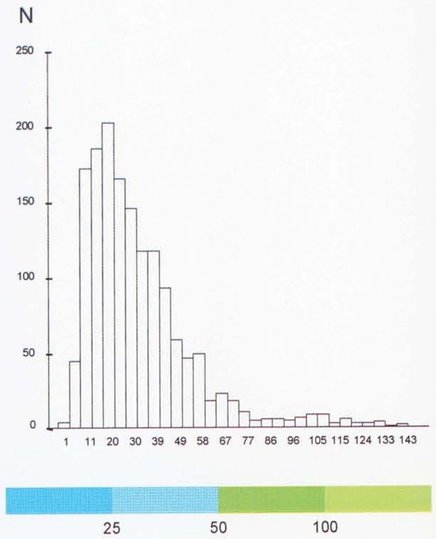
1:200 000

Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

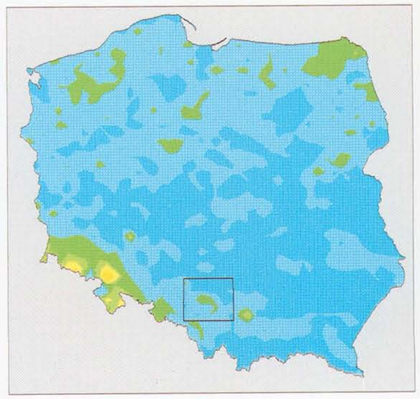
Ti TYTAN TITANIUM

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/kg = g/t

Liczba próbek	1564	Number of samples
Minimum	1	Minimum
Maksimum	396	Maximum
Średnia arytm.	35	Arithmetic mean
Średnia geom.	27	Geometric mean
Mediana	28	Median
Granica wykrywalności	1	Detection limit

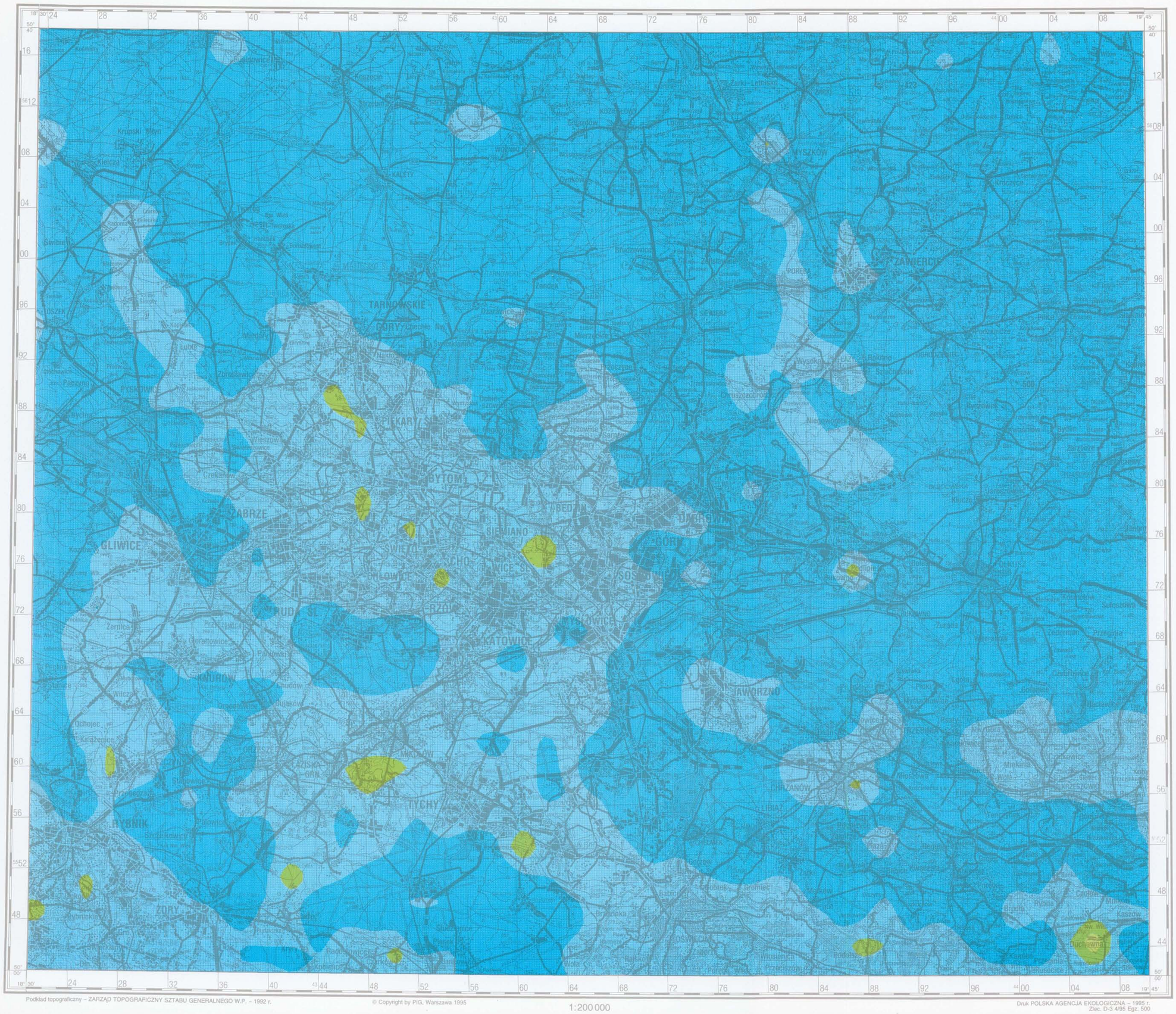


80 Wartość graniczna dla tła w glebach Polski
Limit value for background in soil of Poland



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

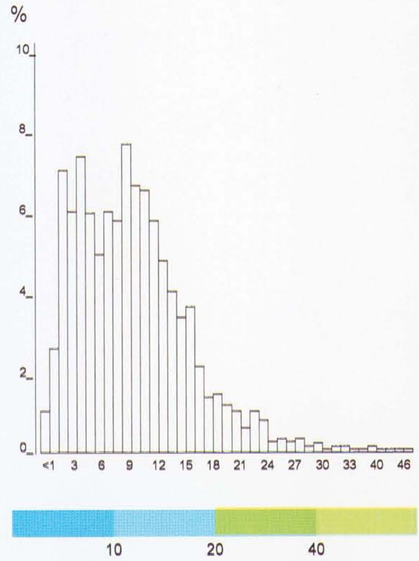
1:200 000
Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500



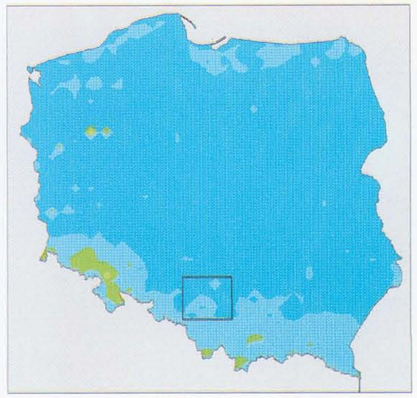
V WANAD VANADIUM

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/kg = g/t

Liczba próbek	1564	Number of samples
Minimum	< 1	Minimum
Maksimum	94	Maximum
Średnia arytm.	10	Arithmetic mean
Średnia geom.	8	Geometric mean
Mediana	9	Median
Granica wykrywalności	1	Detection limit

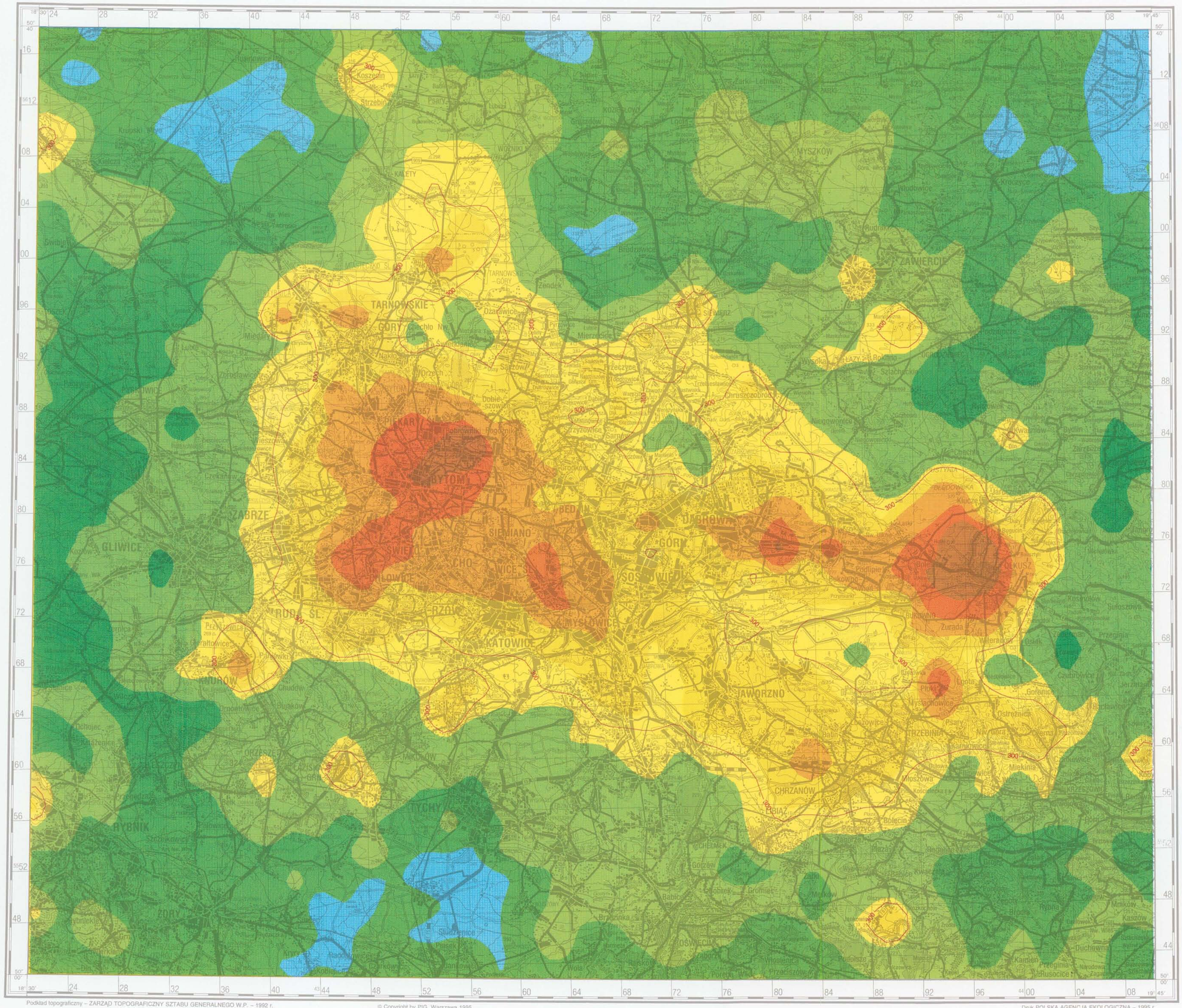


26 Wartość graniczna dla tła w glebach Polski
Limit value for background in soil of Poland



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000
Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

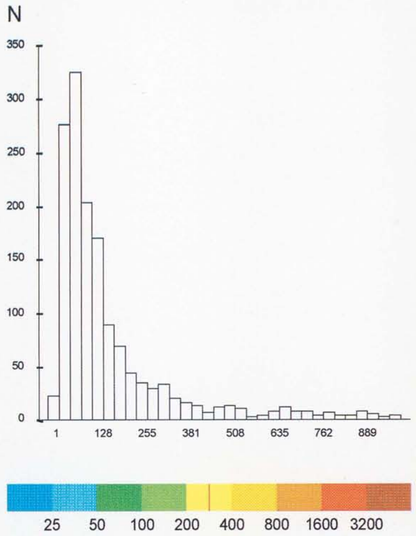
1:200 000

Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

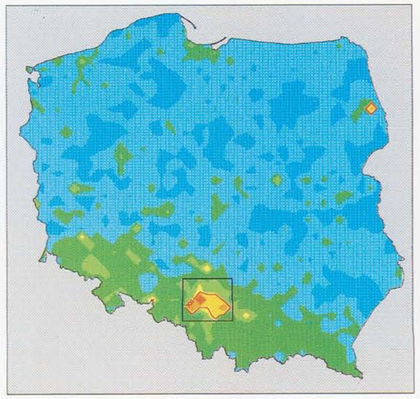
Zn CYNK ZINC

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/kg = g/t

Liczba próbek	1564	Number of samples
Minimum	5	Minimum
Maksimum	87500	Maximum
Średnia arytm.	331	Arithmetic mean
Średnia geom.	121	Geometric mean
Mediana	104	Median
Granica wykrywalności	5	Detection limit



300 — Wartość graniczna w glebach
Limit value in soil

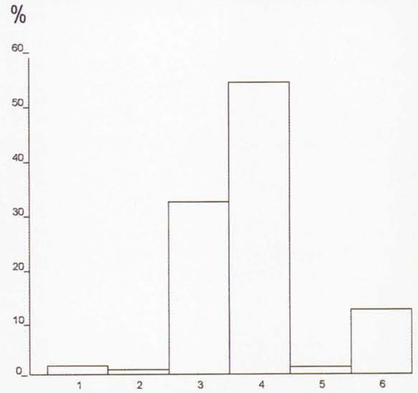


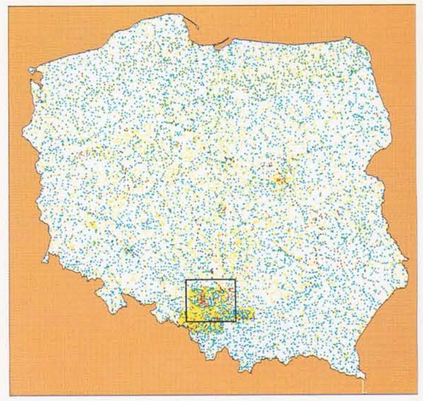
OPRÓBOWANIE
SAMPLING

Zbiorniki wodne — Water bodies

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
Liczba próbek
Number of samples

Rzeki o długości:		Length of rivers:
1 > 500 km	22	1 > 500 km
2 ≥ 100 km ≤ 500 km	11	2 ≥ 100 km ≤ 500 km
3 < 100 km	458	3 < 100 km
4 Małe cieki bez nazwy	158	4 Unnamed small streams
5 Jeziora i sztuczne zbiorniki	782	5 Lakes and artificial reservoires
6 Małe zbiorniki bez nazwy	19	6 Unnamed small reservoires





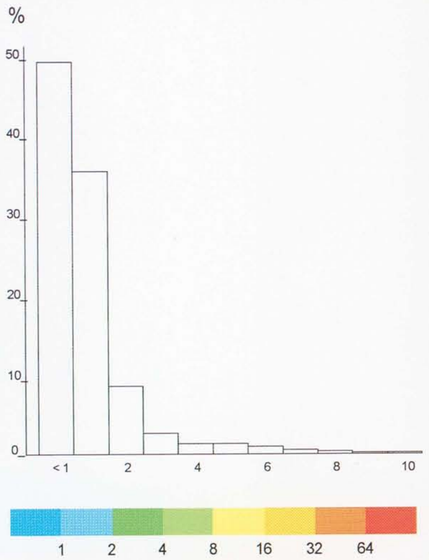
Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000
Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

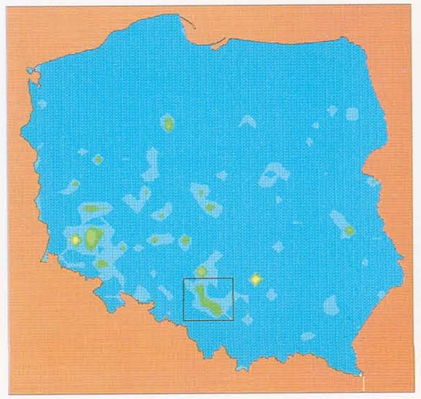
Ag SREBRO SILVER

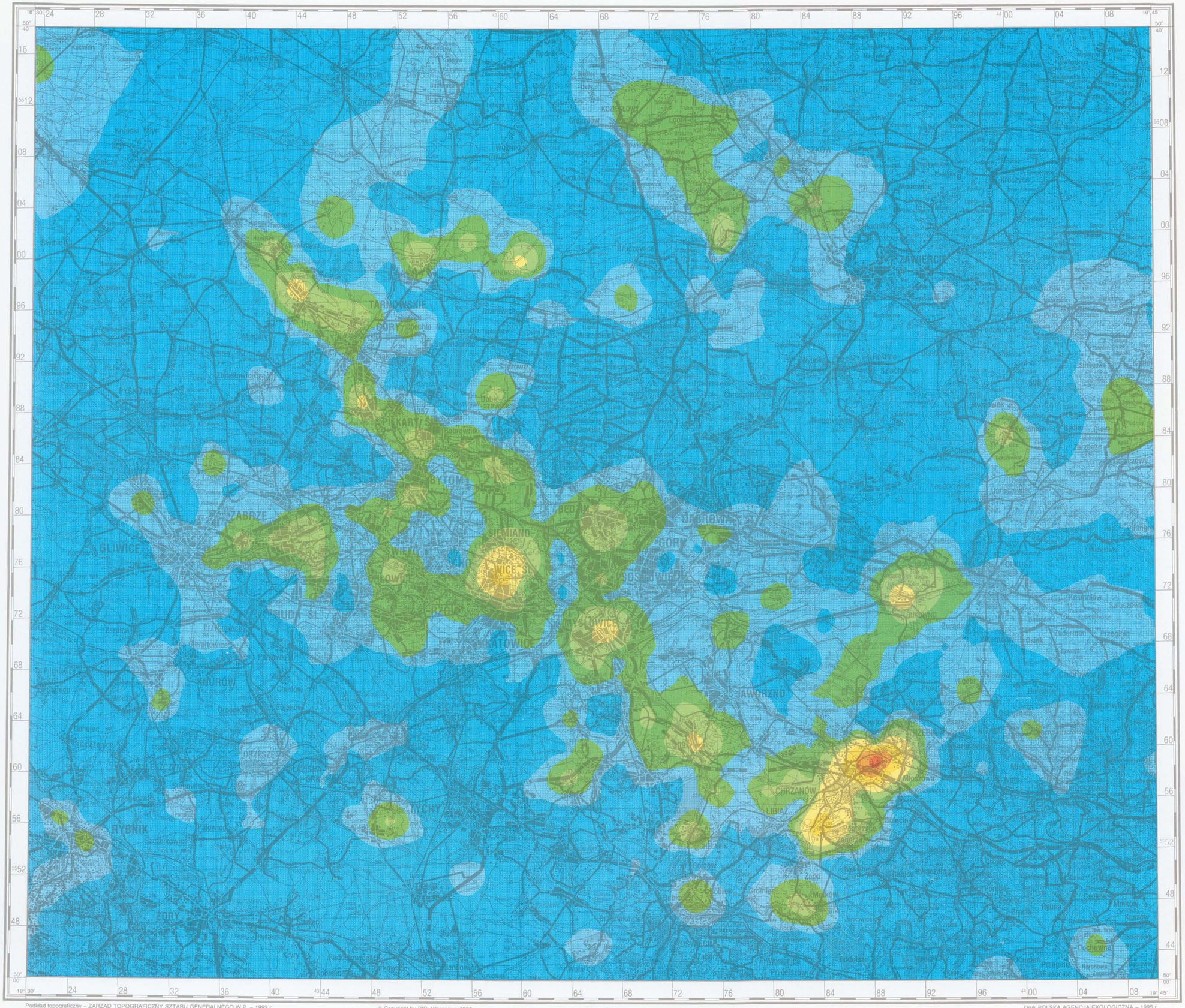
PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/kg = g/t

Liczba próbek	1459	Number of samples
Minimum	< 1	Minimum
Maksimum	117	Maximum
Średnia arytm.	1	Arithmetic mean
Średnia geom.	< 1	Geometric mean
Mediana	1	Median
Granica wykrywalności	1	Detection limit



< 1 Wartość graniczna dla tła w osadach wodnych Polski
Limit value for background in water sediments of Poland





Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

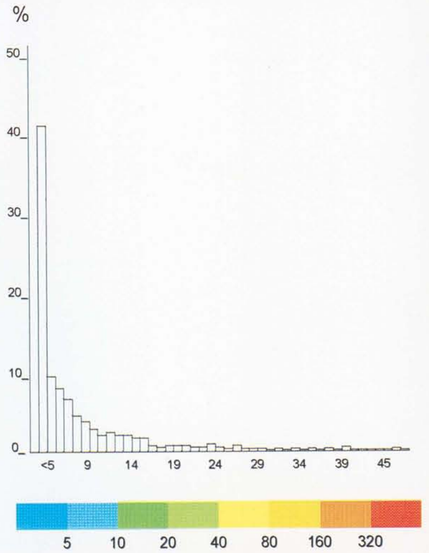
1:200 000

Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

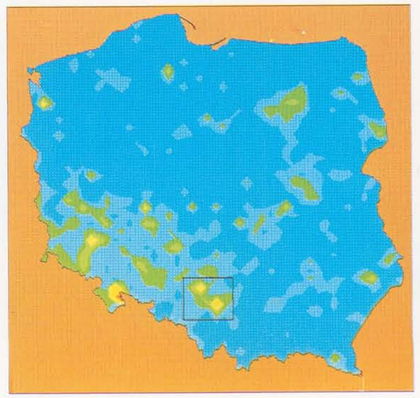
As ARSEN ARSENIC

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/kg = g/t

Liczba próbek	1459	Number of samples
Minimum	< 5	Minimum
Maksimum	901	Maximum
Średnia arytm.	12	Arithmetic mean
Średnia geom.	6	Geometric mean
Mediana	6	Median
Granica wykrywalności	5	Detection limit



< 5 Wartość graniczna dla tła w osadach wodnych Polski
Limit value for background in water sediments of Poland



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

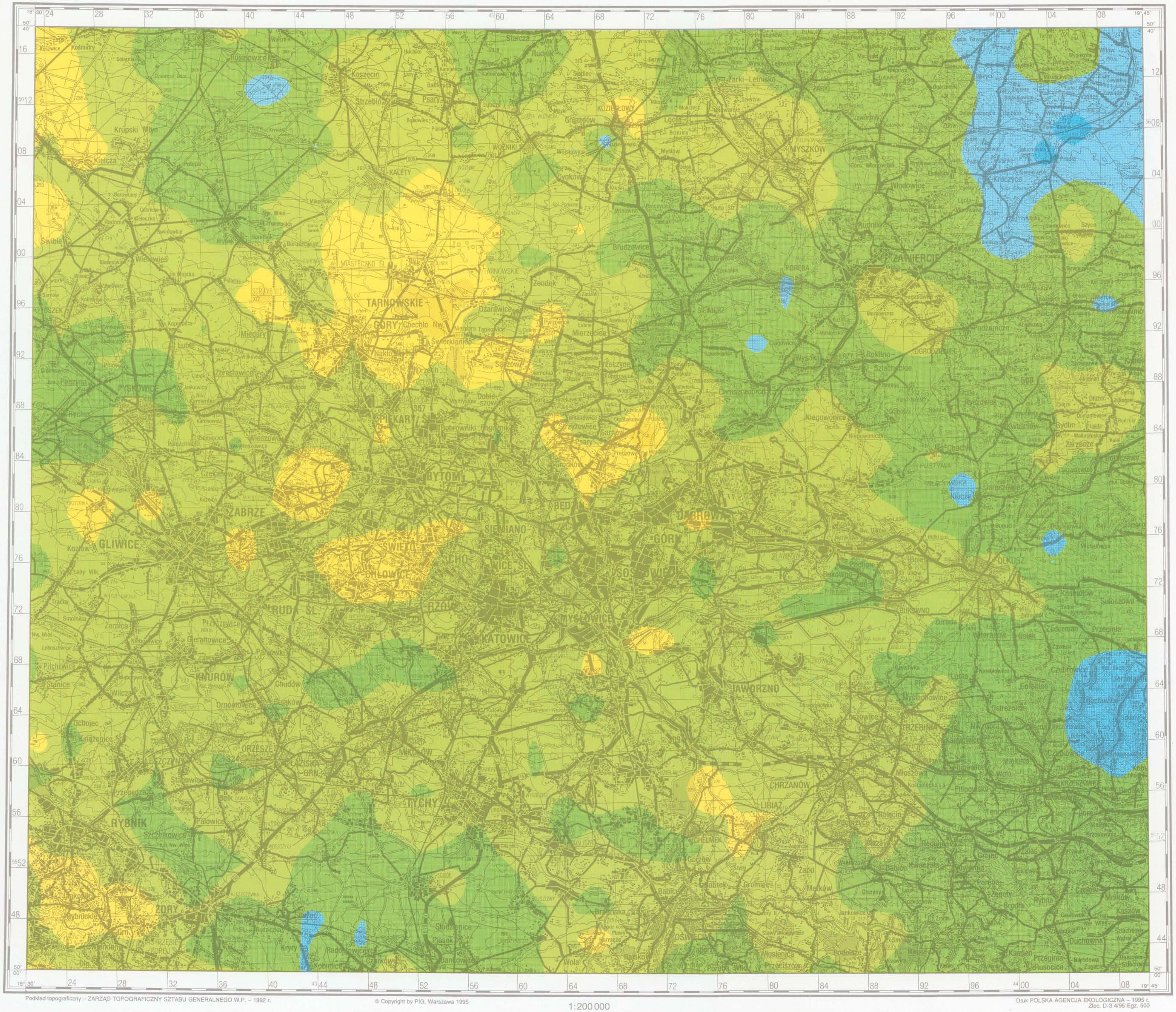
1:200 000

Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

OSADY WODNE
WATER SEDIMENTS

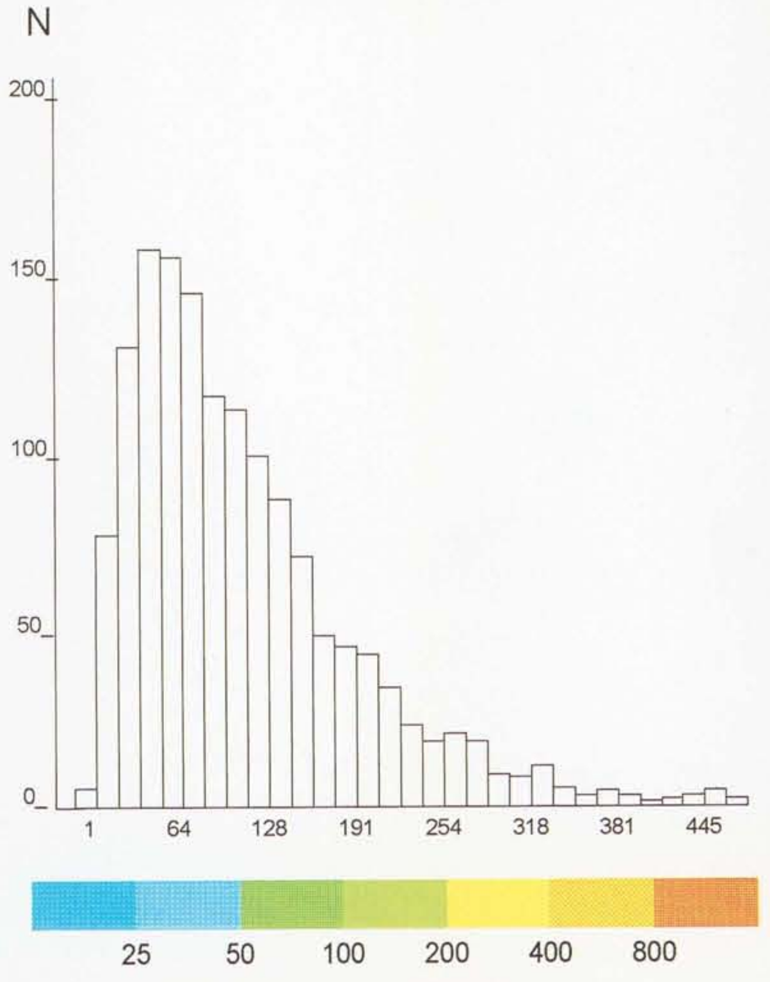
TABLICA
PLATE **26**

Ba BAR BARIUM

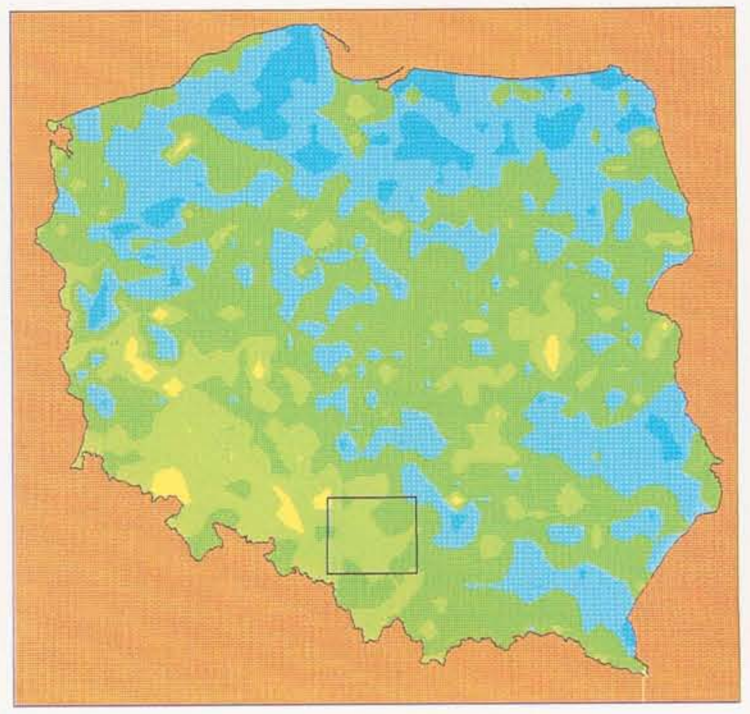


PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/kg = g/t

Liczba próbek	1459	Number of samples
Minimum	3	Minimum
Maksimum	1794	Maximum
Średnia arytm.	127	Arithmetic mean
Średnia geom.	93	Geometric mean
Mediana	98	Median
Granica wykrywalności	1	Detection limit



150 Wartość graniczna dla tła w osadach wodnych Polski
Limit value for background in water sediments of Poland

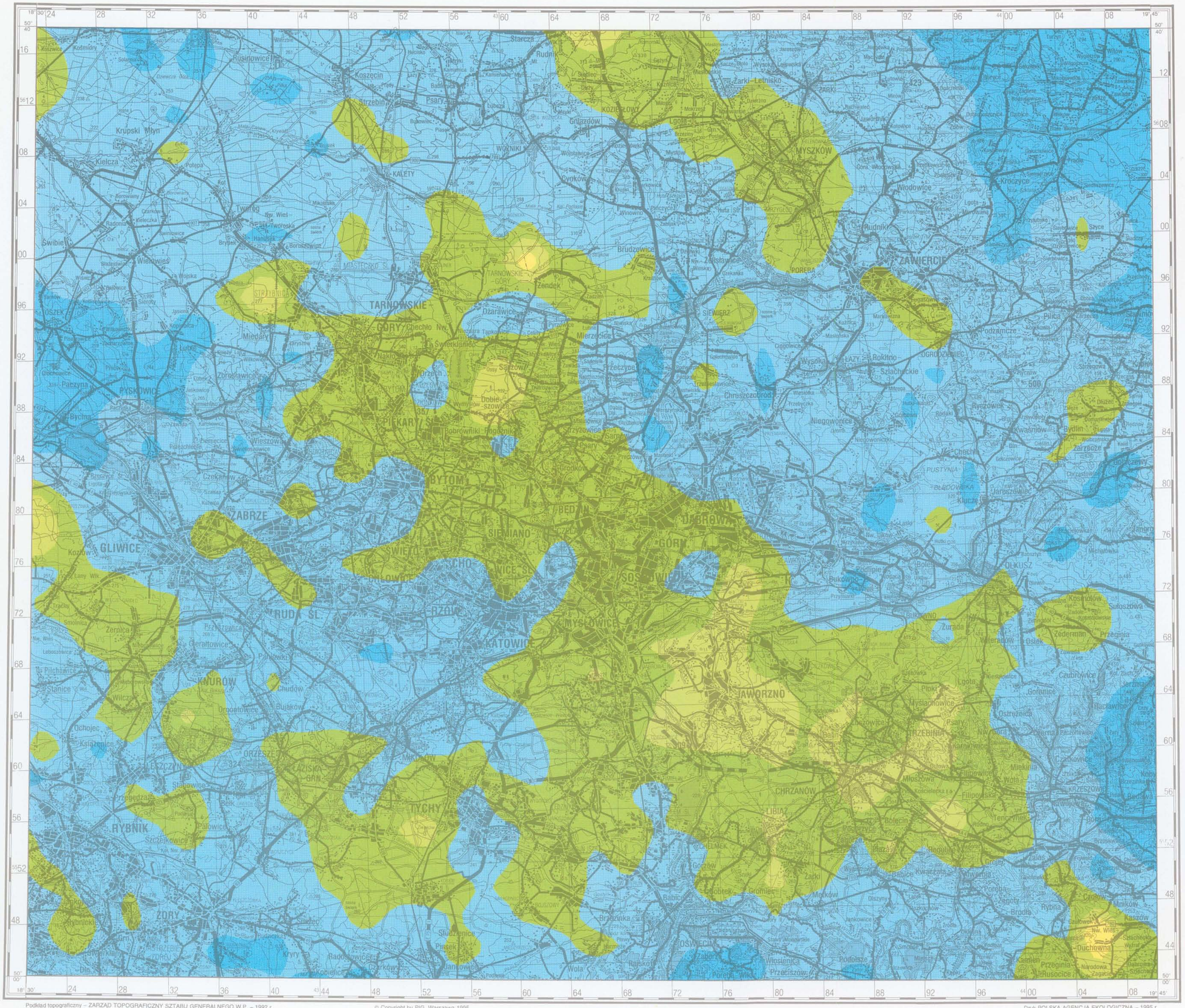


Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000

Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

Be BERYL BERYLLIUM



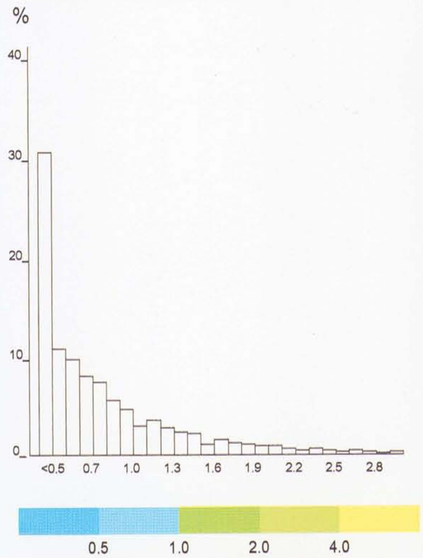
Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000

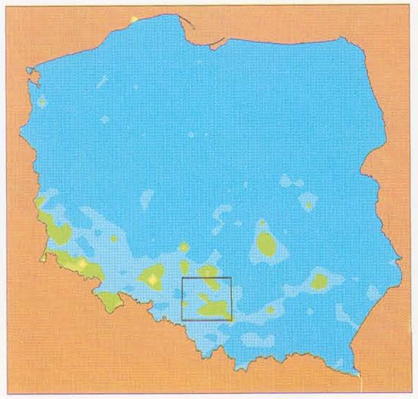
Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

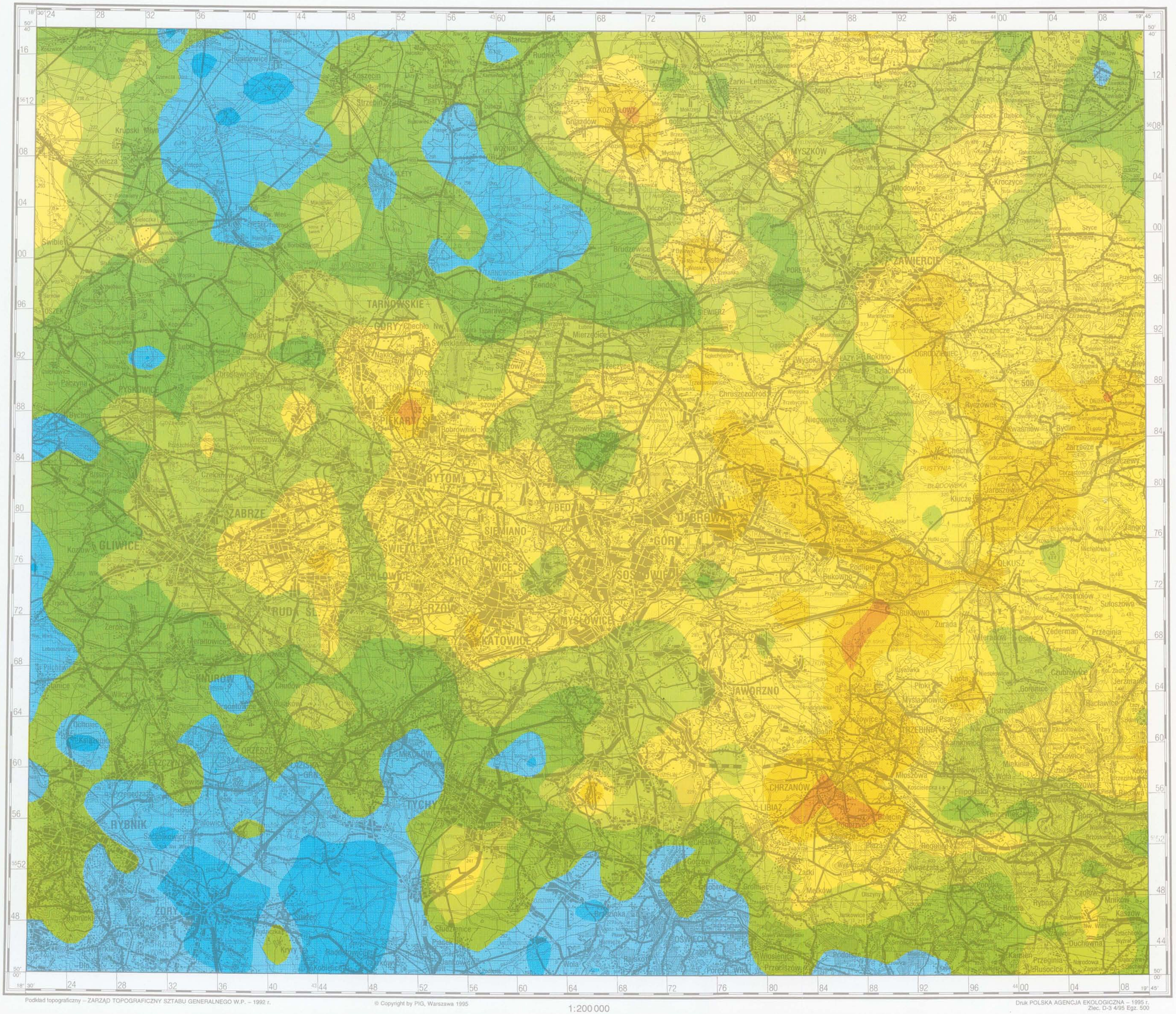
PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/kg = g/t

Liczba próbek	1459	Number of samples
Minimum	< 0.5	Minimum
Maksimum	19.9	Maximum
Średnia arytm.	0.9	Arithmetic mean
Średnia geom.	0.6	Geometric mean
Mediana	0.6	Median
Granica wykrywalności	0.5	Detection limit



< 0.5 Wartość graniczna dla tła w osadach wodnych Polski
Limit value for background in water sediments of Poland





Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

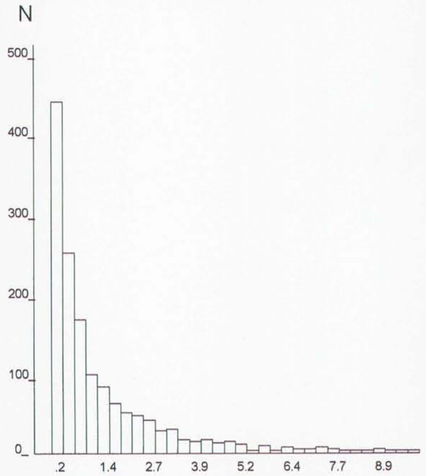
1:200 000

Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

Ca WAPŃ CALCIUM

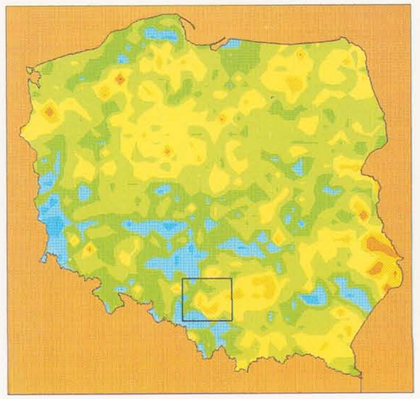
PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
% = procent = percent

Liczba próbek	1459	Number of samples
Minimum	0.02	Minimum
Maksimum	26.55	Maximum
Średnia arytm.	1.63	Arithmetic mean
Średnia geom.	0.71	Geometric mean
Mediana	0.71	Median
Granica wykrywalności	0.01	Detection limit



0.25 0.50 1.00 2.00 4.00 8.00 16.00

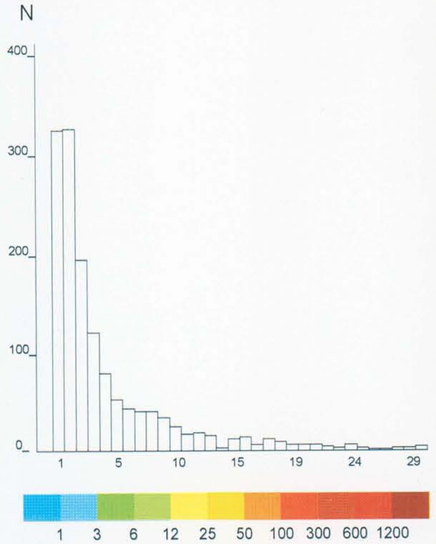
2.4 Wartość graniczna dla tła w osadach wodnych Polski
Limit value for background in water sediments of Poland



Cd KADM CADMIUM

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/kg = g/t

Liczba próbek	1459	Number of samples
Minimum	< 0.5	Minimum
Maksimum	8735.9	Maximum
Średnia arytm.	17.0	Arithmetic mean
Średnia geom.	2.8	Geometric mean
Mediana	2.5	Median
Granica wykrywalności	0.5	Detection limit



1.8 Wartość graniczna dla tła w osadach wodnych Polski
Limit value for background in water sediments of Poland

1:200 000

Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

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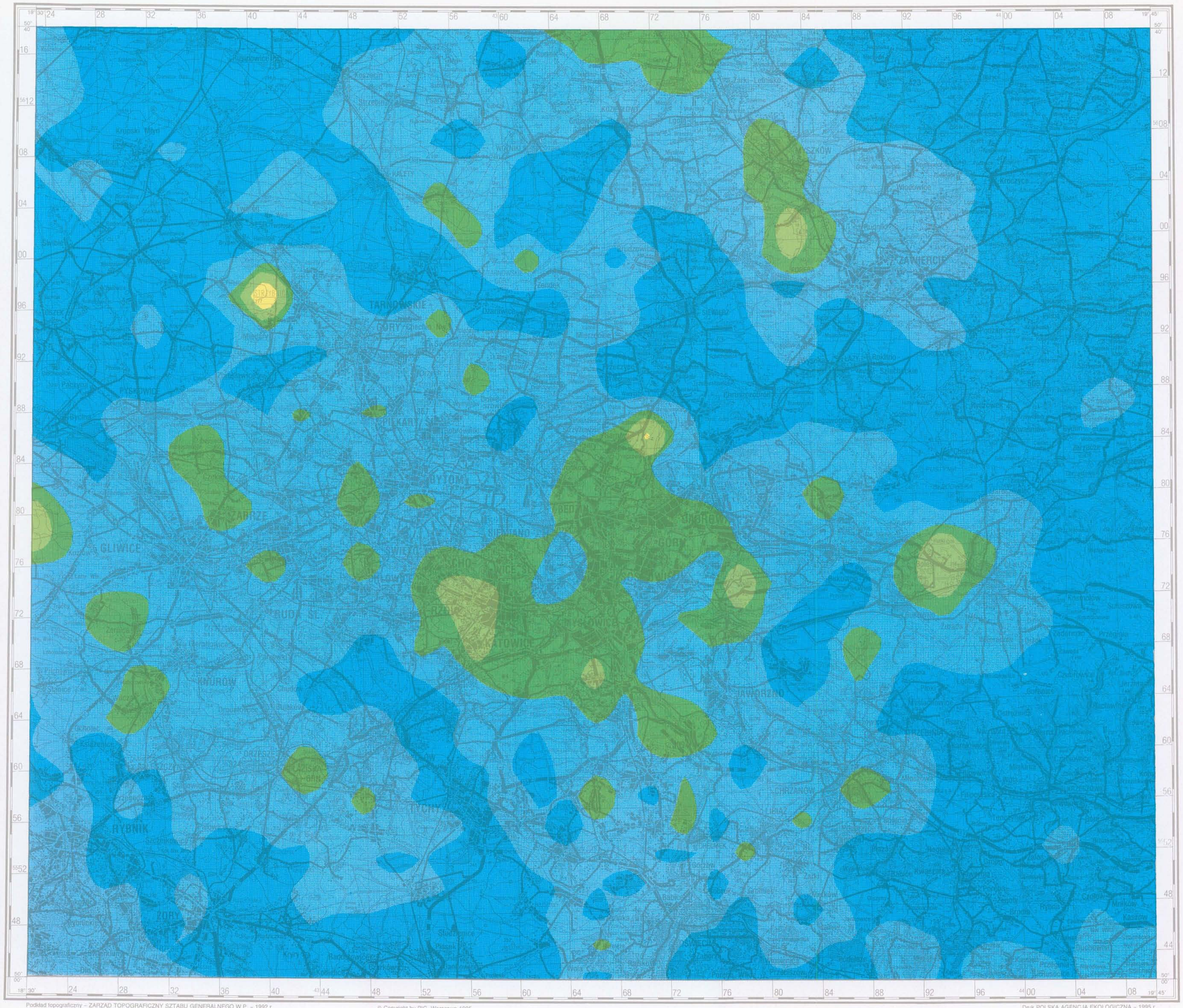

Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000

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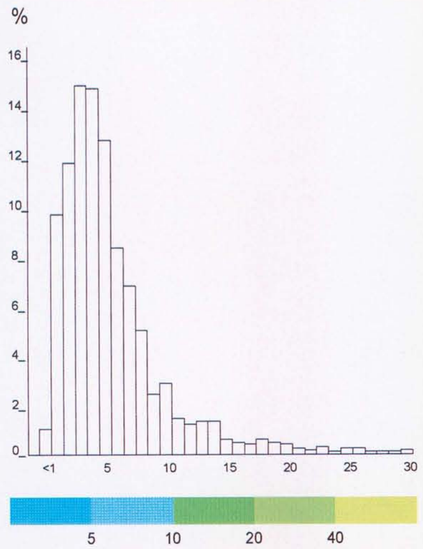
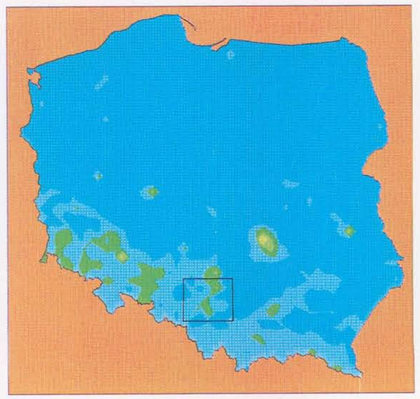
Co KOBALT COBALT

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/kg = g/t

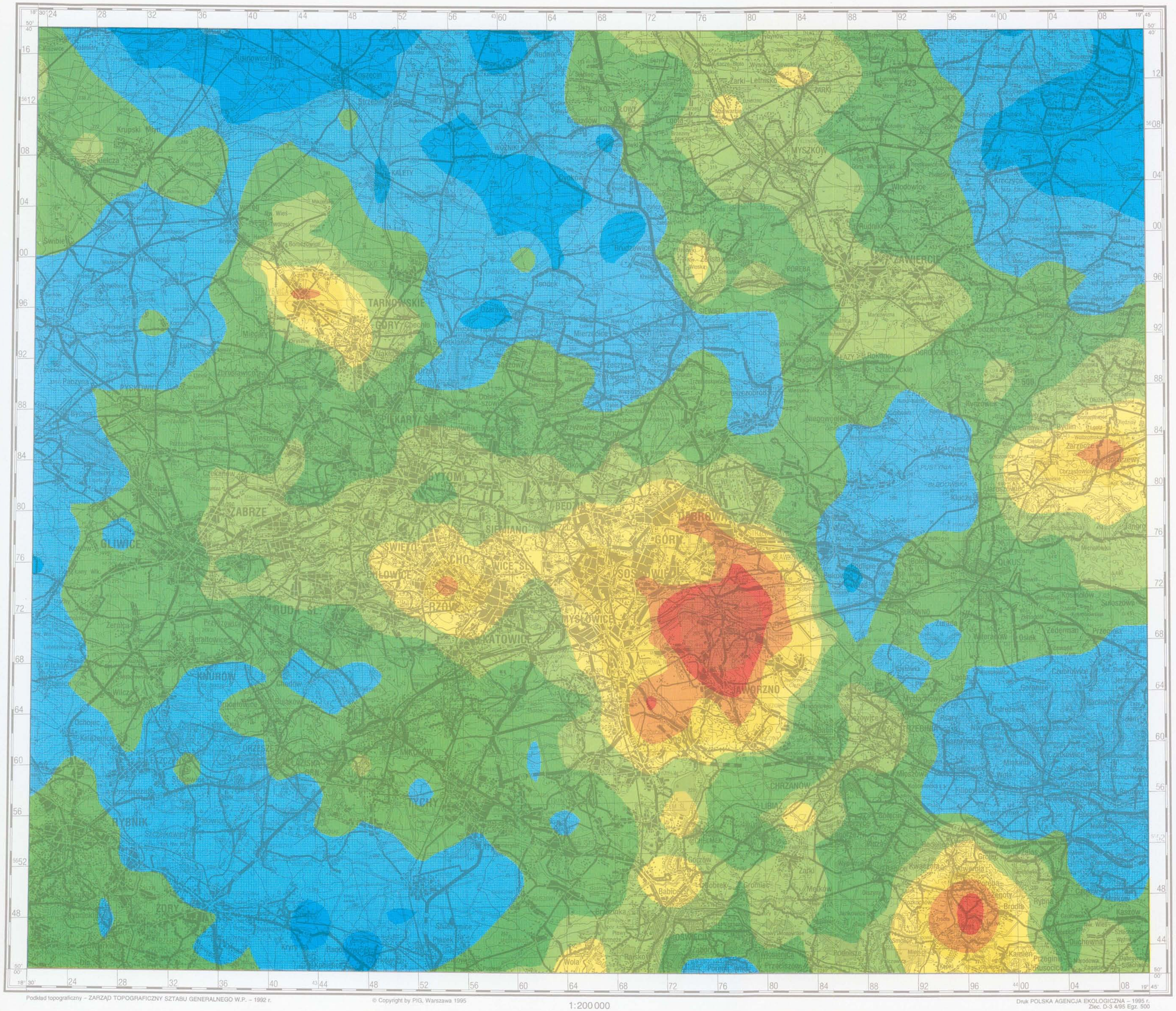
Liczba próbek	1459	Number of samples
Minimum	< 1	Minimum
Maksimum	164	Maximum
Średnia arytm.	6	Arithmetic mean
Średnia geom.	4	Geometric mean
Mediana	4	Median
Granica wykrywalności	1	Detection limit



9 Wartość graniczna dla tła w osadach wodnych Polski
Limit value for background in water sediments of Poland

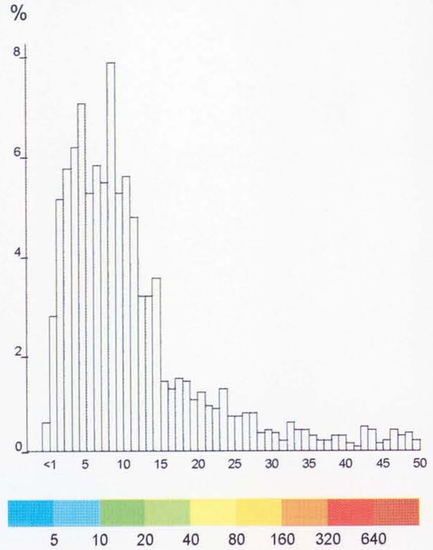


Cr CHROM CHROMIUM

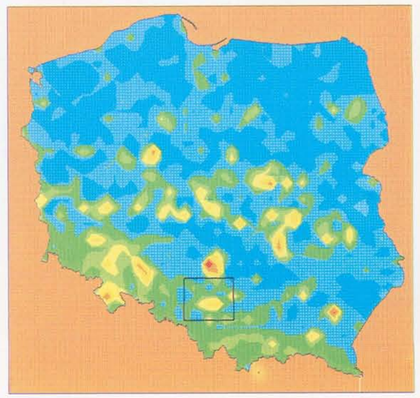


PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/kg = g/t

Liczba próbek	1459	Number of samples
Minimum	< 1	Minimum
Maksimum	12251	Maximum
Średnia arytm.	32	Arithmetic mean
Średnia geom.	10	Geometric mean
Mediana	9	Median
Granica wykrywalności	1	Detection limit



18 Wartość graniczna dla tła w osadach wodnych Polski
Limit value for background in water sediments of Poland



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000

Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
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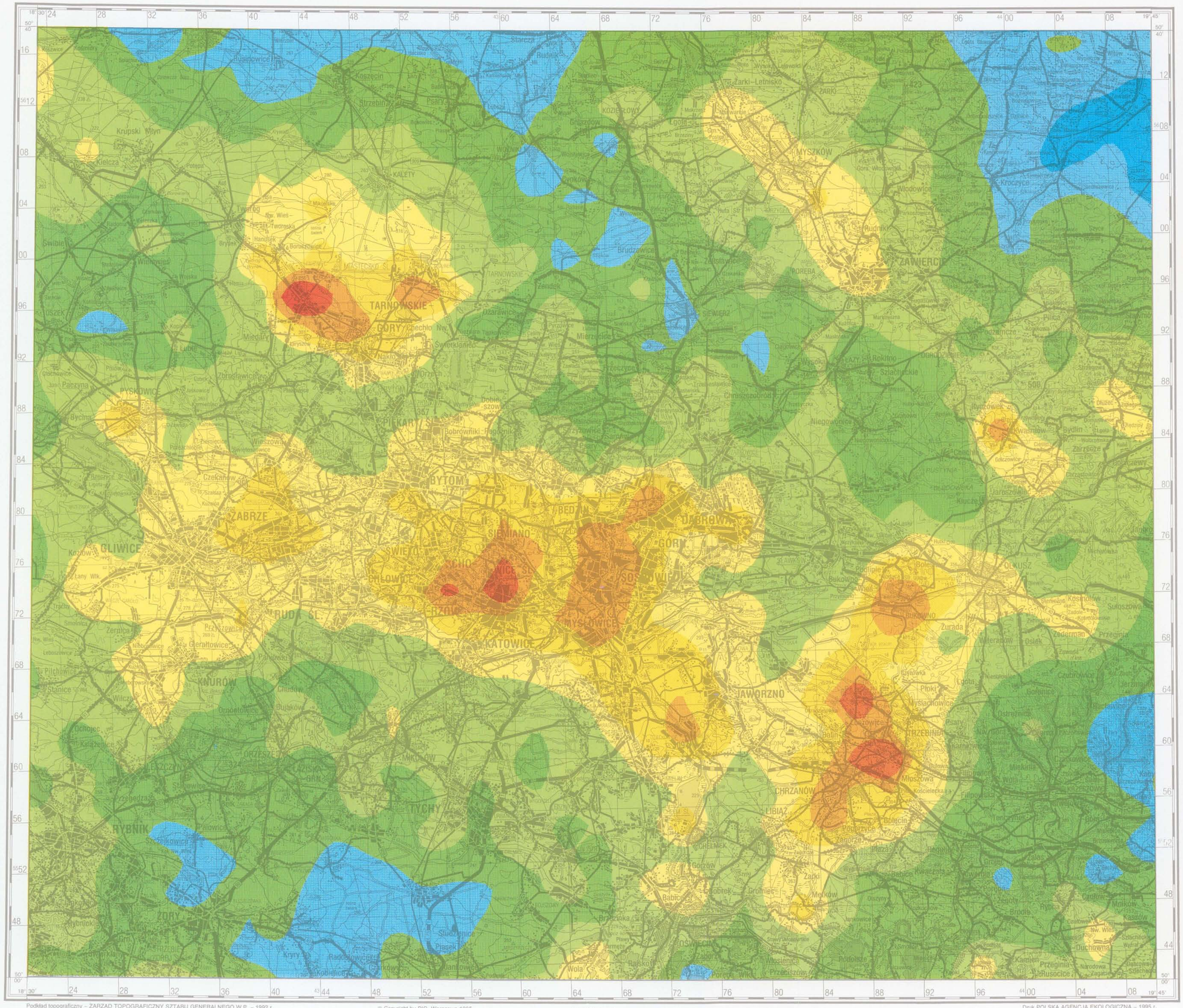


Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

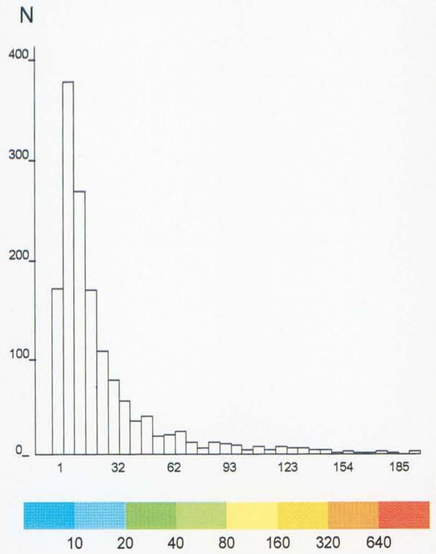
1:200 000

Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

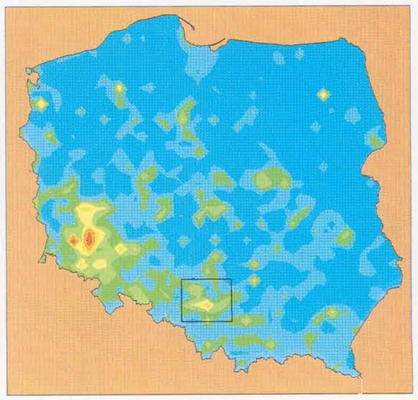
Cu MIEDŹ COPPER

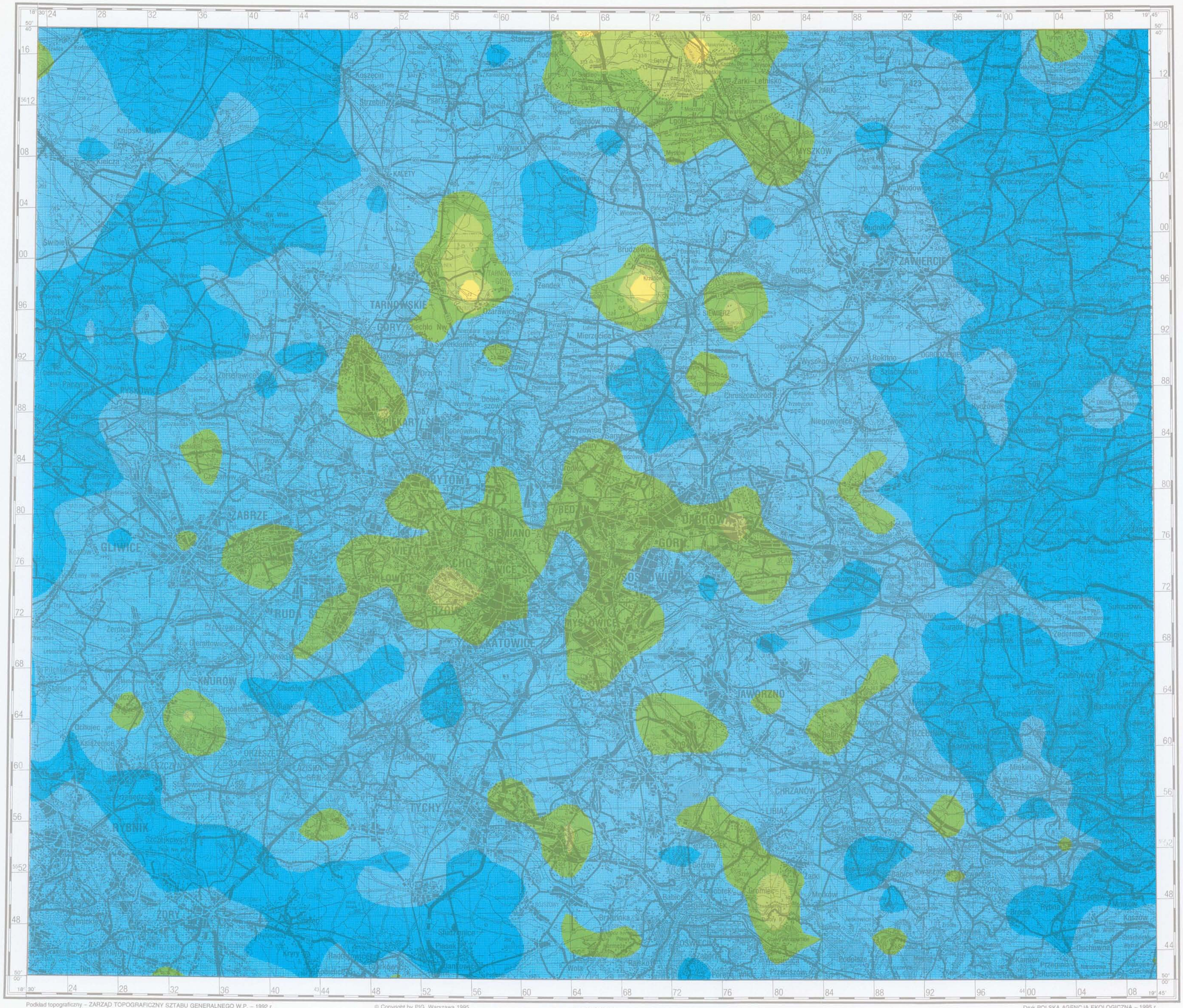
PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/kg = g/t

Liczba próbek	1459	Number of samples
Minimum	1	Minimum
Maksimum	1886	Maximum
Średnia arytm.	39	Arithmetic mean
Średnia geom.	16	Geometric mean
Mediana	15	Median
Granica wykrywalności	1	Detection limit



25 Wartość graniczna dla tła w osadach wodnych Polski
Limit value for background in water sediments of Poland





OSADY WODNE
WATER SEDIMENTS

TABLICA
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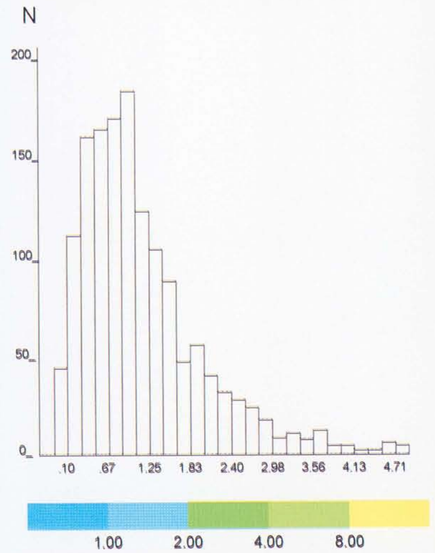
Fe ŻELAZO
IRON

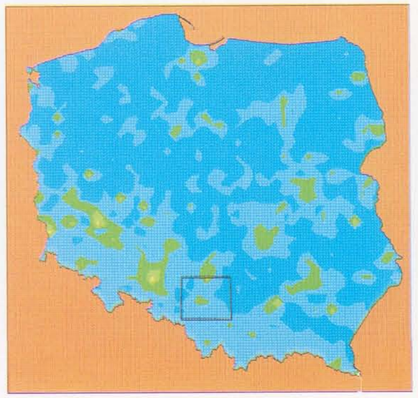
PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS

% = procent = percent

Liczba próbek	1459	Number of samples
Minimum	0.03	Minimum
Maksimum	26.43	Maximum
Średnia arytm.	1.42	Arithmetic mean
Średnia geom.	1.01	Geometric mean
Mediana	1.07	Median
Granica wykrywalności	0.01	Detection limit



2.25 Wartość graniczna dla tła w osadach wodnych Polski
Limit value for background in water sediments of Poland



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000

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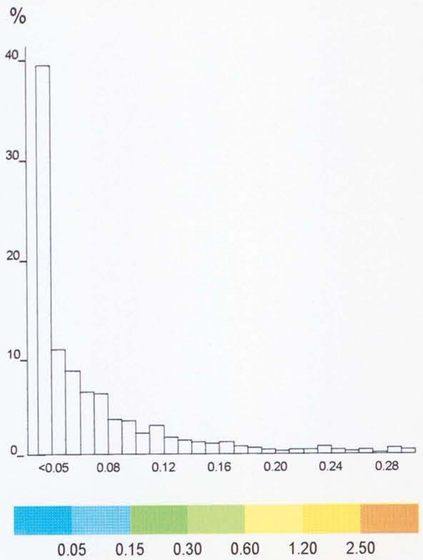
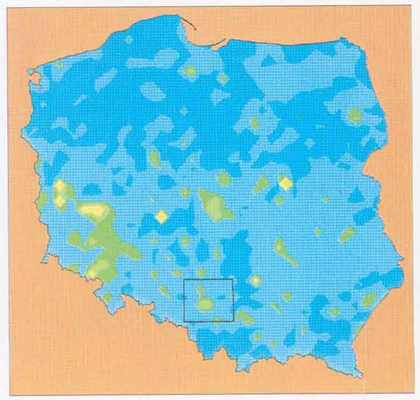
Hg RTĘĆ MERCURY

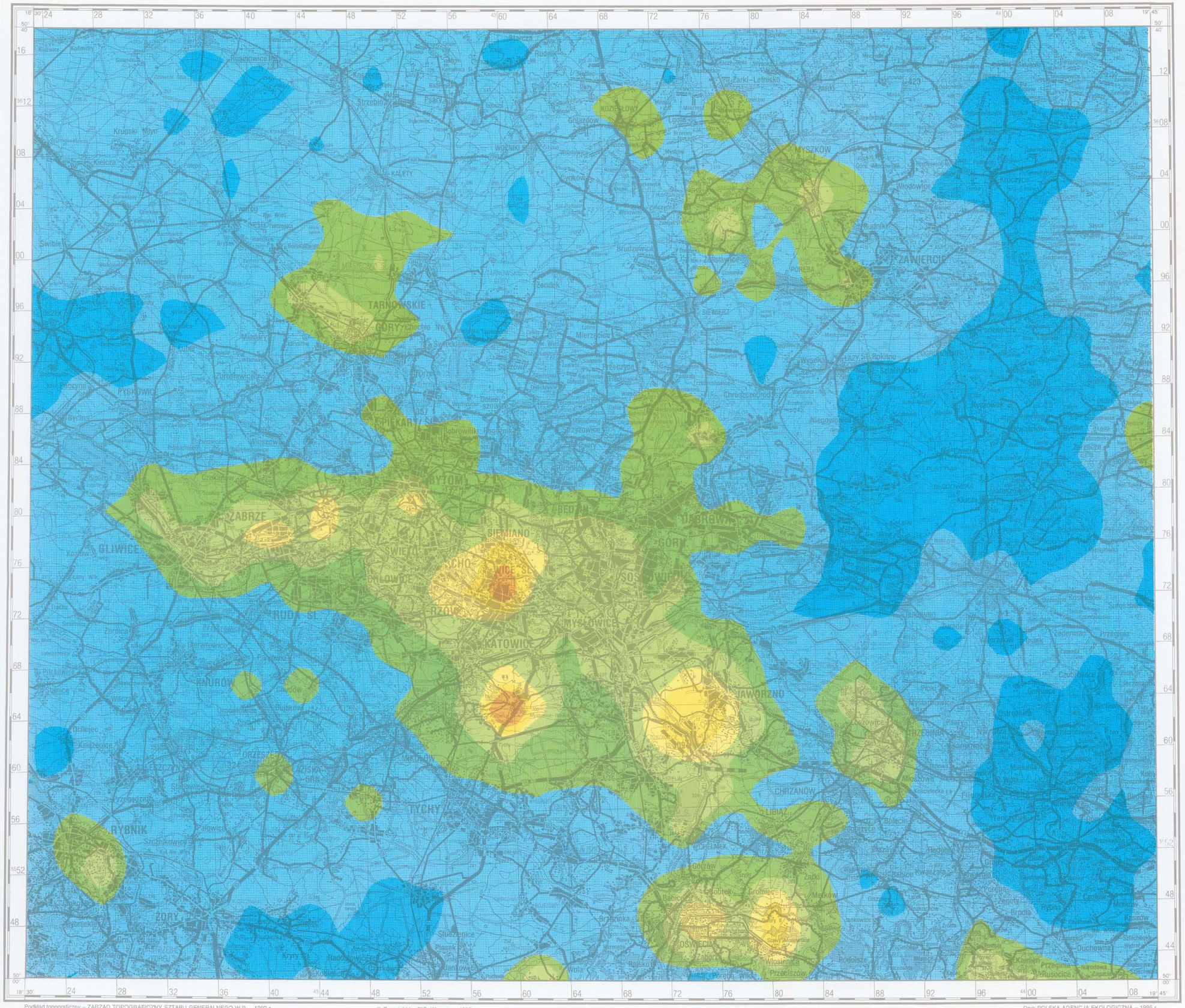
PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/kg = g/t

Liczba próbek	1459	Number of samples
Minimum	< 0.05	Minimum
Maksimum	10.50	Maximum
Średnia arytm.	0.15	Arithmetic mean
Średnia geom.	<0.05	Geometric mean
Mediana	0.06	Median
Granica wykrywalności	0.05	Detection limit



0.10 Wartość graniczna dla tła w osadach wodnych Polski
Limit value for background in water sediments of Poland





Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000

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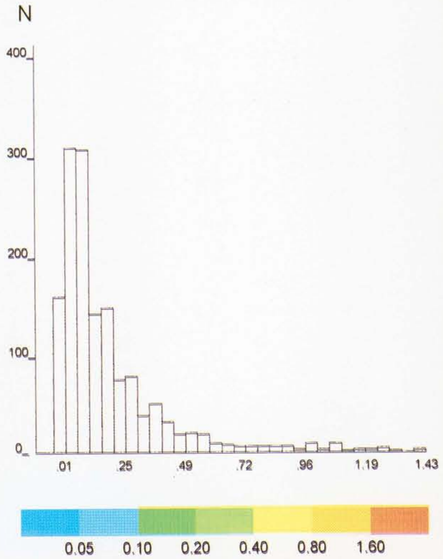
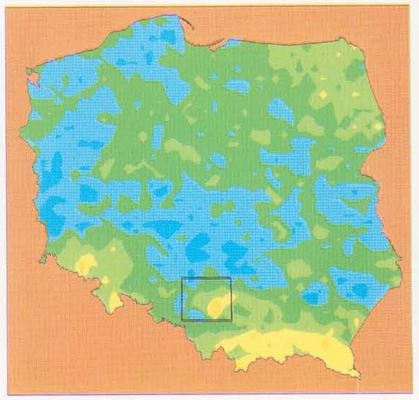
Mg MAGNEZ MAGNESIUM

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
% = procent = percent

Liczba próbek	1459	Number of samples
Minimum	0.01	Minimum
Maksimum	5.87	Maximum
Średnia arytm.	0.25	Arithmetic mean
Średnia geom.	0.13	Geometric mean
Mediana	0.13	Median
Granica wykrywalności	0.01	Detection limit



0.33 Wartość graniczna dla tła w osadach wodnych Polski
Limit value for background in water sediments of Poland



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000

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OSADY WODNE
WATER SEDIMENTS

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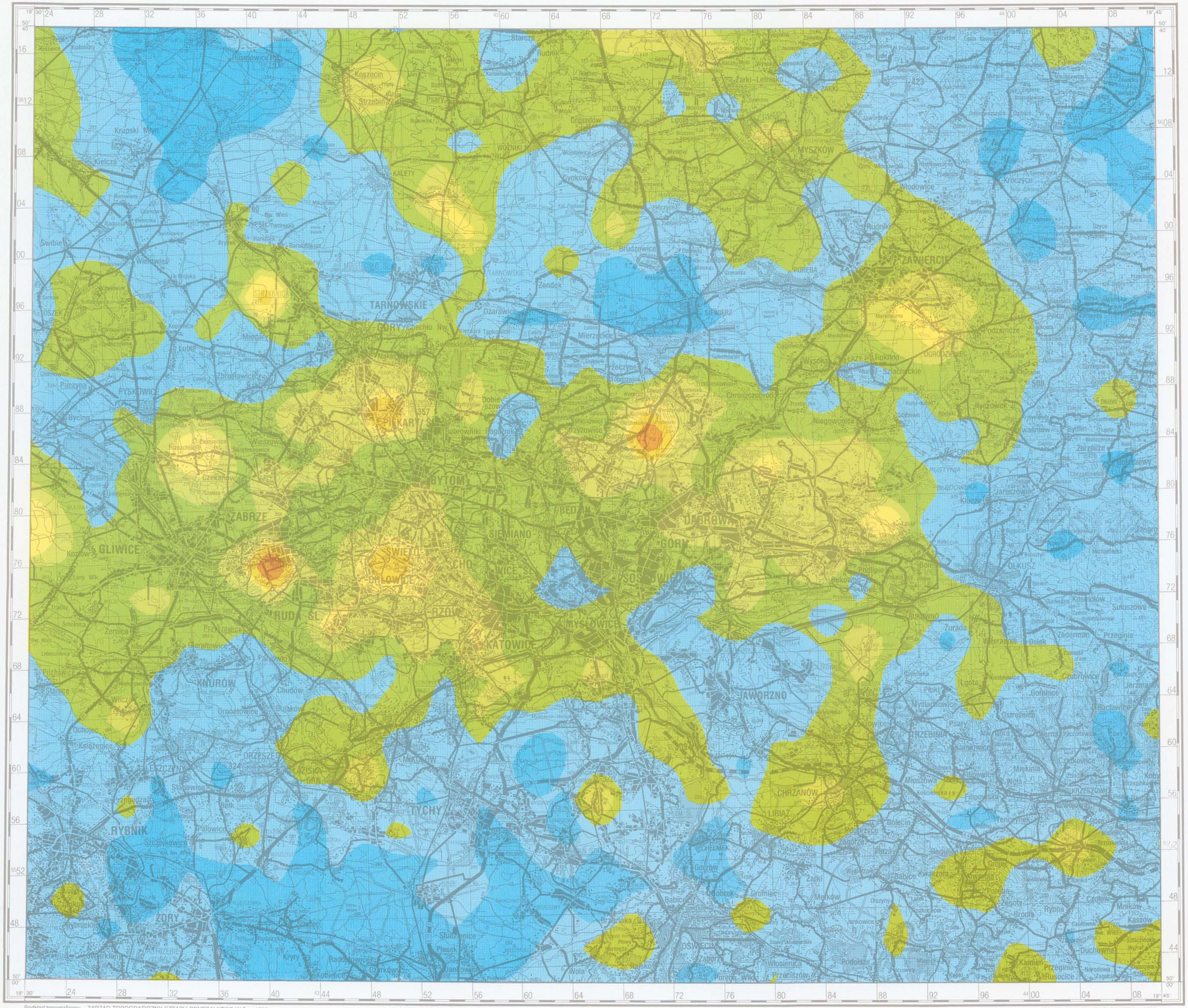
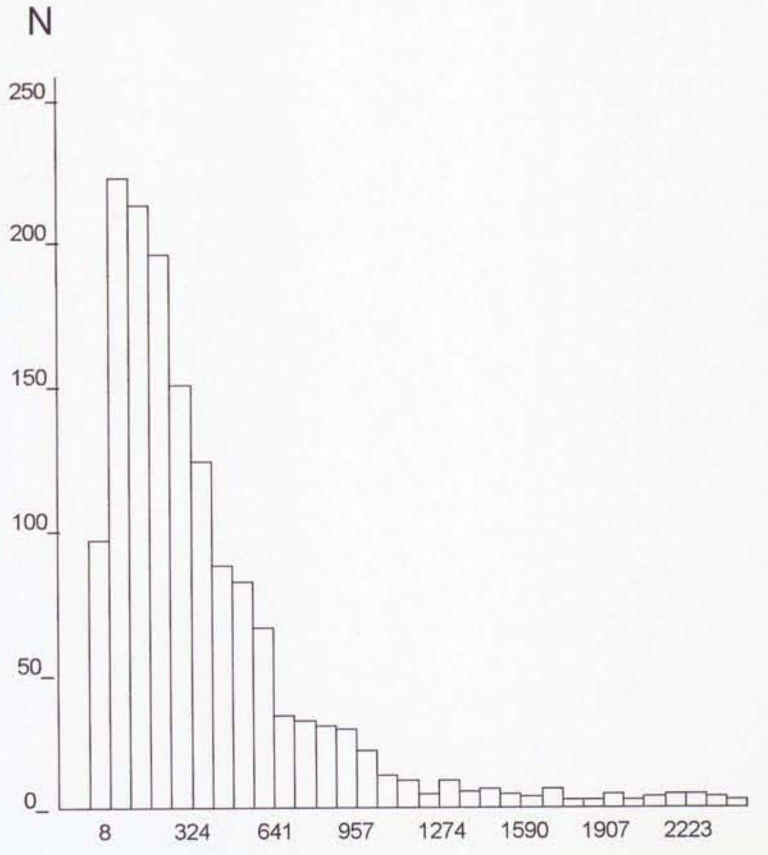
Mn MANGAN
MANGANESE

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/kg = g/t

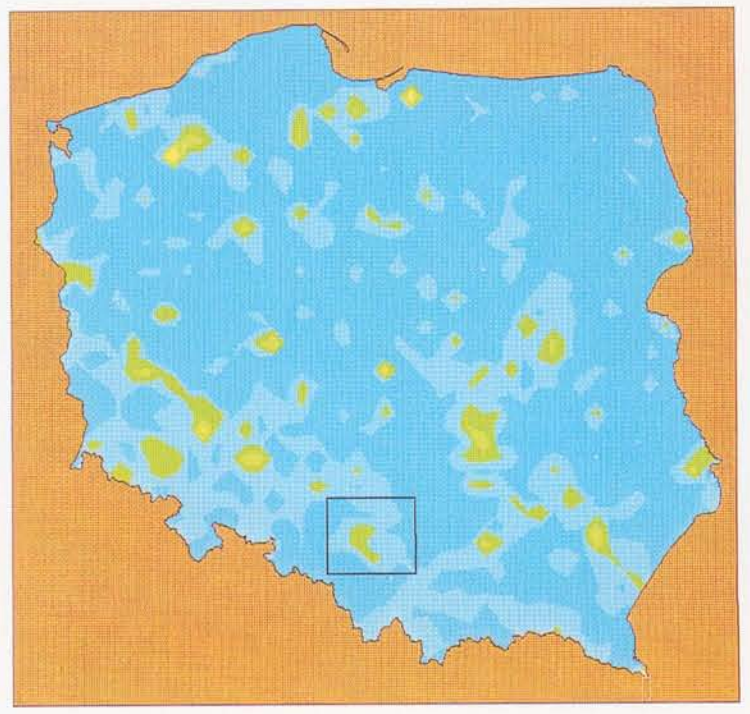
Liczba próbek	1459	Number of samples
Minimum	4	Minimum
Maksimum	21295	Maximum
Średnia arytm.	558	Arithmetic mean
Średnia geom.	280	Geometric mean
Mediana	292	Median
Granica wykrywalności	1	Detection limit





500 1000 2000 4000 8000

770 Wartość graniczna dla tła w osadach wodnych Polski
Limit value for background in water sediments of Poland



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000

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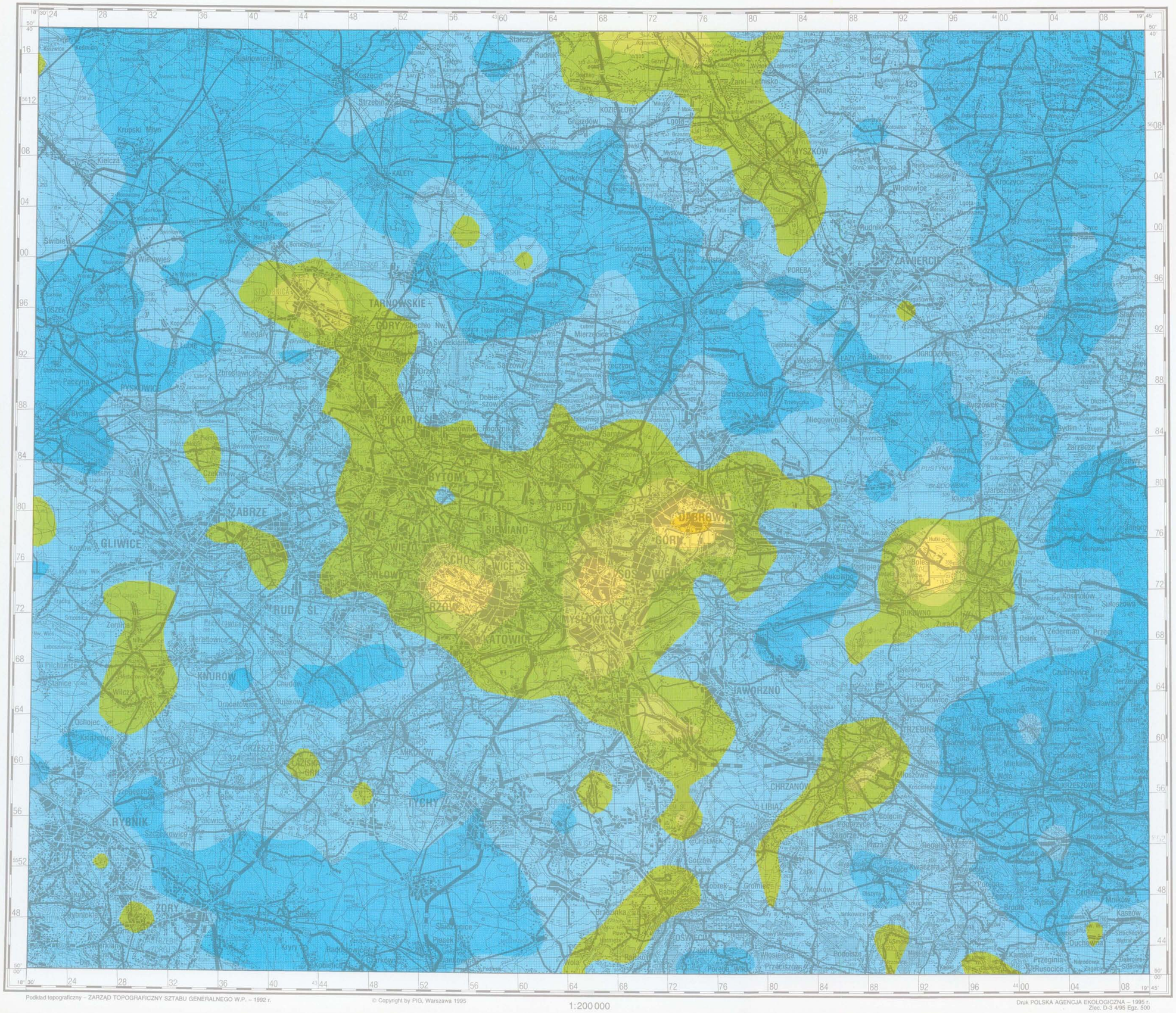
Zlec. D-3 4/95 Egz. 500



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000

Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
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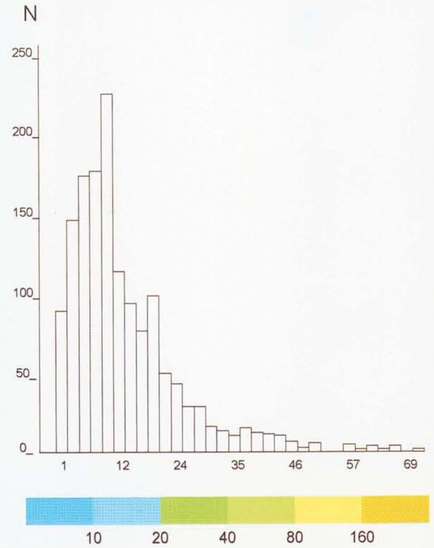
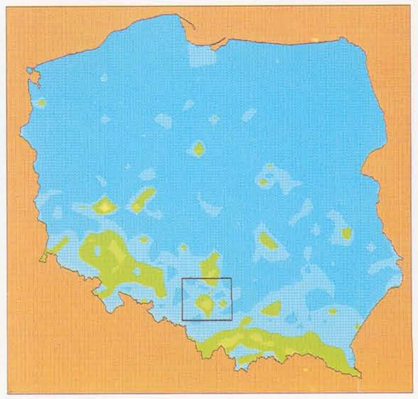
Ni NIKIEL NICKEL

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/kg = g/t

Liczba próbek	1459	Number of samples
Minimum	< 1	Minimum
Maksimum	795	Maximum
Średnia arytm.	16	Arithmetic mean
Średnia geom.	10	Geometric mean
Mediana	11	Median
Granica wykrywalności	1	Detection limit



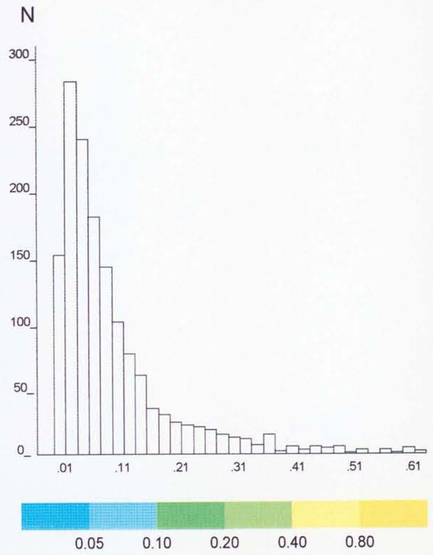
18 Wartość graniczna dla tła w osadach wodnych Polski
Limit value for background in water sediments of Poland



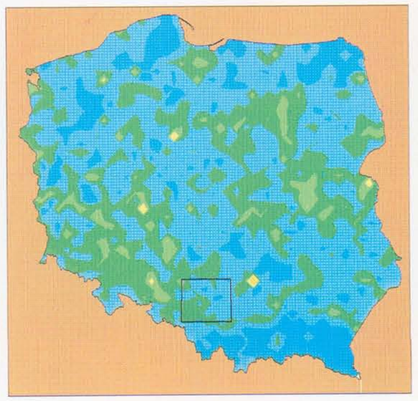
P FOSFOR PHOSPHORUS

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
% = procent = percent

Liczba próbek	1459	Number of samples
Minimum	< 0.005	Minimum
Maksimum	3.961	Maximum
Średnia arytm.	0.107	Arithmetic mean
Średnia geom.	0.067	Geometric mean
Mediana	0.066	Median
Granica wykrywalności	0.005	Detection limit



0.190 Wartość graniczna dla tła w osadach wodnych Polski
Limit value for background in water sediments of Poland



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000

Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
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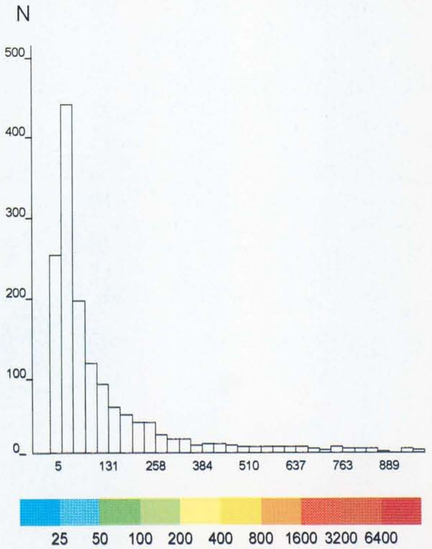
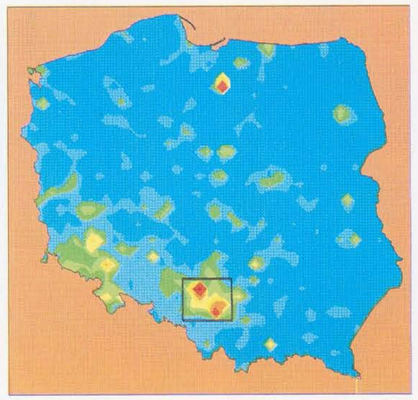
Pb OŁÓW LEAD

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/kg = g/t

Liczba próbek	1459	Number of samples
Minimum	< 5	Minimum
Maksimum	43878	Maximum
Średnia arytm.	328	Arithmetic mean
Średnia geom.	72	Geometric mean
Mediana	59	Median
Granica wykrywalności	5	Detection limit



45 Wartość graniczna dla tła w osadach wodnych Polski
Limit value for background in water sediments of Poland



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000

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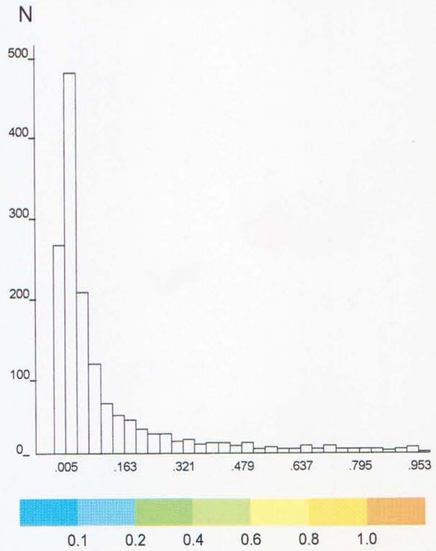
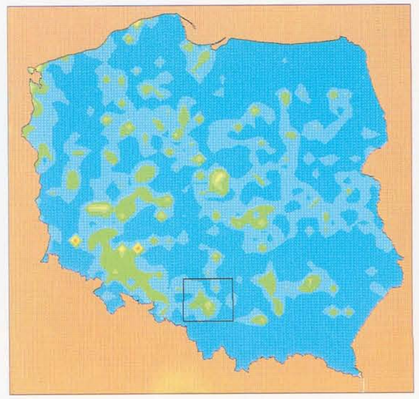
S SIARKA SULPHUR

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
% = procent = percent

Liczba próbek	1459	Number of samples
Minimum	< 0.005	Minimum
Maksimum	2.193	Maximum
Średnia arytm.	0.150	Arithmetic mean
Średnia geom.	0.064	Geometric mean
Mediana	0.052	Median
Granica wykrywalności	0.005	Detection limit



0.140 Wartość graniczna dla tła w osadach wodnych Polski
Limit value for background in water sediments of Poland



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000

Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
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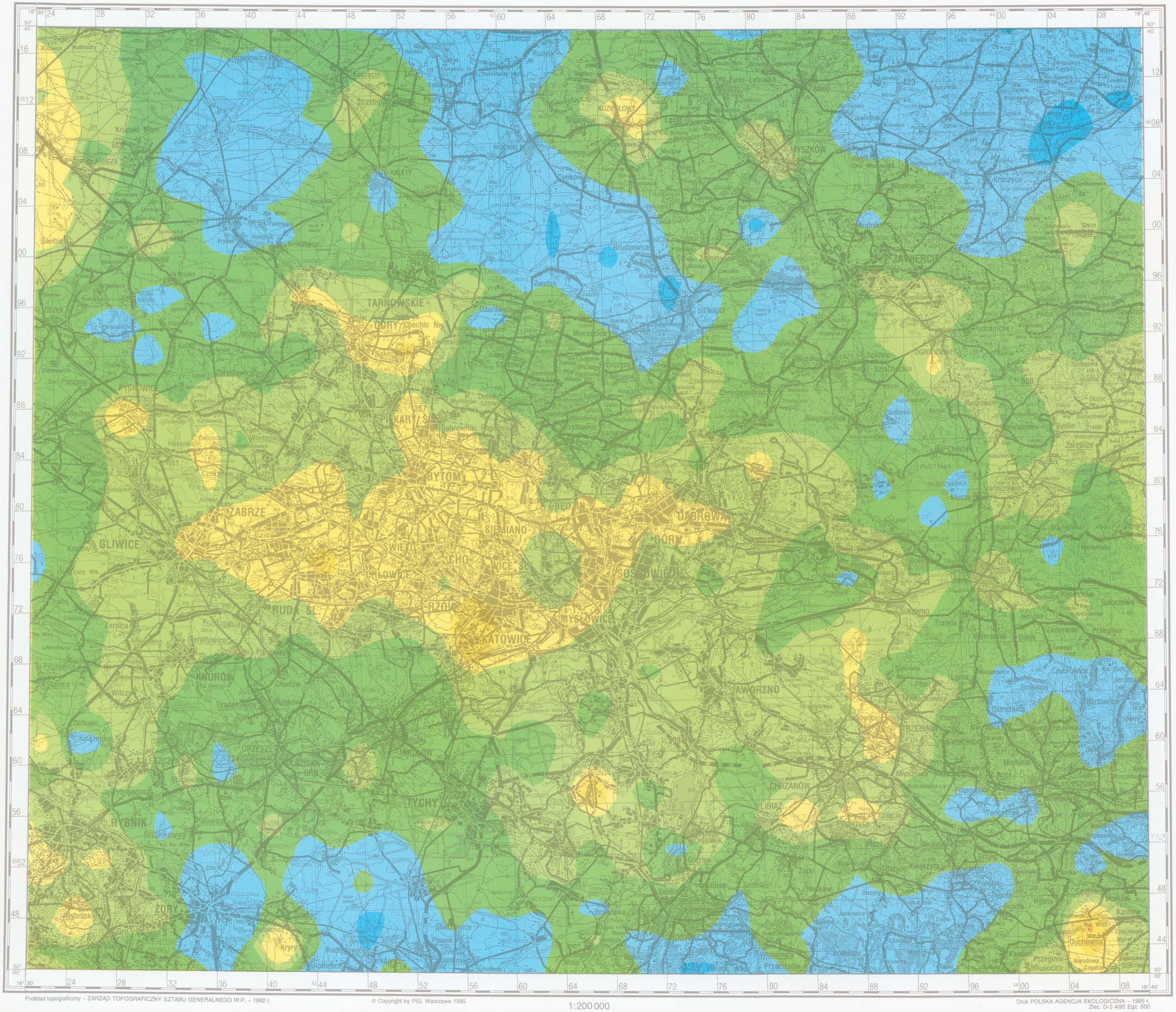


Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

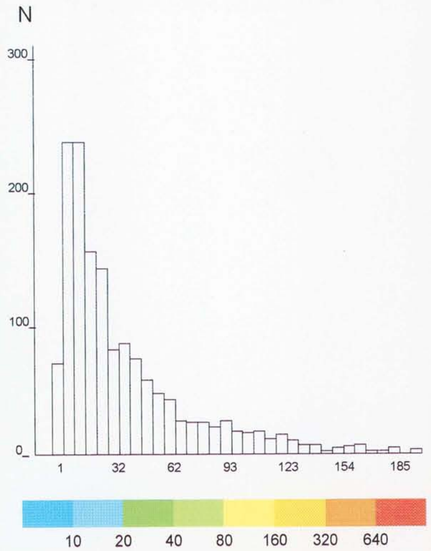
1:200 000

Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

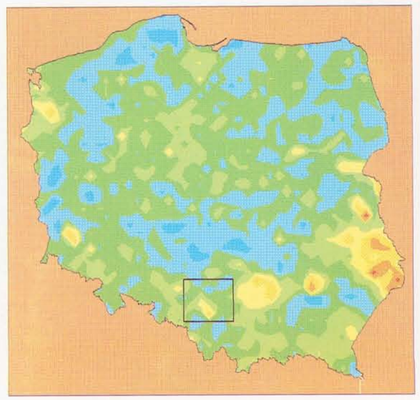
Sr STRONT STRONTIUM

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/kg = g/t

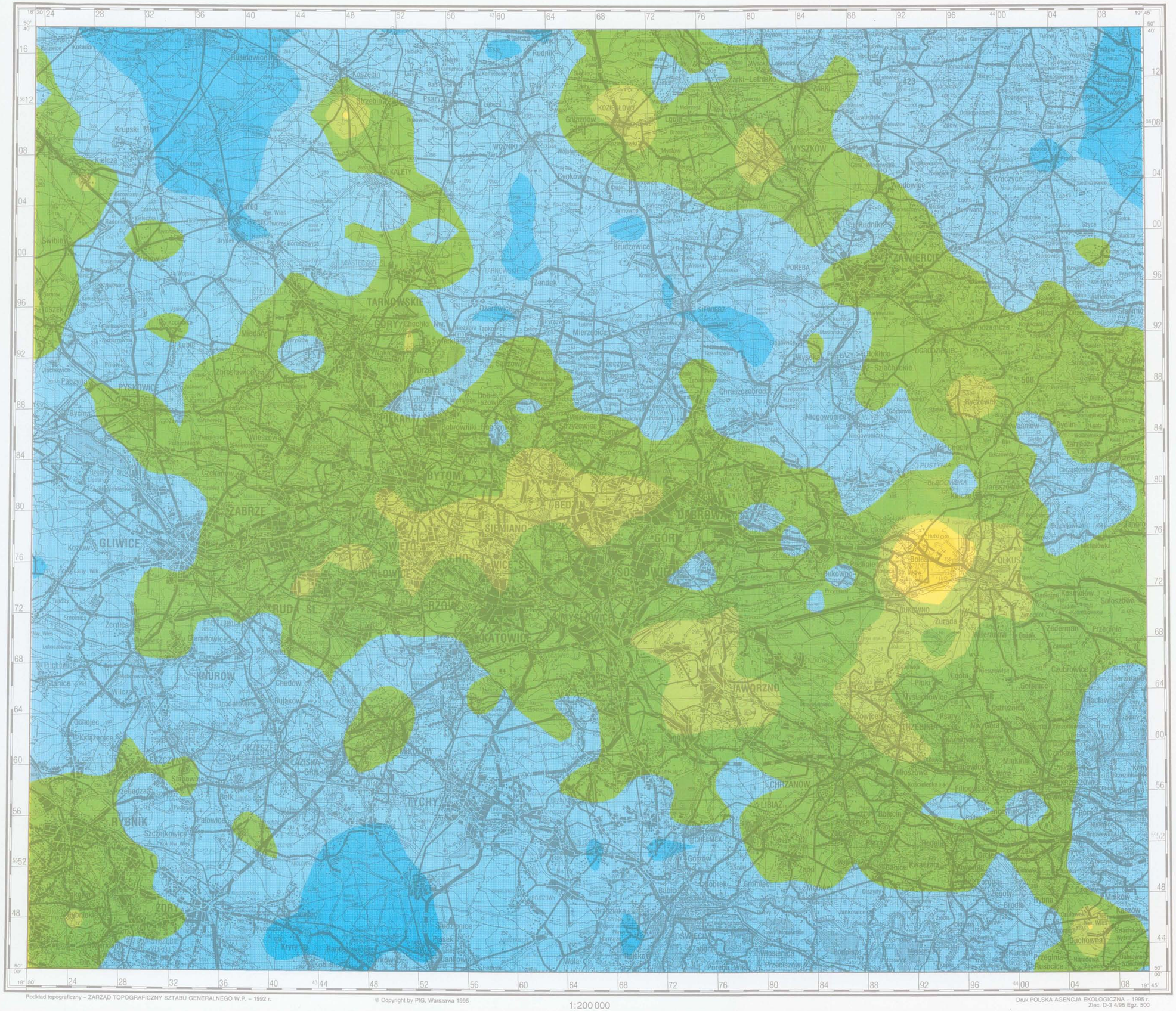
Liczba próbek	1459	Number of samples
Minimum	1	Minimum
Maksimum	1120	Maximum
Średnia arytm.	43	Arithmetic mean
Średnia geom.	25	Geometric mean
Mediana	24	Median
Granica wykrywalności	1	Detection limit



63 Wartość graniczna dla tła w osadach wodnych Polski
Limit value for background in water sediments of Poland



Ti TYTAN TITANIUM



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000

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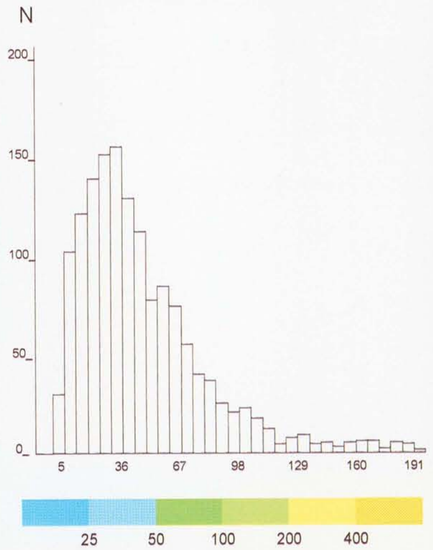
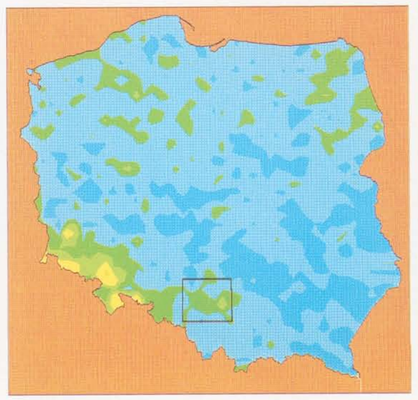
Zlec. D-3 4/95 Egz. 500

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/kg = g/t

Liczba próbek	1459	Number of samples
Minimum	3	Minimum
Maksimum	3439	Maximum
Średnia arytm.	54	Arithmetic mean
Średnia geom.	40	Geometric mean
Mediana	42	Median
Granica wykrywalności	1	Detection limit



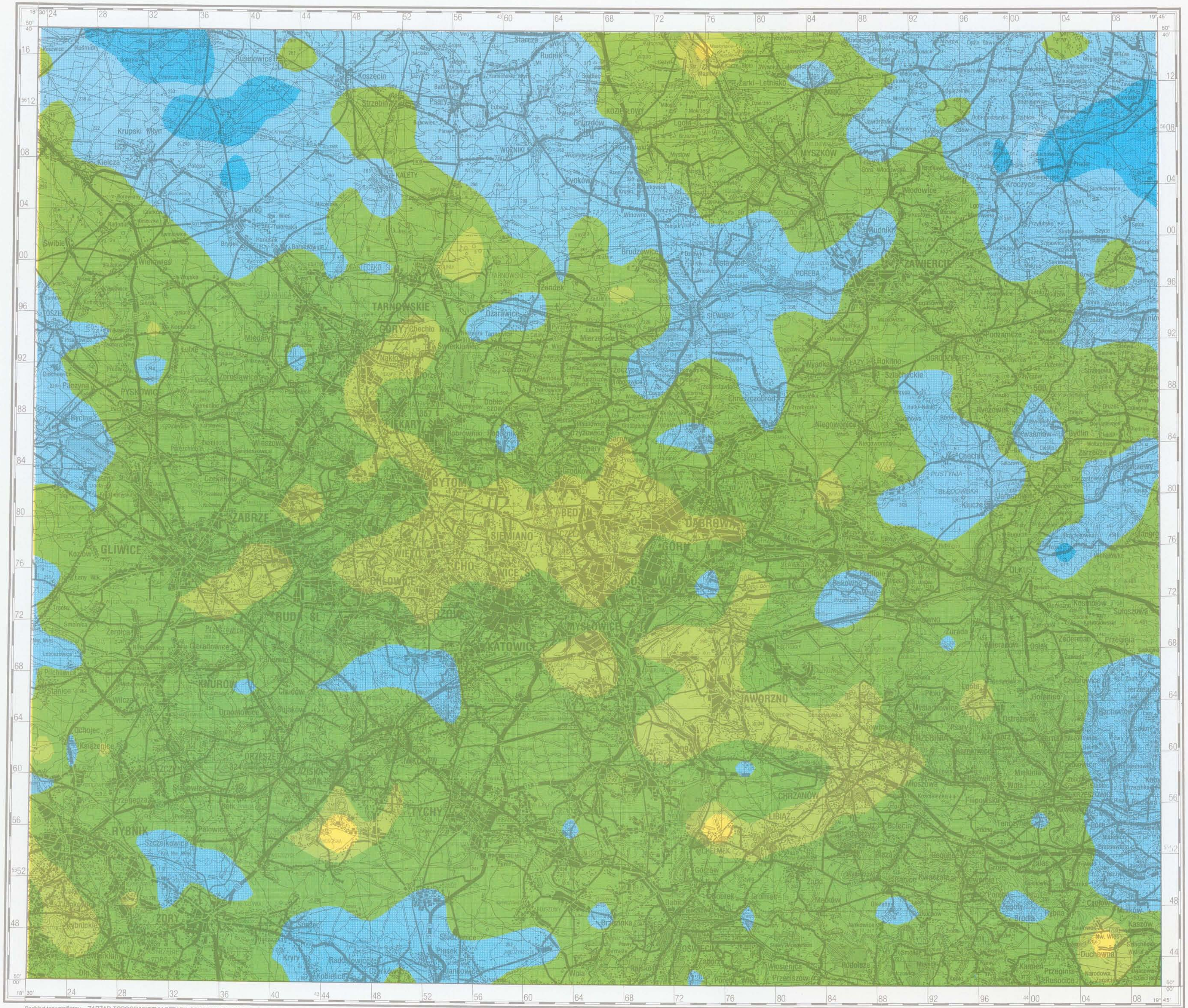
90 Wartość graniczna dla tła w osadach wodnych Polski
Limit value for background in water sediments of Poland



OSADY WODNE
WATER SEDIMENTS

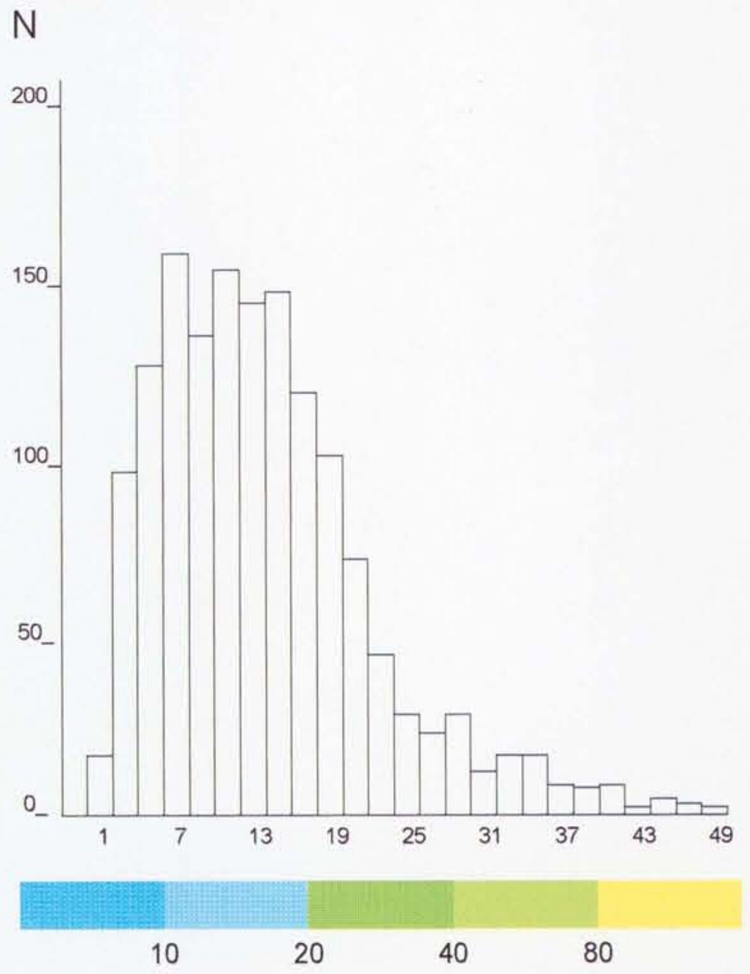
TABLICA
PLATE
43

V WANAD
VANADIUM

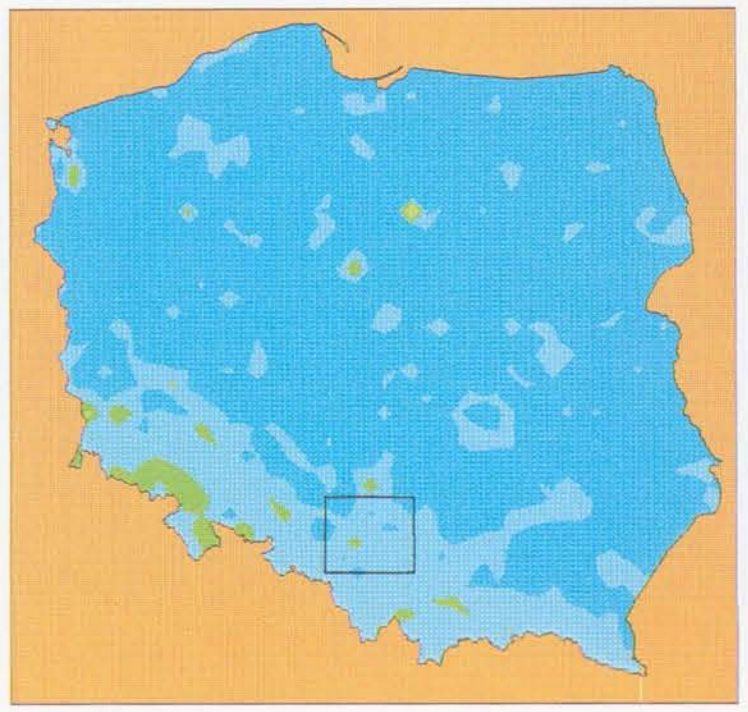


PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/kg = g/t

Liczba próbek	1459	Number of samples
Minimum	< 1	Minimum
Maksimum	155	Maximum
Średnia arytm.	14	Arithmetic mean
Średnia geom.	11	Geometric mean
Mediana	12	Median
Granica wykrywalności	1	Detection limit



33 Wartość graniczna dla tła w osadach wodnych Polski
Limit value for background in water sediments of Poland



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000

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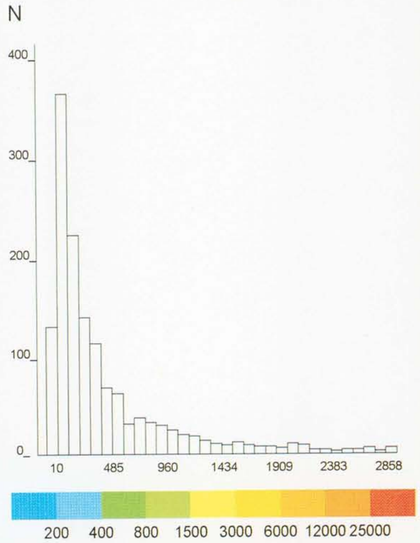
Zlec. D-3 4/95 Egz. 500

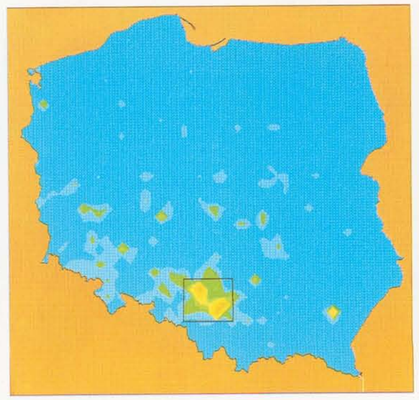
Zn CYNK ZINC

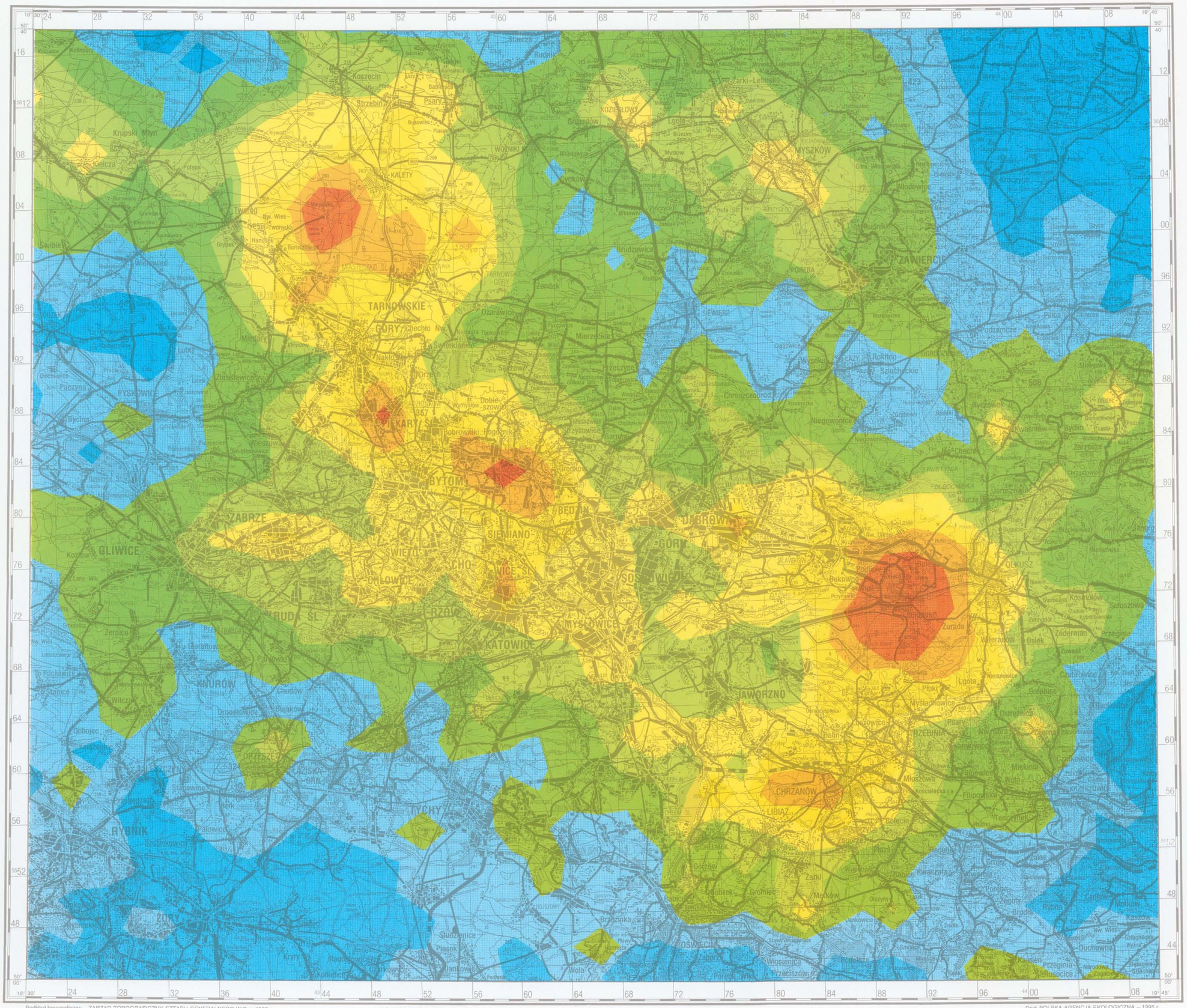
PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/kg = g/t

Liczba próbek	1459	Number of samples
Minimum	11	Minimum
Maksimum	63157	Maximum
Średnia arytm.	903	Arithmetic mean
Średnia geom.	300	Geometric mean
Mediana	259	Median
Granica wykrywalności	1	Detection limit



220 Wartość graniczna dla tła w osadach wodnych Polski
Limit value for background in water sediments of Poland





Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000

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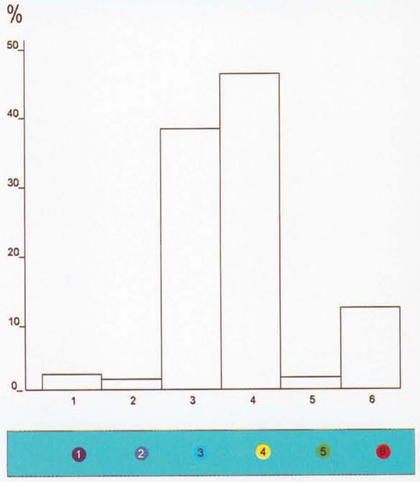
Zlec. D-3 4/95 Egz. 500

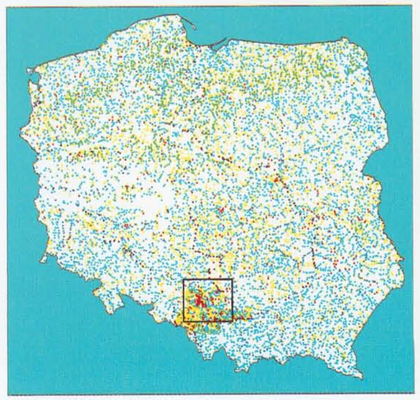
OPRÓBOWANIE
SAMPLING

Zbiorniki wodne — Water bodies

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
Liczba próbek
Number of samples

Rzeki o długości:			Length of rivers:
1 > 500 km	23		1 > 500 km
2 ≥ 100 km ≤ 500 km	12		2 ≥ 100 km ≤ 500 km
3 < 100 km	447		3 < 100 km
4 Małe cieki bez nazwy	541		4 Unnamed small streams
5 Jeziora i sztuczne zbiorniki	19		5 Lakes and artificial reservoires
6 Małe zbiorniki bez nazwy	139		6 Unnamed small reservoires





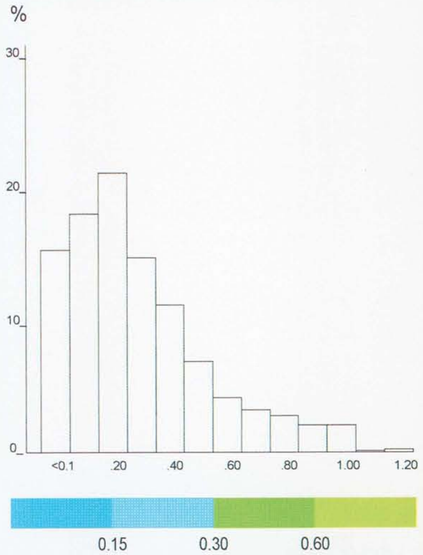
Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000
Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

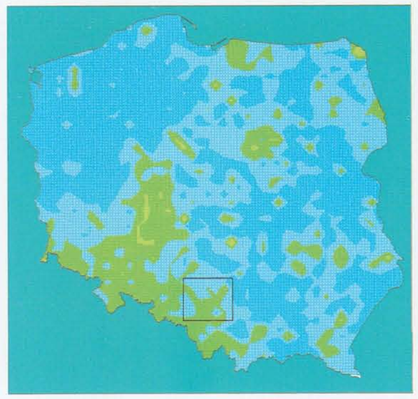
Al GLIN ALUMINIUM

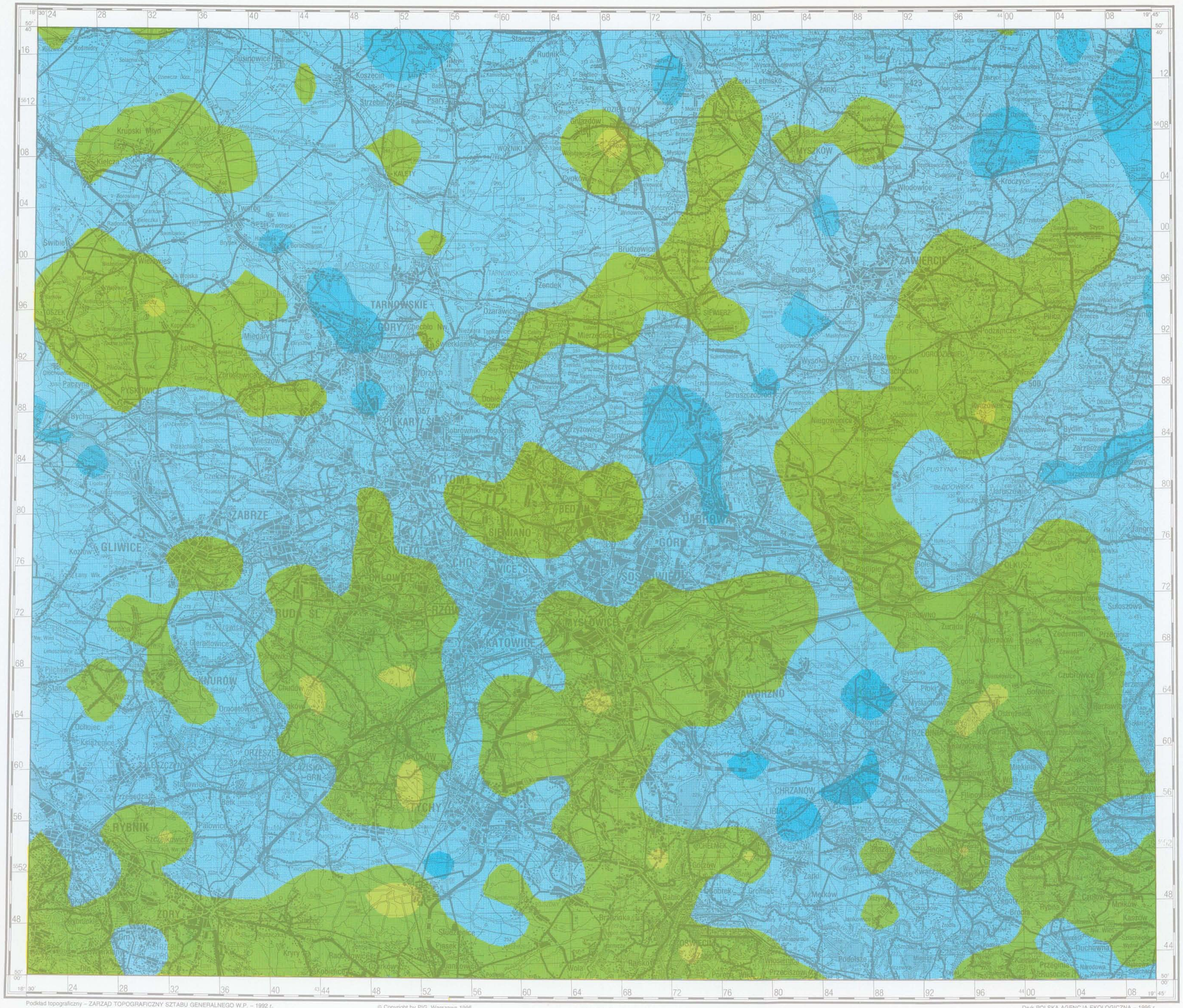
PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/l

Liczba próbek	1188	Number of samples
Minimum	< 0.1	Minimum
Maksimum	1.2	Maximum
Średnia arytm.	0.3	Arithmetic mean
Średnia geom.	0.2	Geometric mean
Mediana	0.2	Median
Granica wykrywalności	0.1	Detection limit



0.3 Wartość graniczna dla tła wód powierzchniowych Polski
Limit value for background in surface waters of Poland





Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

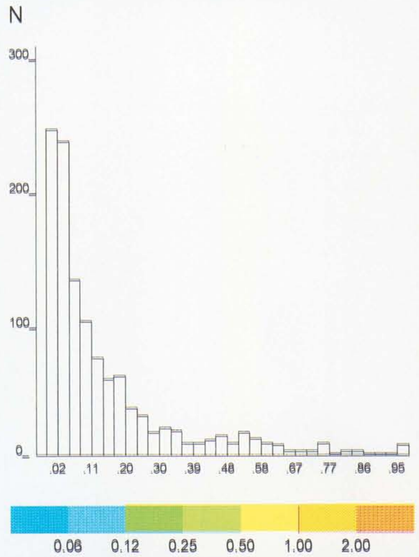
1:200 000

Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

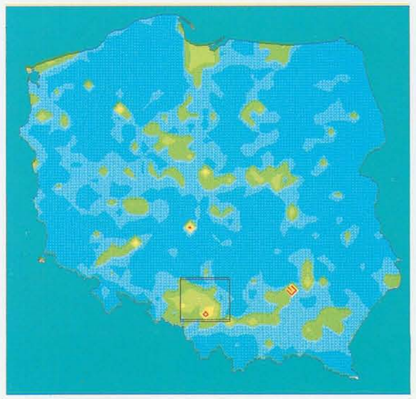
B BOR BORON

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/l

Liczba próbek	1188	Number of samples
Minimum	< 0.02	Minimum
Maksimum	7.92	Maximum
Średnia arytm.	0.24	Arithmetic mean
Średnia geom.	0.09	Geometric mean
Mediana	0.09	Median
Granica wykrywalności	0.02	Detection limit



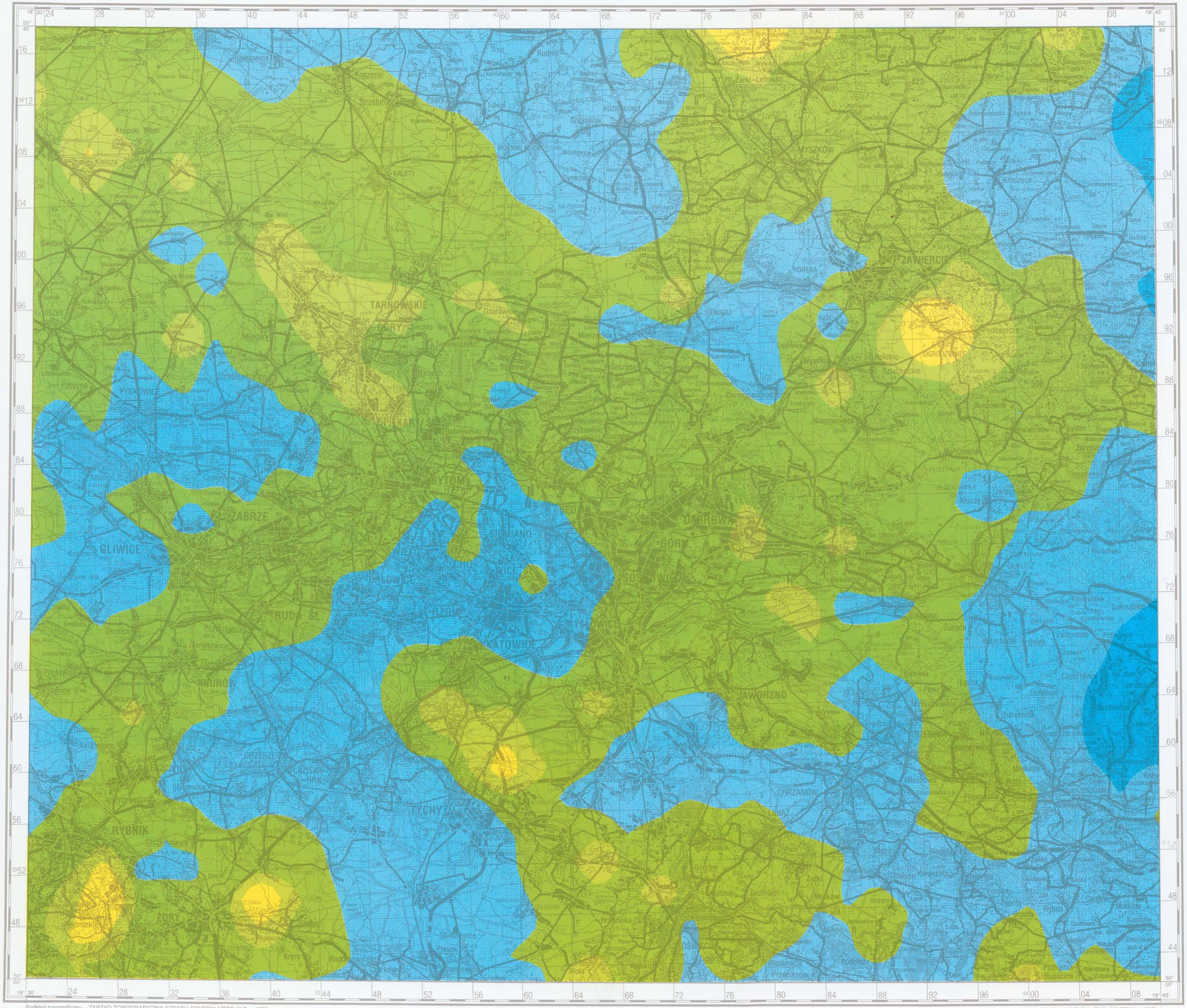
1.0 Wartość graniczna dla I klasy czystości wód powierzchniowych
Limit value for I class purity of surface waters



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000

Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000

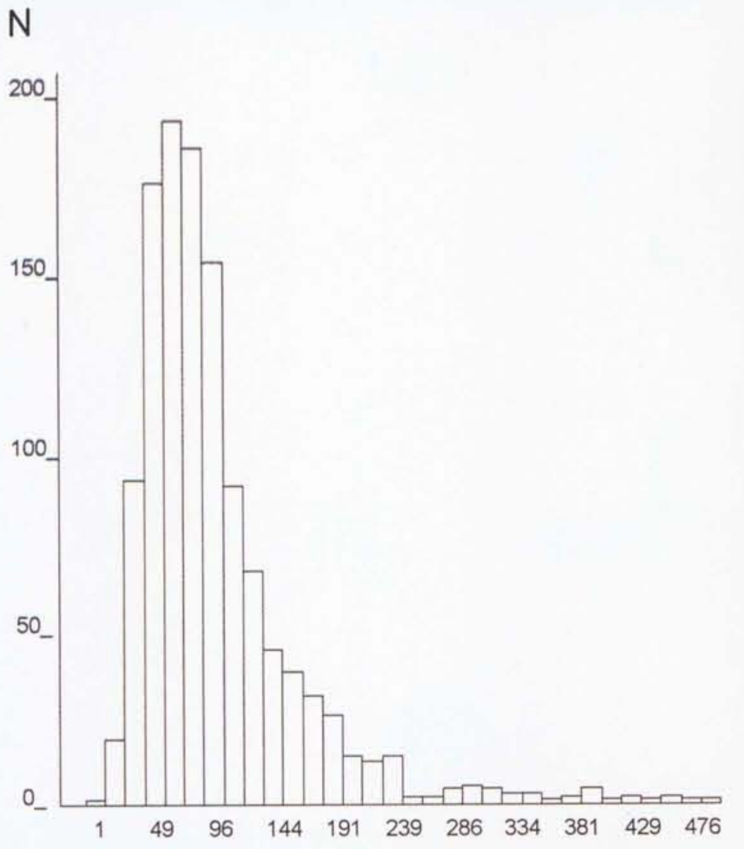
Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

Ba BAR BARIUM

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS

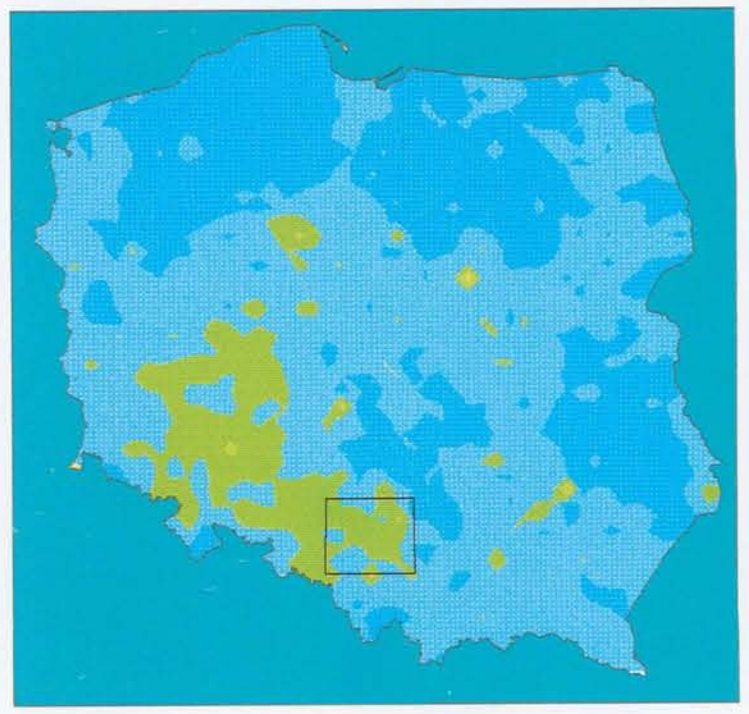
ppb = µg/l

Liczba próbek	1188	Number of samples
Minimum	2	Minimum
Maksimum	3470	Maximum
Średnia arytm.	117	Arithmetic mean
Średnia geom.	87	Geometric mean
Mediana	82	Median
Granica wykrywalności	1	Detection limit



🟦 50 🟦 100 🟩 200 🟩 400 🟨

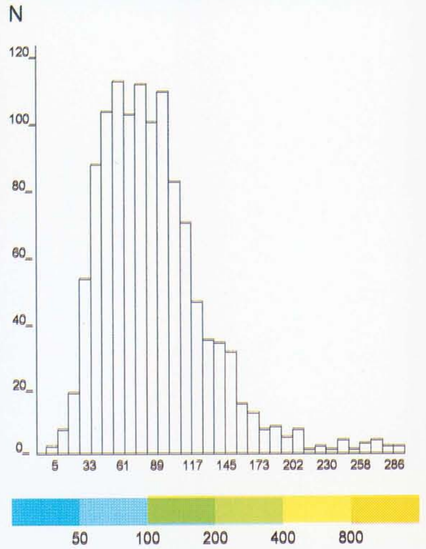
170 Wartość graniczna dla tła wód powierzchniowych Polski
Limit value for background of surface waters of Poland



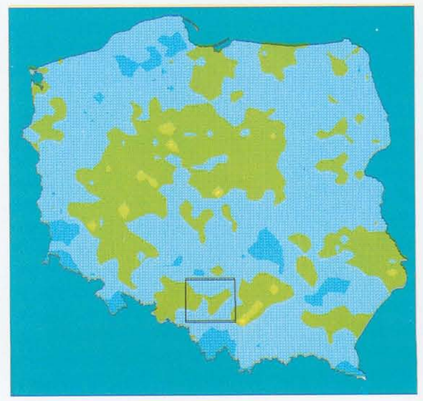
Ca WAPŃ CALCIUM

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/l

Liczba próbek	1188	Number of samples
Minimum	3	Minimum
Maksimum	6400	Maximum
Średnia arytm.	104	Arithmetic mean
Średnia geom.	83	Geometric mean
Mediana	85	Median
Granica wykrywalności	1	Detection limit



246 Wartość graniczna dla tła wód powierzchniowych Polski
Limit value for background of surface waters of Poland



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

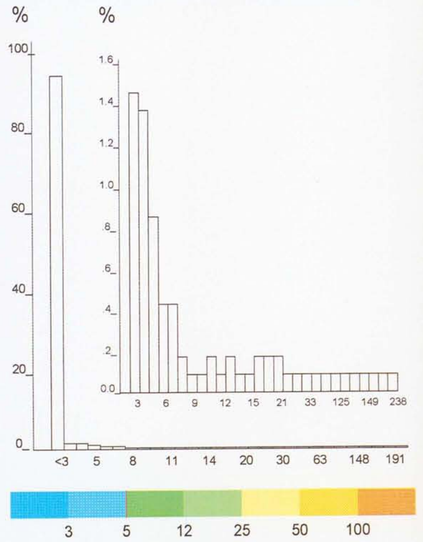
1:200 000

Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

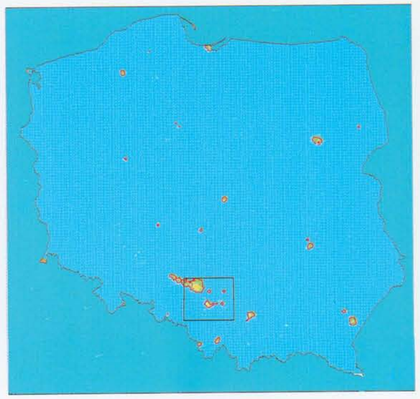
Cd KADM CADMIUM

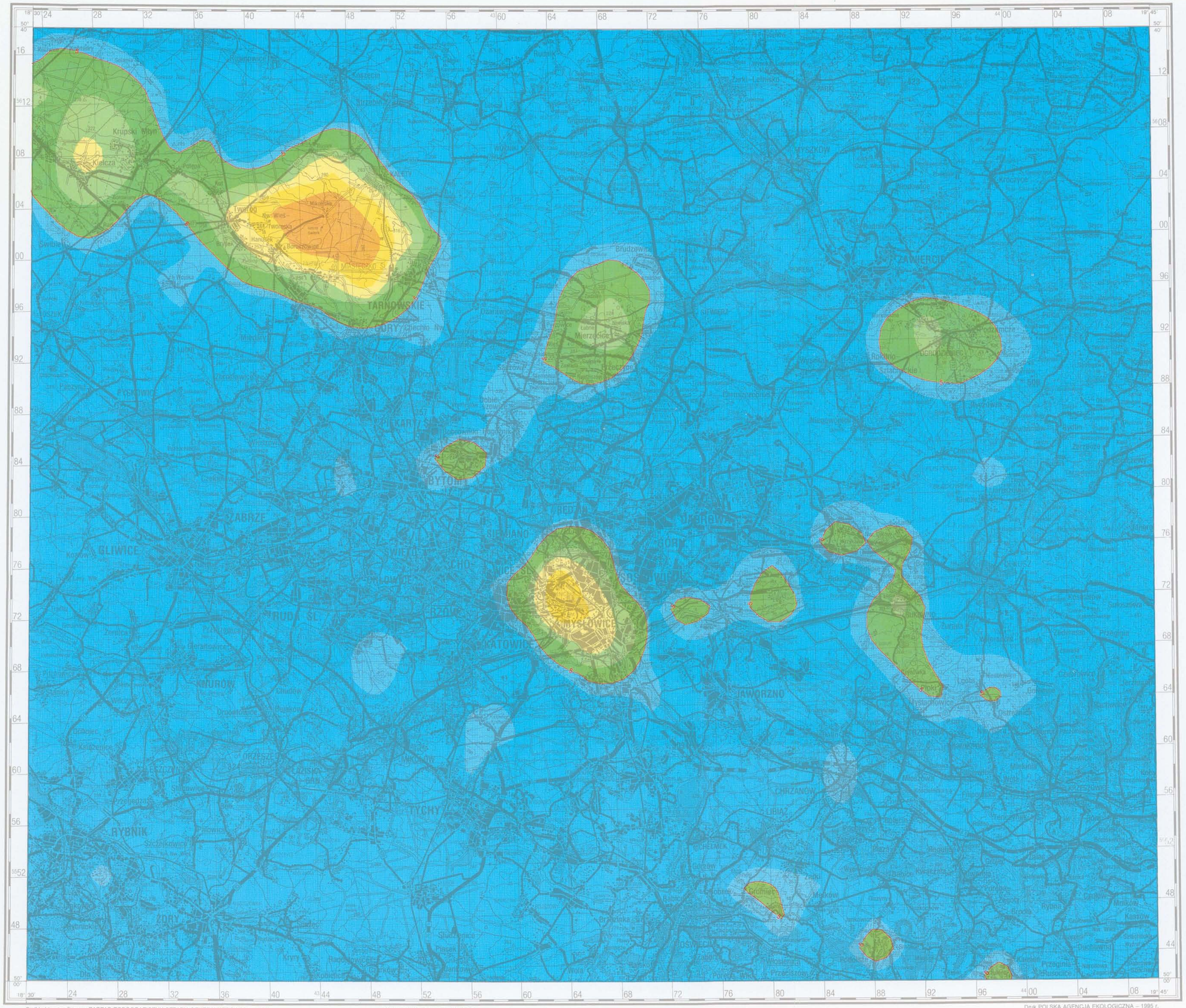
PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppb = µg/l

Liczba próbek	1188	Number of samples
Minimum	< 3	Minimum
Maksimum	238	Maximum
Średnia arytm.	< 3	Arithmetic mean
Średnia geom.	< 3	Geometric mean
Mediana	< 3	Median
Granica wykrywalności	3	Detection limit



5 — Wartość graniczna dla I klasy czystości wód powierzchniowych
Limit value for I class purity of surface waters



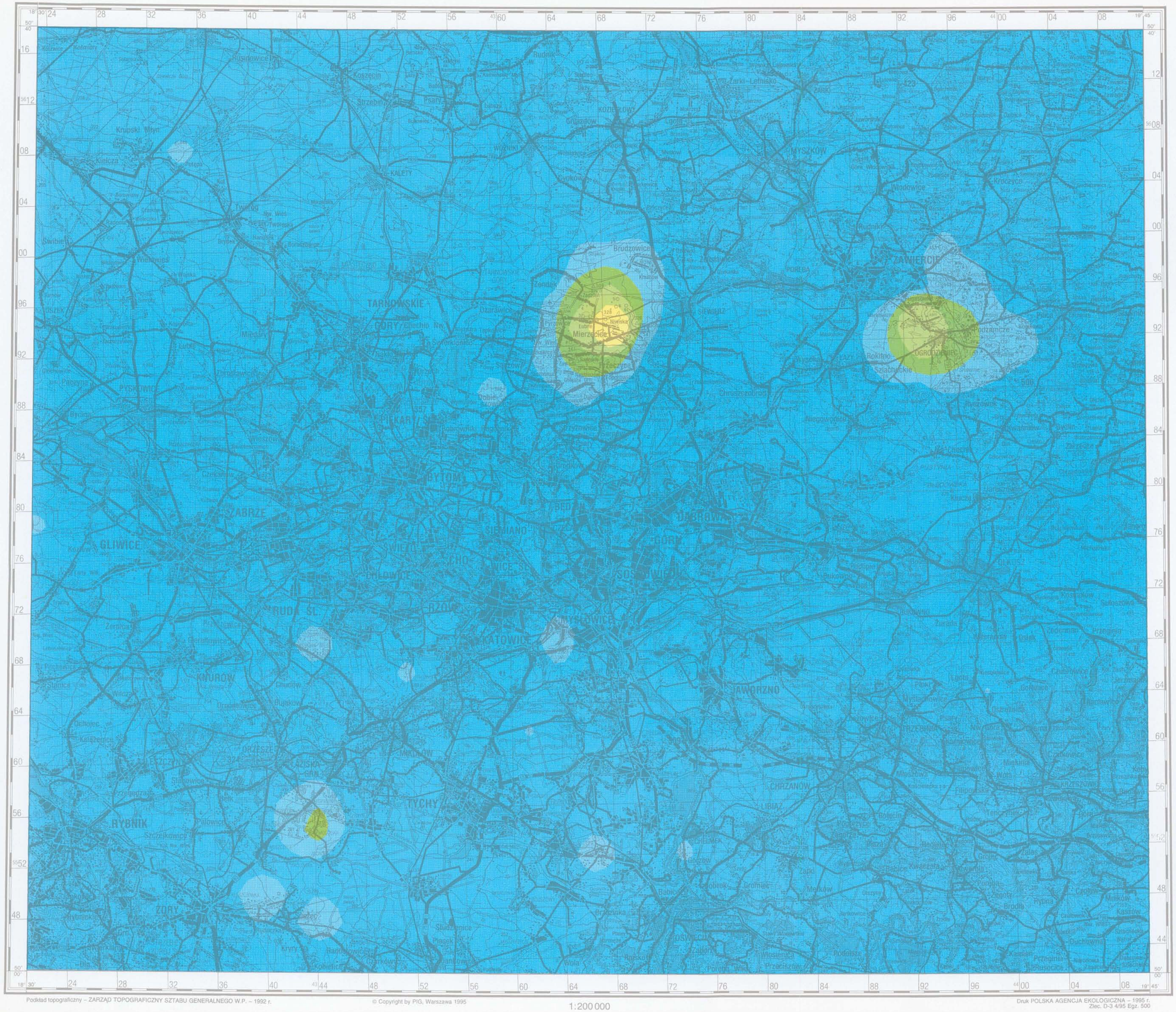


Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000

Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

Co KOBALT COBALT



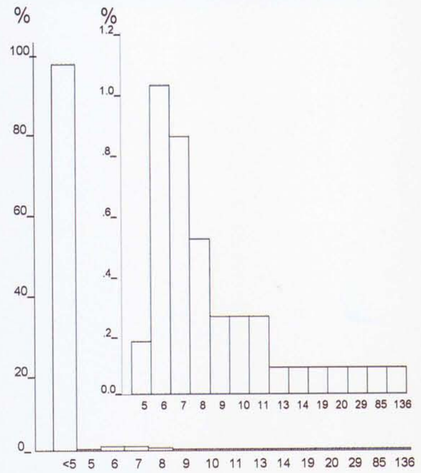
Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000

Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

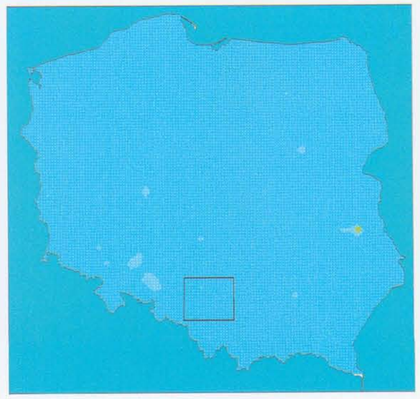
PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppb = µg/l

Liczba próbek	1188	Number of samples
Minimum	< 5	Minimum
Maksimum	136	Maximum
Średnia arytm.	< 5	Arithmetic mean
Średnia geom.	< 5	Geometric mean
Mediana	< 5	Median
Granica wykrywalności	5	Detection limit



5 10 20 50

< 5 Wartość graniczna dla tła wód powierzchniowych Polski
Limit value for background in surface waters of Poland



Cr CHROM CHROMIUM

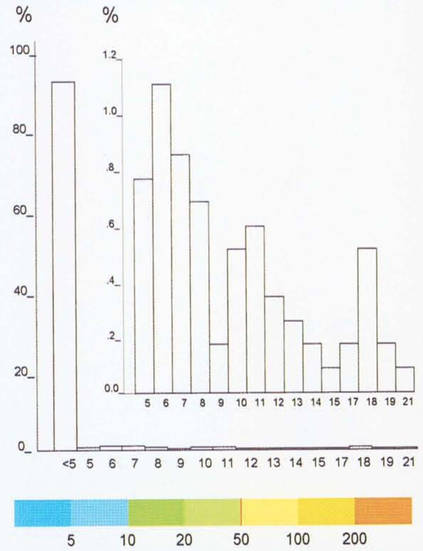
1:200 000

Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

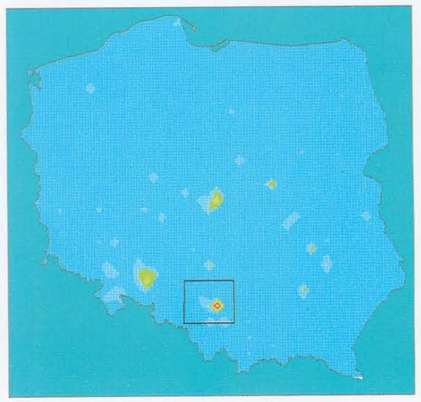
Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppb = µg/l

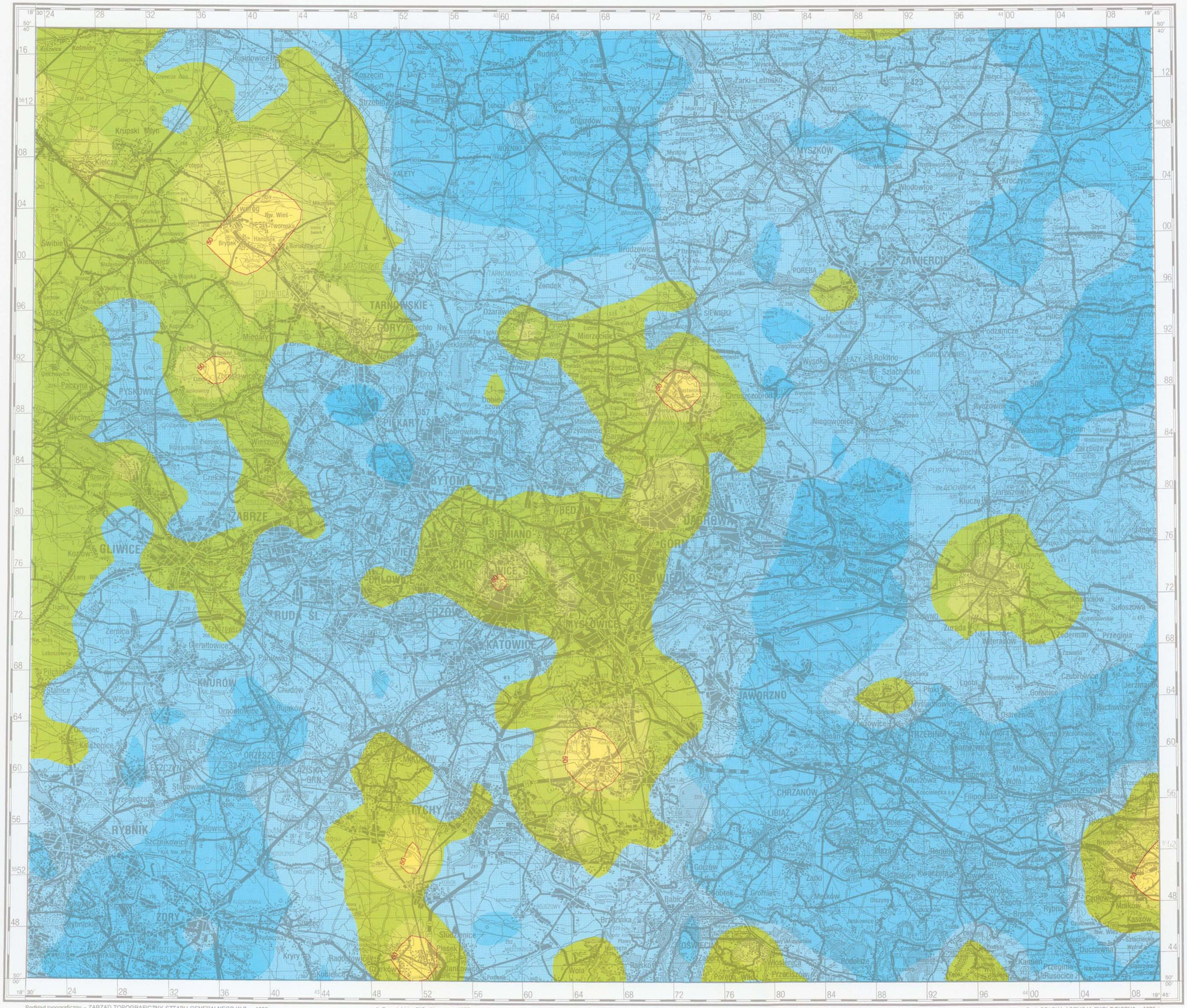
Liczba próbek	1188	Number of samples
Minimum	< 5	Minimum
Maksimum	4445	Maximum
Średnia arytm.	8	Arithmetic mean
Średnia geom.	< 5	Geometric mean
Mediana	< 5	Median
Granica wykrywalności	5	Detection limit



50 — Wartość graniczna dla I klasy czystości wód powierzchniowych
Limit value for I class purity of surface waters



Cu MIEDŹ COPPER



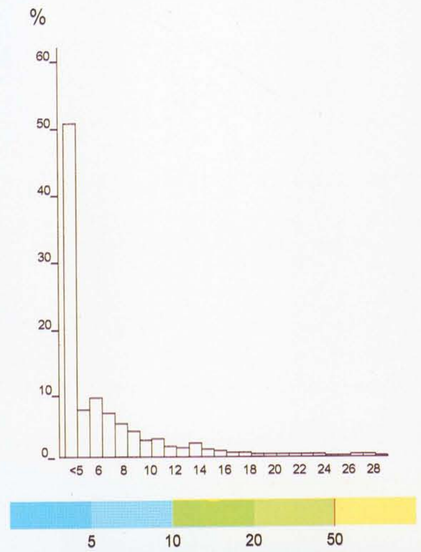
Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000

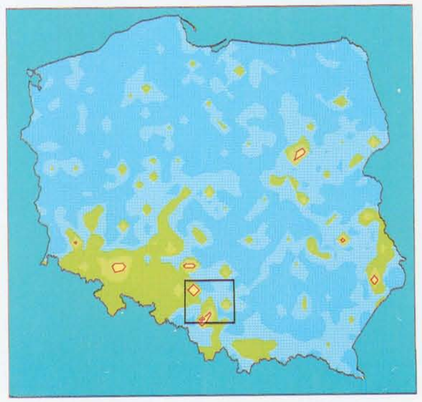
Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

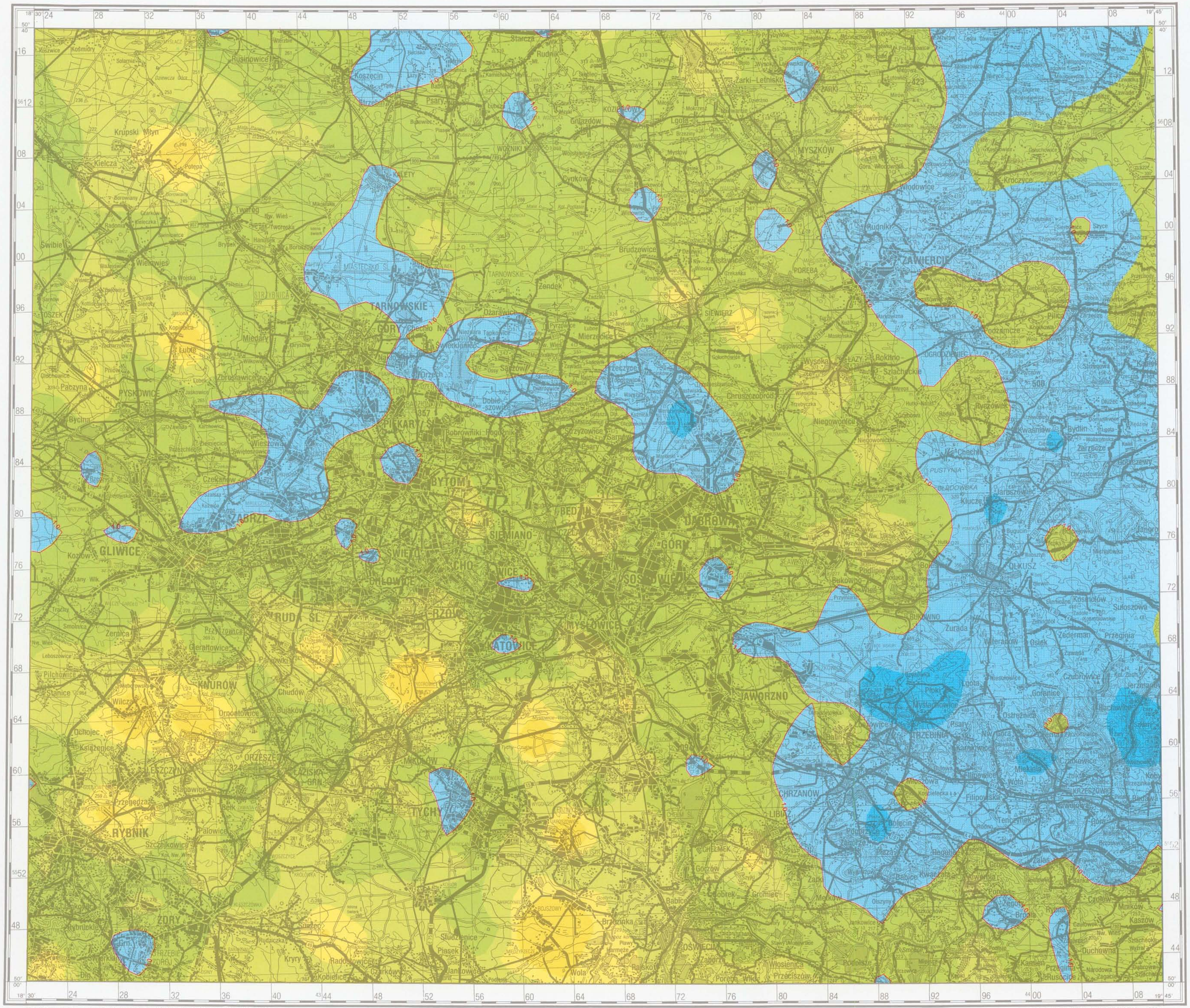
PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppb = µg/l

Liczba próbek	1188	Number of samples
Minimum	< 5	Minimum
Maksimum	994	Maximum
Średnia arytm.	10	Arithmetic mean
Średnia geom.	5	Geometric mean
Mediana	5	Median
Granica wykrywalności	5	Detection limit



50 — Wartość graniczna dla I klasy czystości wód powierzchniowych
Limit value for I class purity of surface waters





WODY POWIERZCHNIOWE
SURFACE WATERS

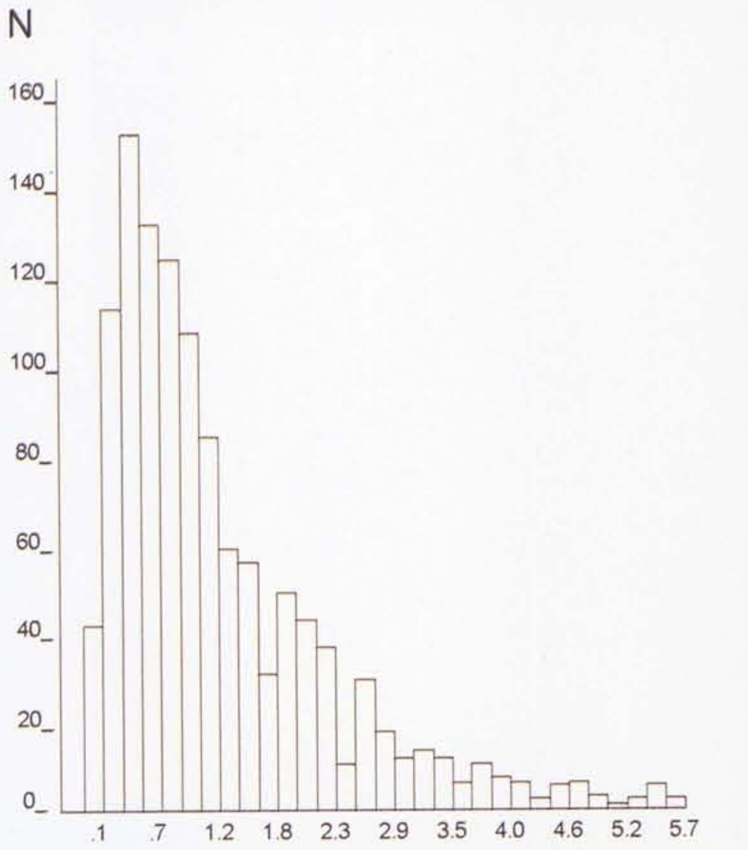
TABLICA
PLATE **54**

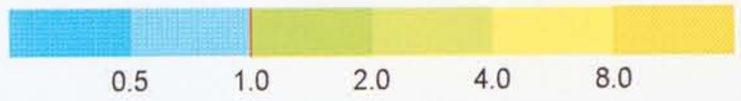
Fe ŻELAZO IRON

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS

ppm = mg/l

Liczba próbek	1188	Number of samples
Minimum	< 0.02	Minimum
Maksimum	93.44	Maximum
Średnia arytm.	1.79	Arithmetic mean
Średnia geom.	1.01	Geometric mean
Mediana	1.00	Median
Granica wykrywalności	0.02	Detection limit





—— 1.0 —— Wartość graniczna dla I klasy czystości wód powierzchniowych
Limit value for I class purity of surface waters

Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000

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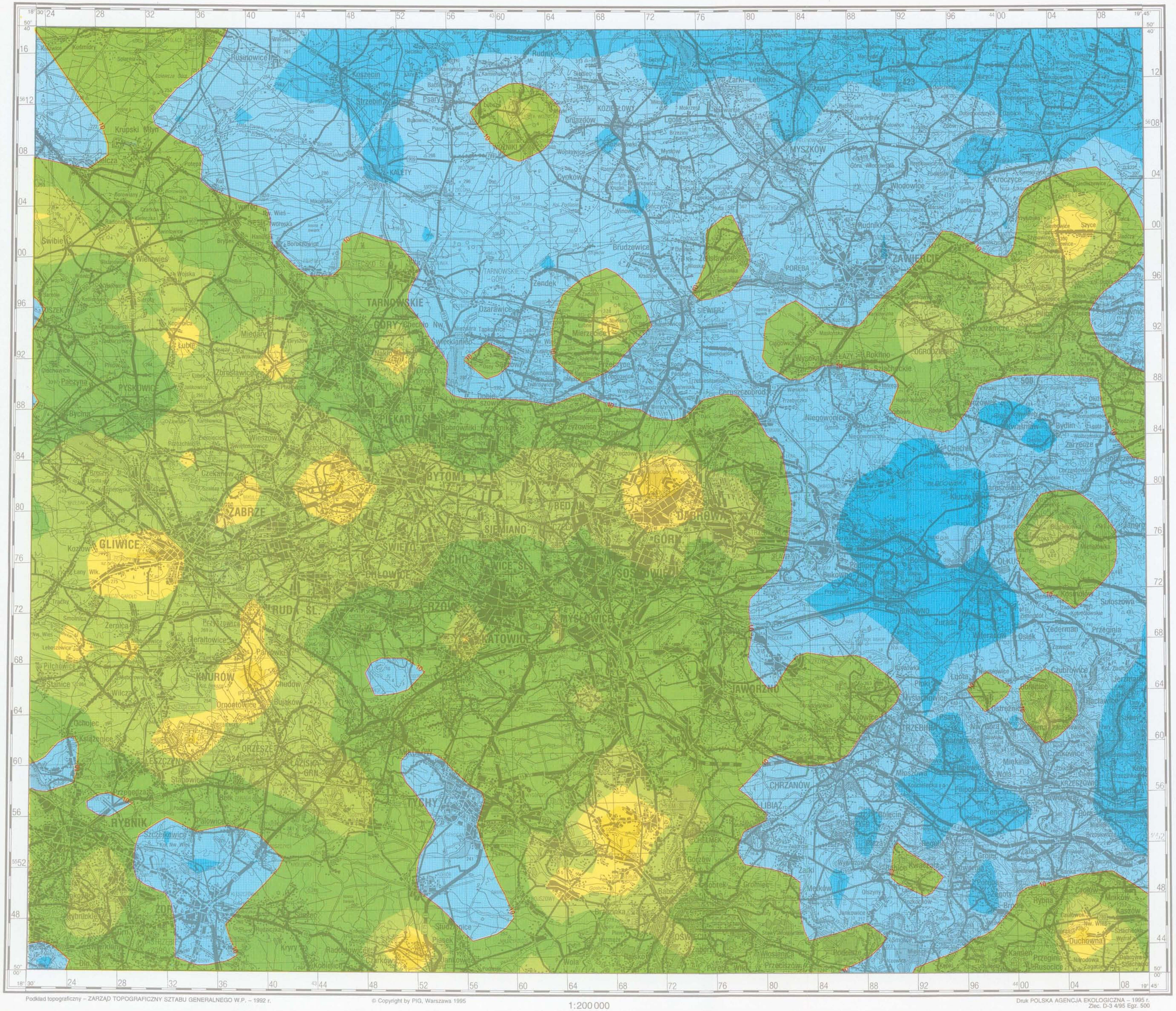
Zlec. D-3 4/95 Egz. 500

WODY POWIERZCHNIOWE
SURFACE WATERS

TABLICA
PLATE
55

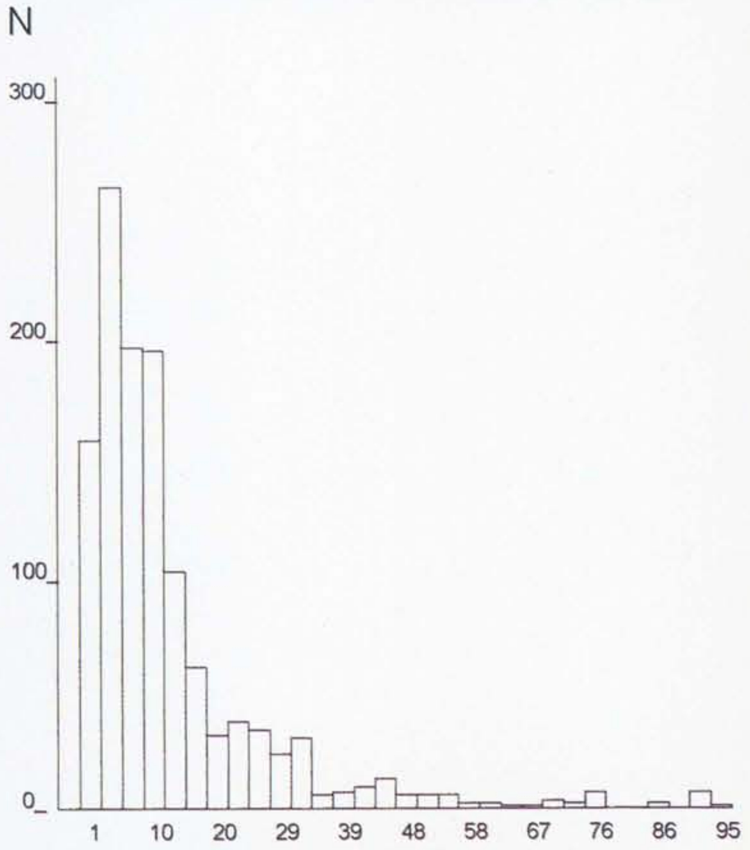
K POTAS
POTASSIUM



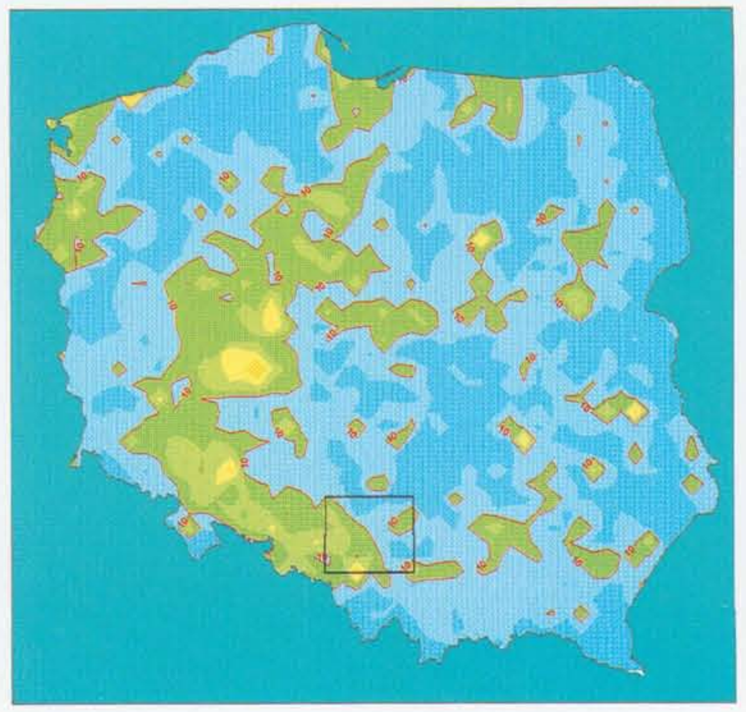
PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS

ppm = mg/l

Liczba próbek	1188	Number of samples
Minimum	< 1	Minimum
Maksimum	473	Maximum
Średnia arytm.	15	Arithmetic mean
Średnia geom.	8	Geometric mean
Mediana	8	Median
Granica wykrywalności	1	Detection limit



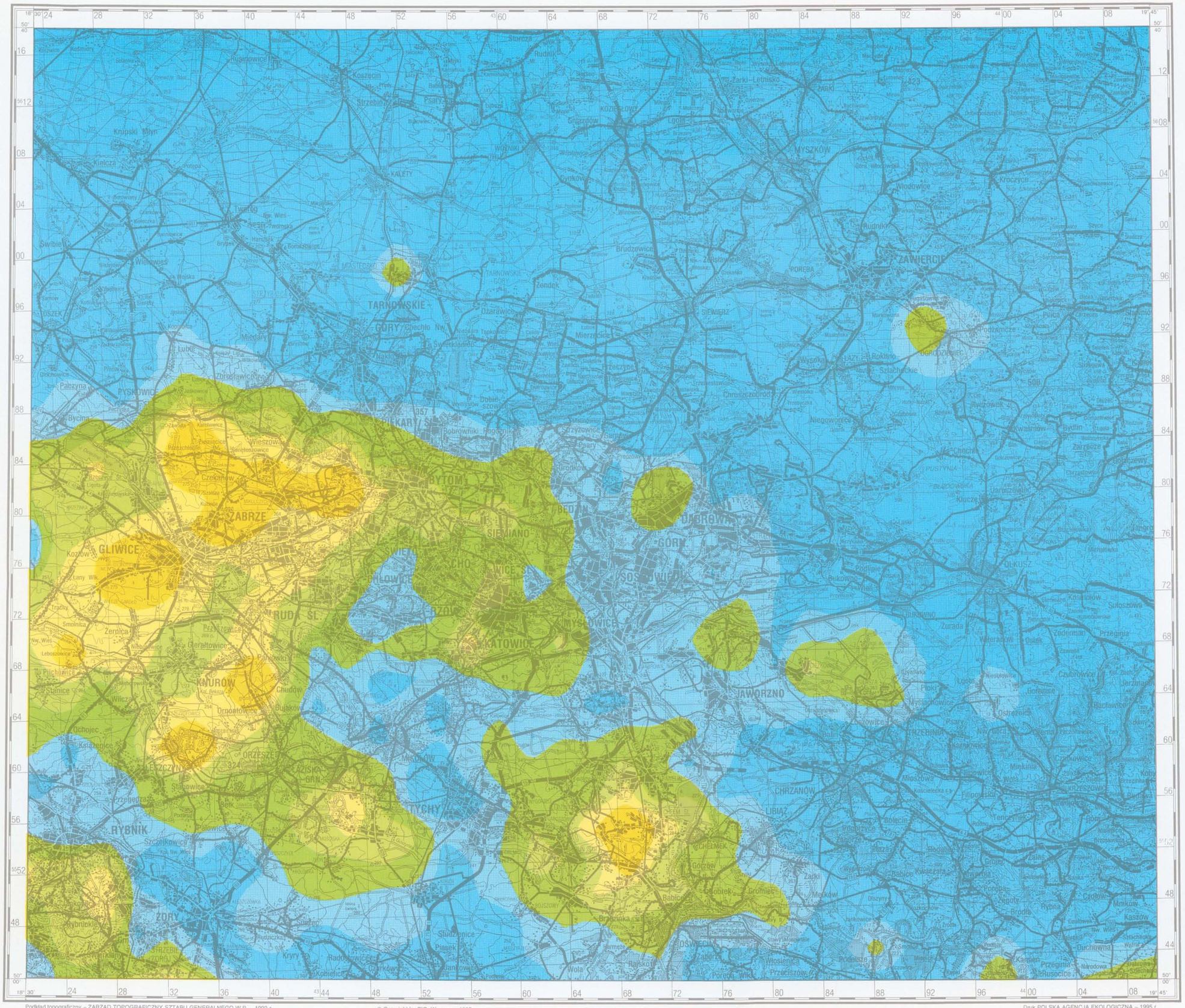
— 10 — Wartość graniczna dla I klasy czystości wód powierzchniowych
Limit value for I class purity of surface waters



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000

Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

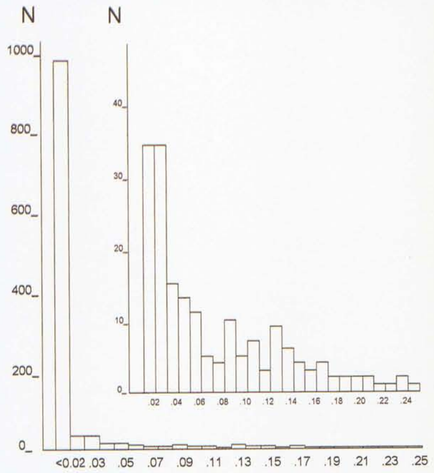
1:200 000

Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

Li LIT LITHIUM

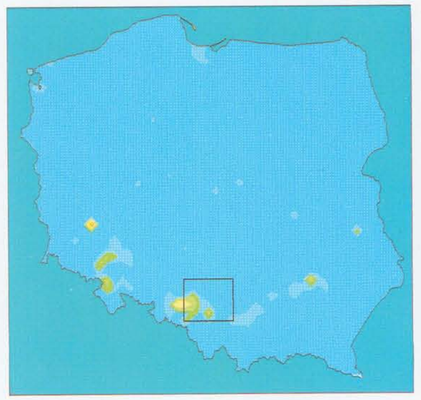
PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/l

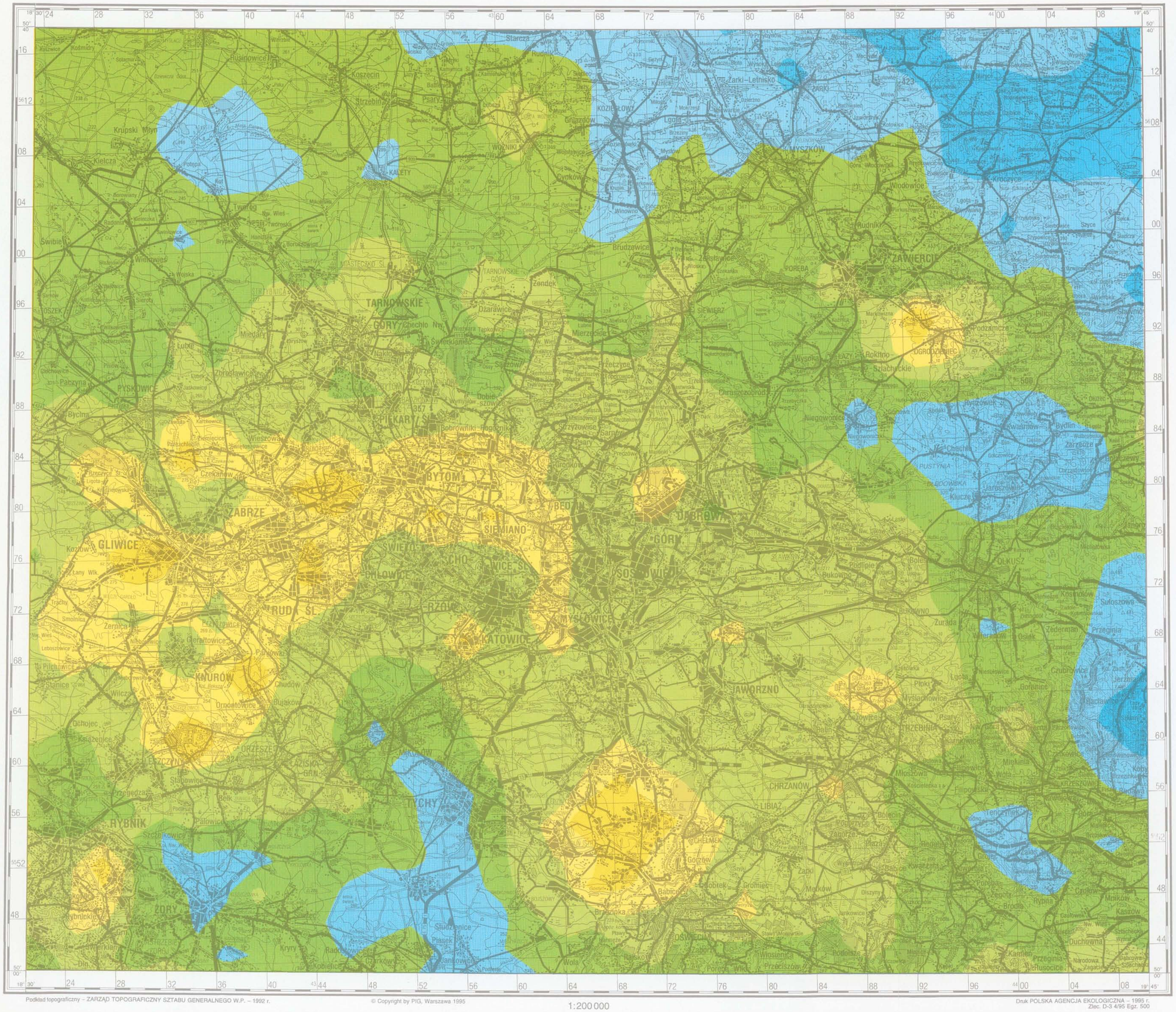
Liczba próbek	1188	Number of samples
Minimum	< 0.02	Minimum
Maksimum	2.78	Maximum
Średnia arytm.	0.05	Arithmetic mean
Średnia geom.	< 0.02	Geometric mean
Mediana	< 0.02	Median
Granica wykrywalności	0.02	Detection limit



0.02 0.04 0.08 0.16 0.30

< 0.02 Wartość graniczna dla tła wód powierzchniowych Polski
Limit value for background in surface waters of Poland





Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

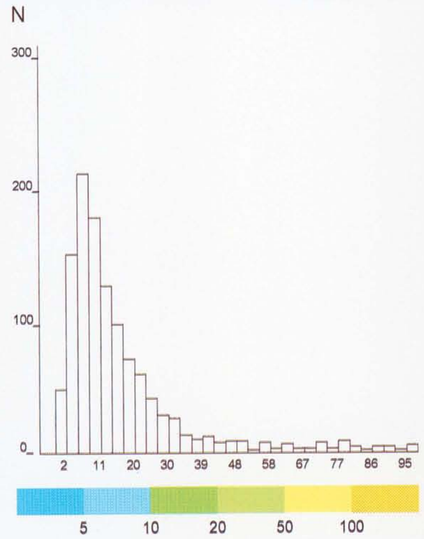
1:200 000

Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

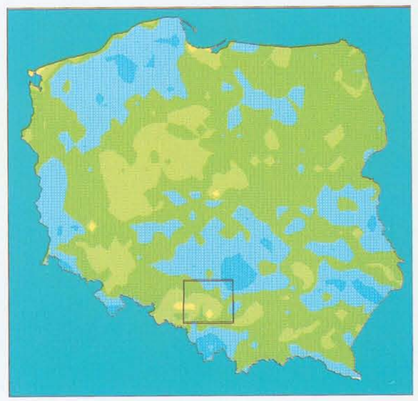
Mg MAGNEZ MAGNESIUM

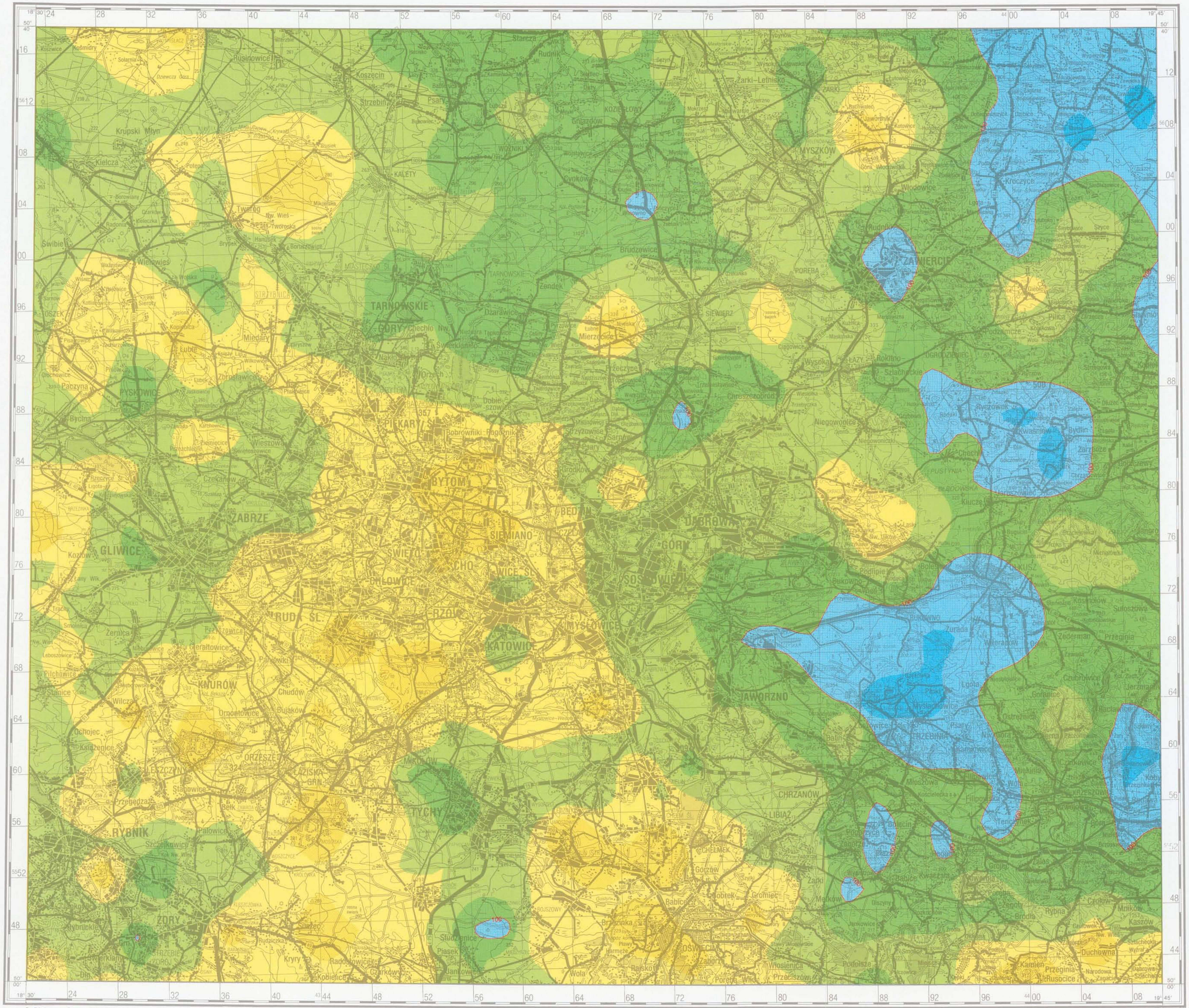
PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/l

Liczba próbek	1188	Number of samples
Minimum	0.2	Minimum
Maksimum	833.8	Maximum
Średnia arytm.	25.8	Arithmetic mean
Średnia geom.	14.1	Geometric mean
Mediana	12.7	Median
Granica wykrywalności	0.1	Detection limit



35 Wartość graniczna dla tła wód powierzchniowych Polski
Limit value for background in surface waters of Poland





Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000

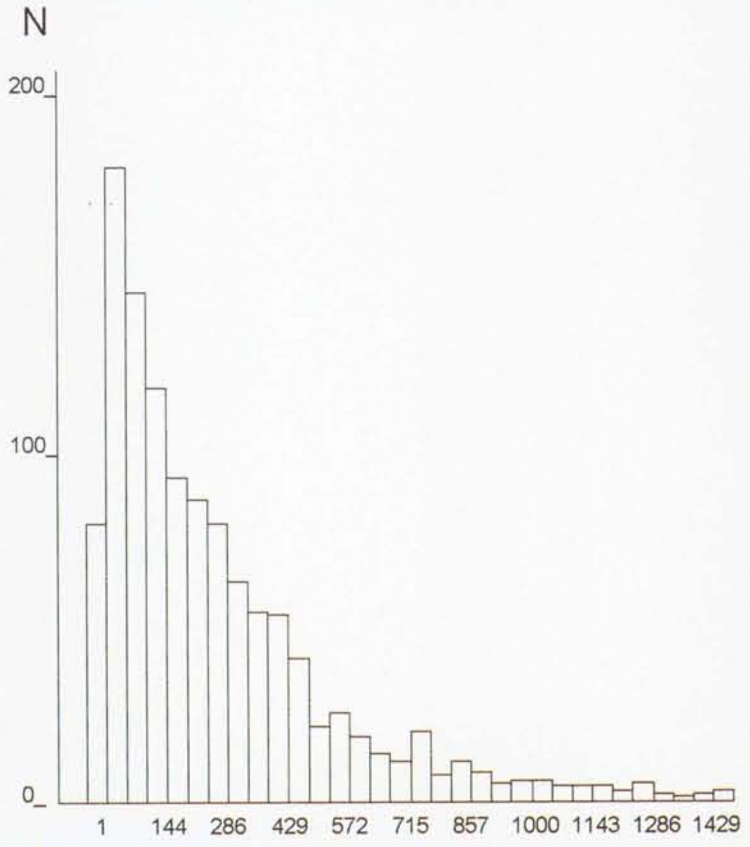
Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

WODY POWIERZCHNIOWE TABLICA 58
SURFACE WATERS PLATE

Mn MANGAN
MANGANESE

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppb = µg/l

Liczba próbek	1188	Number of samples
Minimum	1	Minimum
Maksimum	16829	Maximum
Średnia arytm.	481	Arithmetic mean
Średnia geom.	186	Geometric mean
Mediana	213	Median
Granica wykrywalności	1	Detection limit



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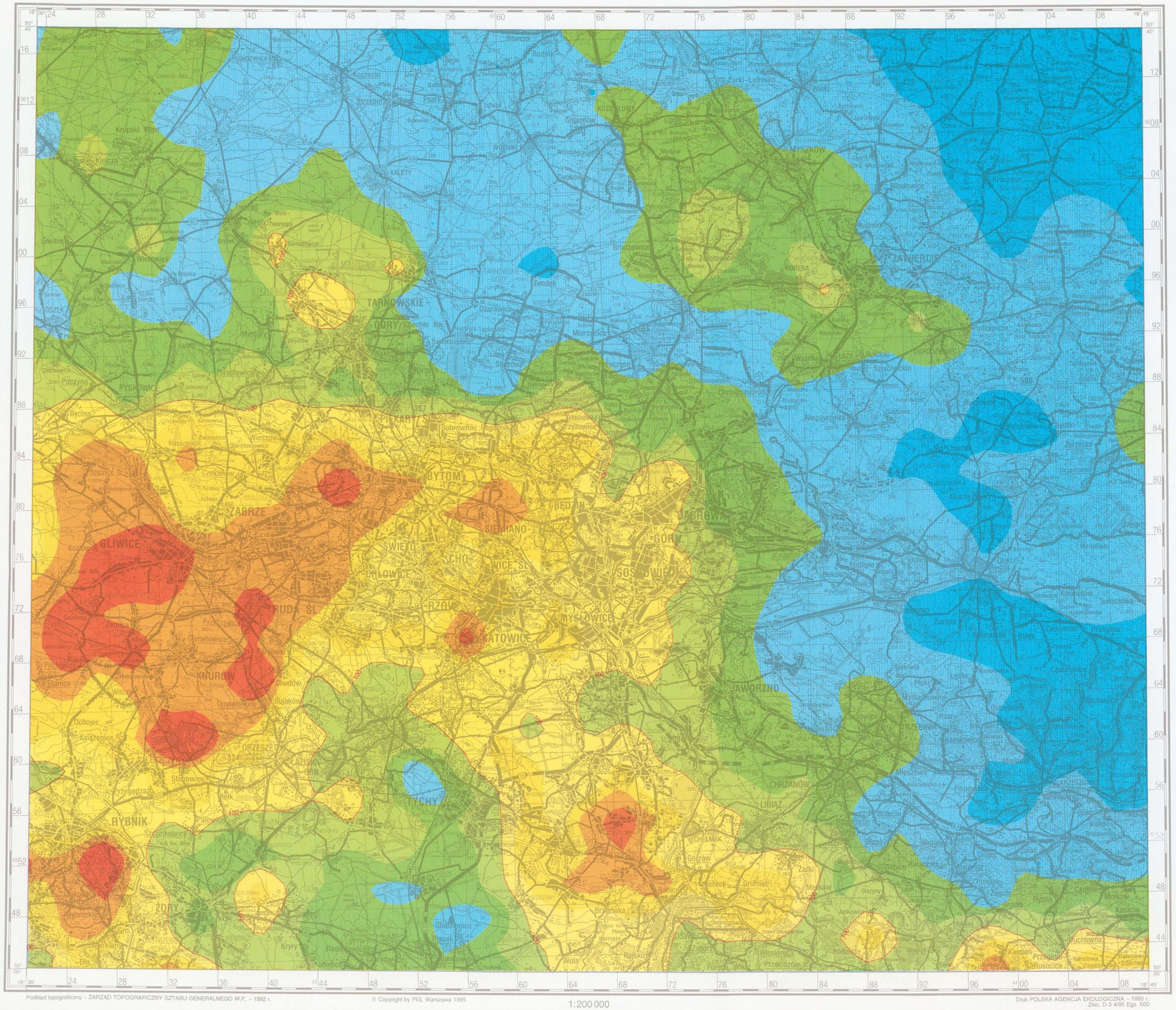
50 100 200 400 800

— 100 — Wartość graniczna dla I klasy czystości wód powierzchniowych
Limit value for I class purity of surface waters



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

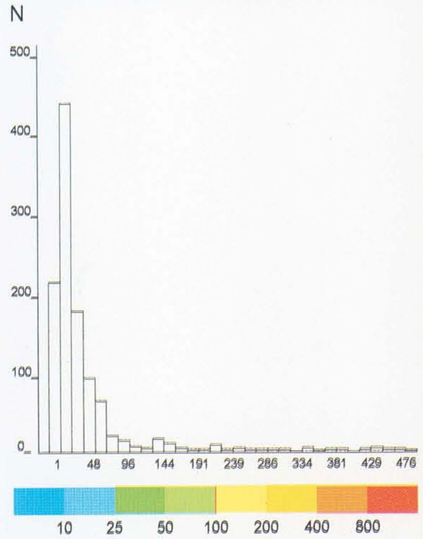
1:200 000

Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

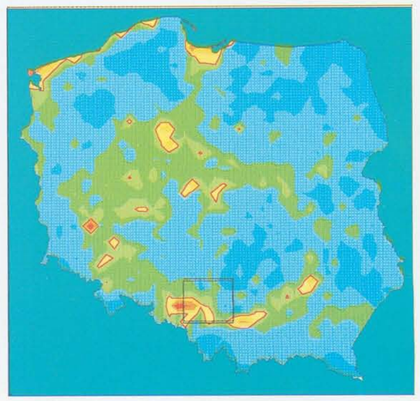
Na SÓD SODIUM

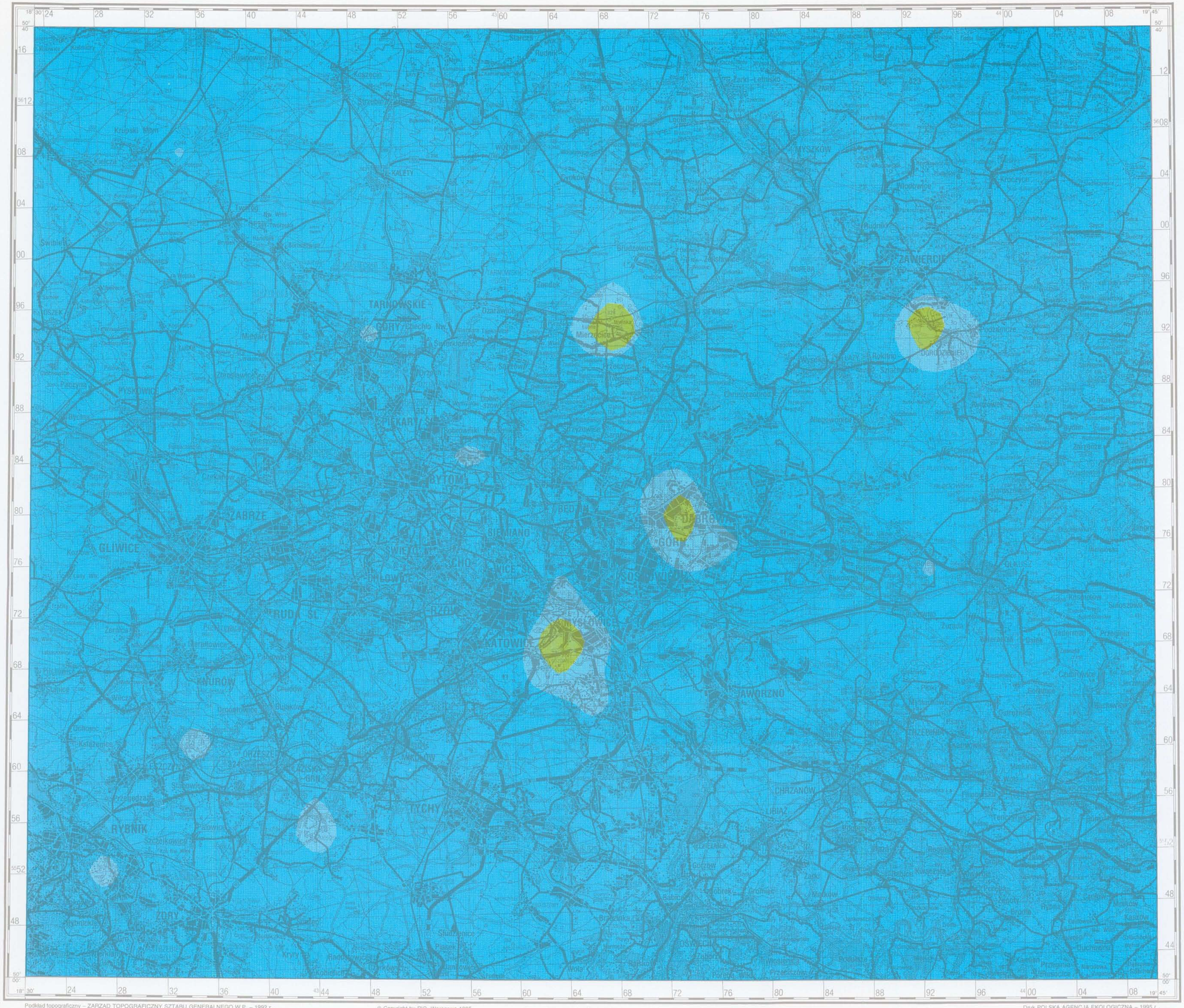
PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/l

Liczba próbek	1188	Number of samples
Minimum	1	Minimum
Maksimum	5723	Maximum
Średnia arytm.	138	Arithmetic mean
Średnia geom.	28	Geometric mean
Mediana	21	Median
Granica wykrywalności	1	Detection limit



100 — Wartość graniczna dla I klasy czystości wód powierzchniowych
Limit value for I class purity of surface waters





Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

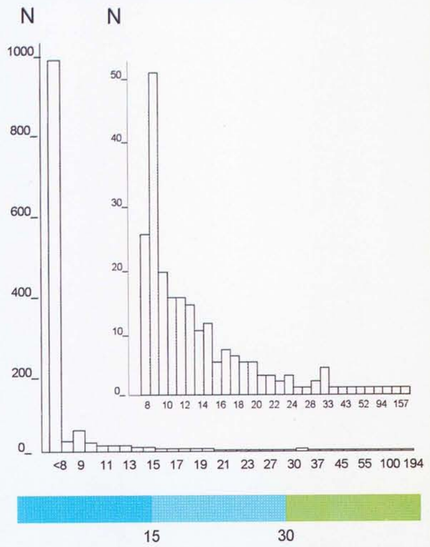
1:200 000

Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

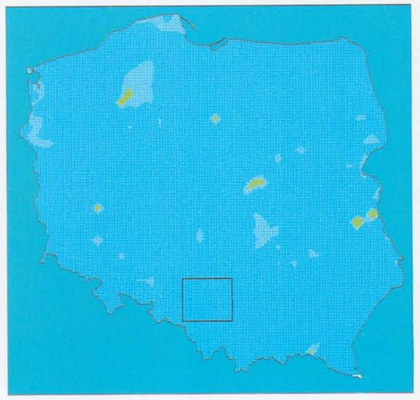
Ni NIKIEL NICKEL

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppb = µg/l

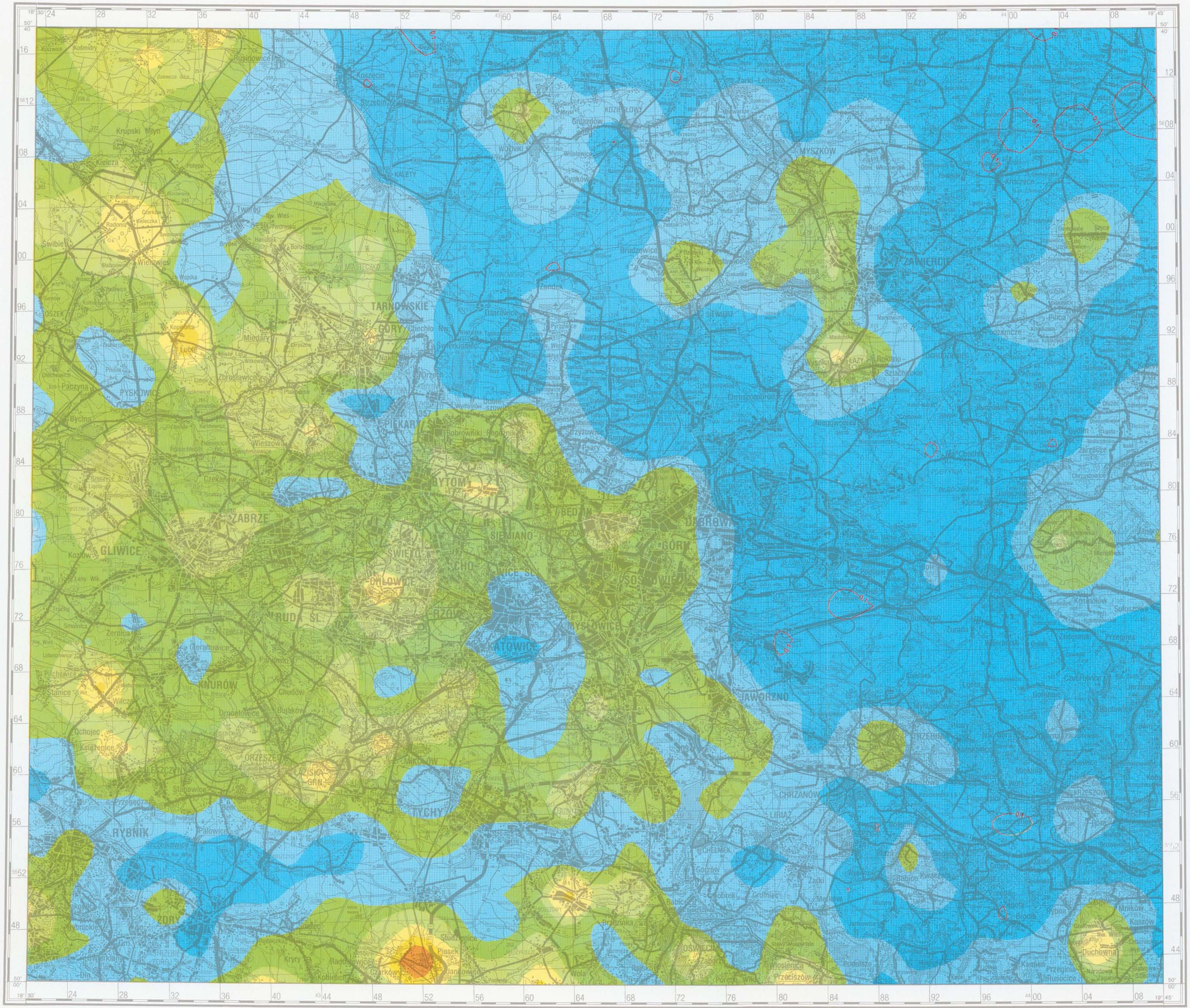
Liczba próbek	1188	Number of samples
Minimum	< 8	Minimum
Maksimum	194	Maximum
Średnia arytm.	< 8	Arithmetic mean
Średnia geom.	< 8	Geometric mean
Mediana	< 8	Median
Granica wykrywalności	8	Detection limit



1000 Wartość graniczna dla I klasy czystości wód powierzchniowych
Limit value for I class purity of surface waters

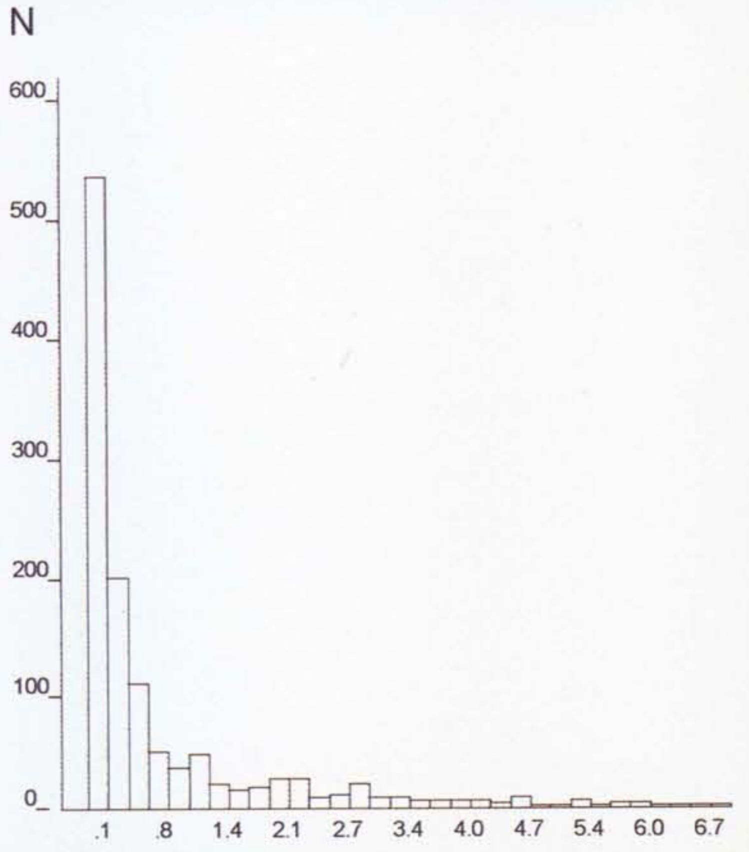


P FOSFOR PHOSPHORUS



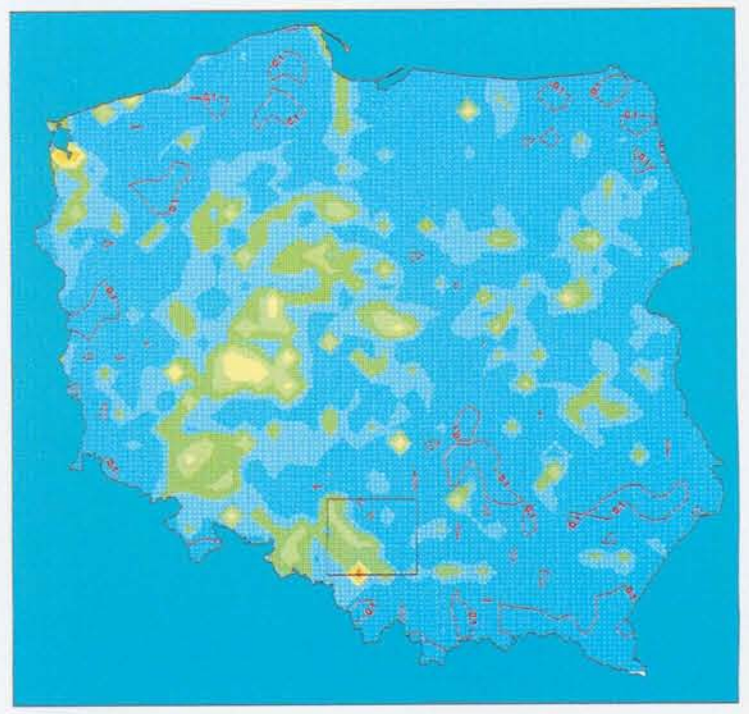
PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/l

Liczba próbek	1188	Number of samples
Minimum	< 0.04	Minimum
Maksimum	45.12	Maximum
Średnia arytm.	1.09	Arithmetic mean
Średnia geom.	0.31	Geometric mean
Mediana	0.26	Median
Granica wykrywalności	0.04	Detection limit



0.5 1.0 2.0 4.0 8.0 16.0

— 0.1 — Wartość graniczna dla I klasy czystości wód powierzchniowych
Limit value for I class purity of surface waters

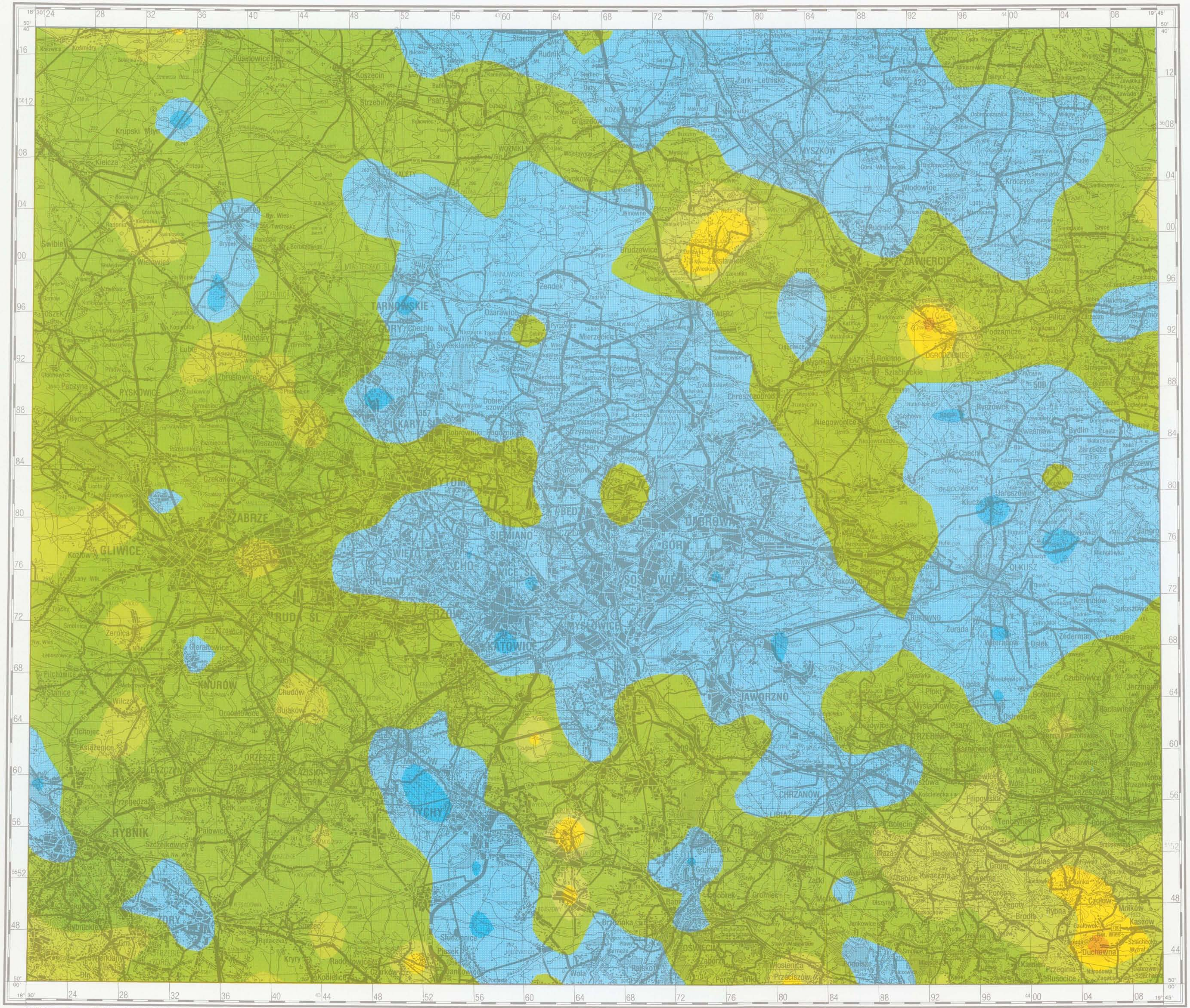


Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000

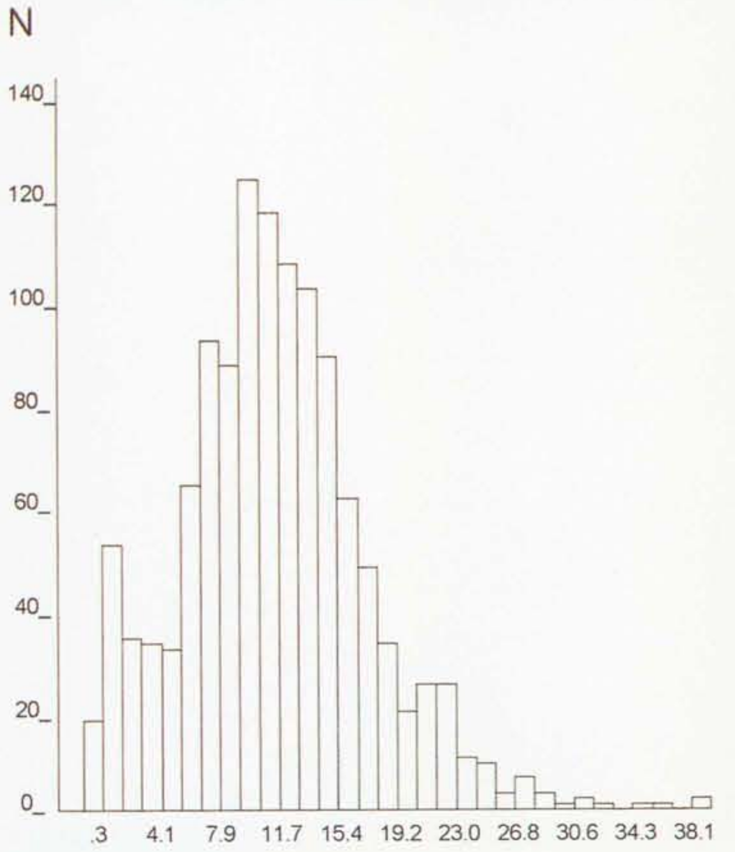
Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

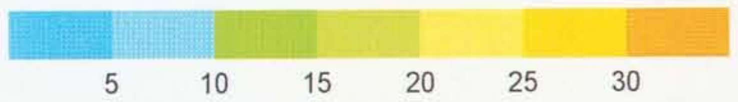
SiO_2 KRZEMIONKA SILICA



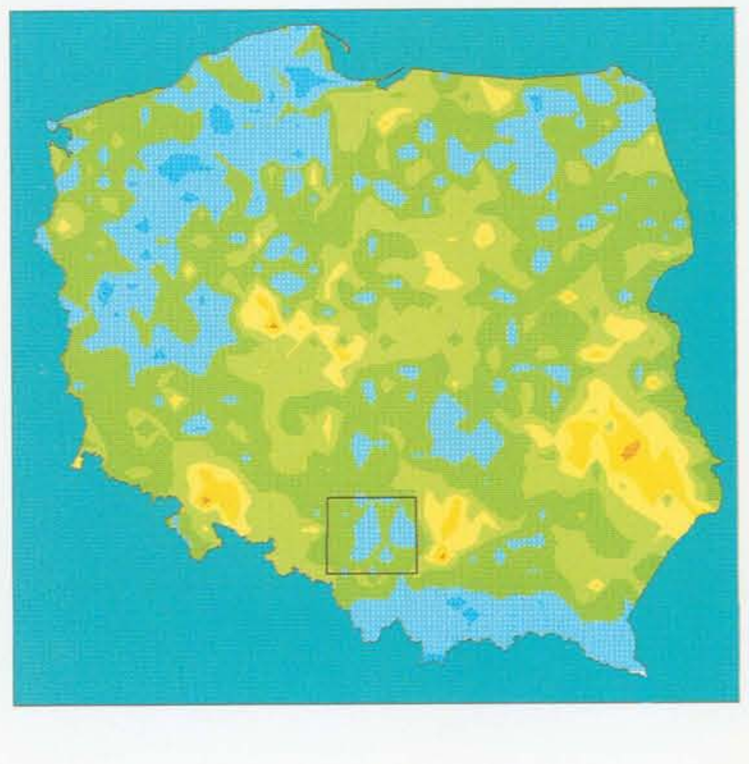
PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/l

Liczba próbek	1188	Number of samples
Minimum	0.3	Minimum
Maksimum	82.5	Maximum
Średnia arytm.	12.2	Arithmetic mean
Średnia geom.	10.2	Geometric mean
Mediana	11.7	Median
Granica wykrywalności	0.3	Detection limit





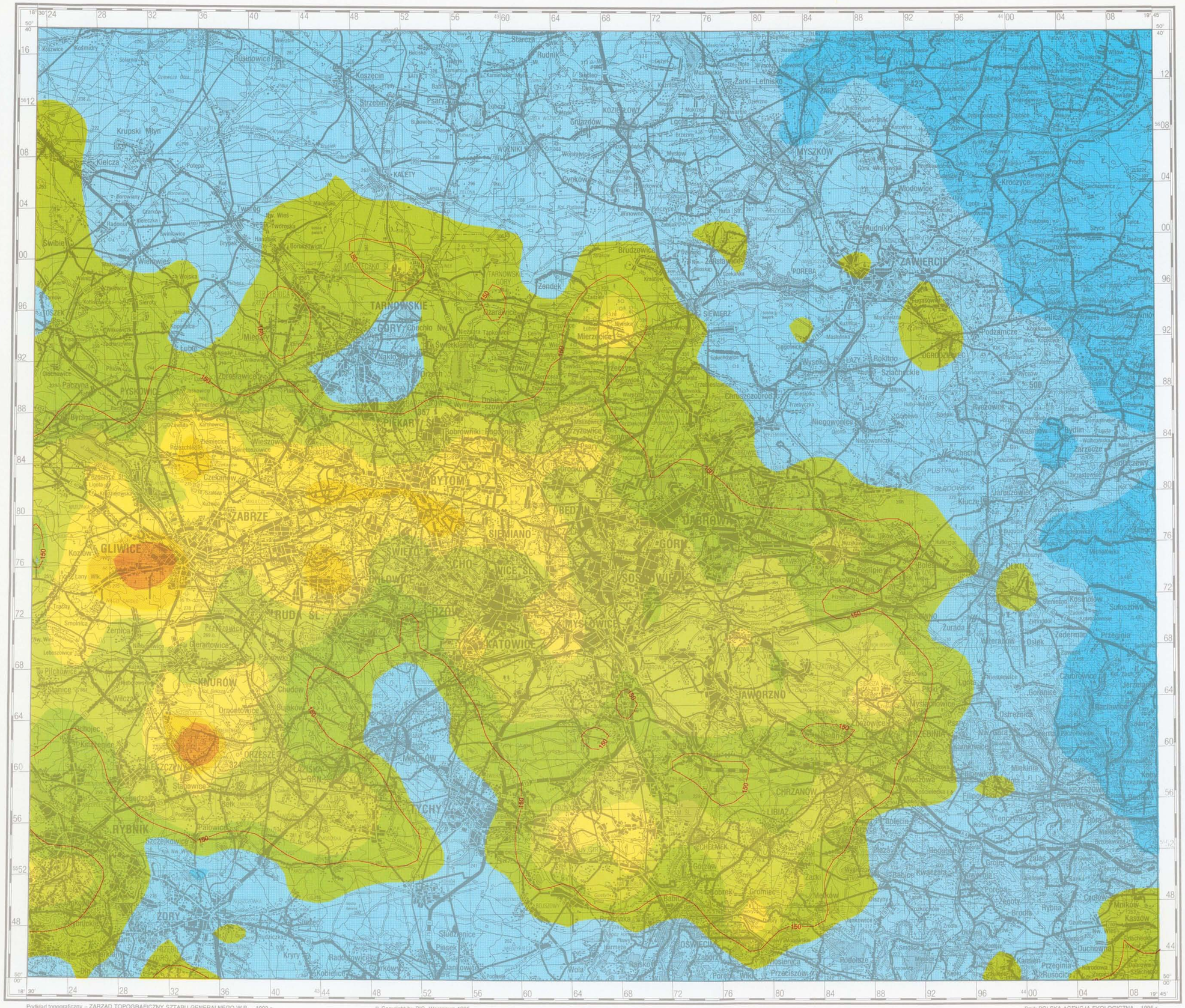
30 Wartość graniczna dla tła wód powierzchniowych Polski
Limit value for background of surface waters of Poland



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000

Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

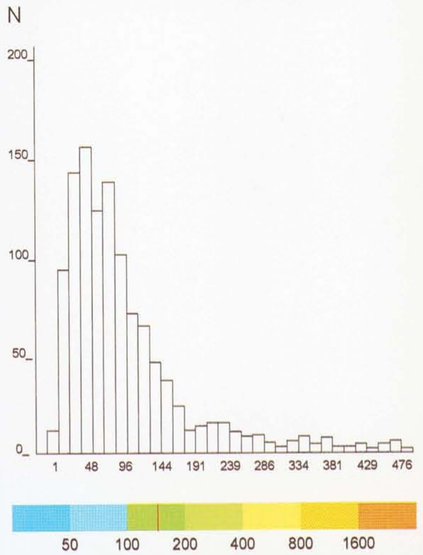
1:200 000

Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

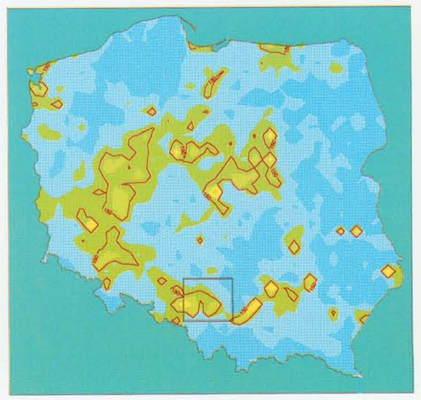
SO_4 SIARCZANY SULPHATES

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppm = mg/l

Liczba próbek	1188	Number of samples
Minimum	3	Minimum
Maksimum	7085	Maximum
Średnia arytm.	162	Arithmetic mean
Średnia geom.	85	Geometric mean
Mediana	81	Median
Granica wykrywalności	1	Detection limit



150 — Wartość graniczna dla I klasy wód powierzchniowych
Limit value for I class purity of surface waters



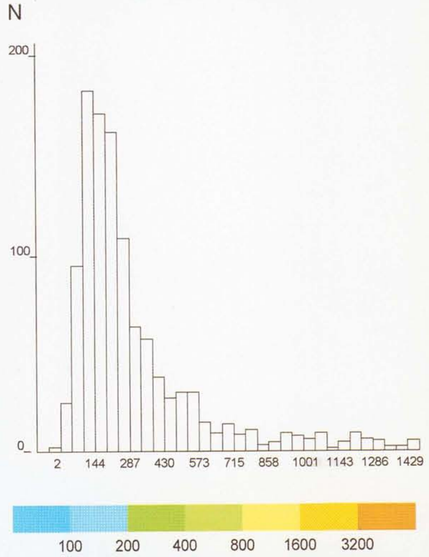
WODY POWIERZCHNIOWE
SURFACE WATERS

TABLICA
PLATE **64**

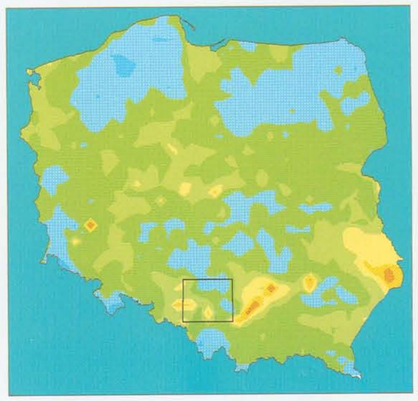
Sr STRONT STRONTIUM

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppb = µg/l

Liczba próbek	1188	Number of samples
Minimum	4	Minimum
Maksimum	26078	Maximum
Średnia arytm.	621	Arithmetic mean
Średnia geom.	310	Geometric mean
Mediana	253	Median
Granica wykrywalności	1	Detection limit



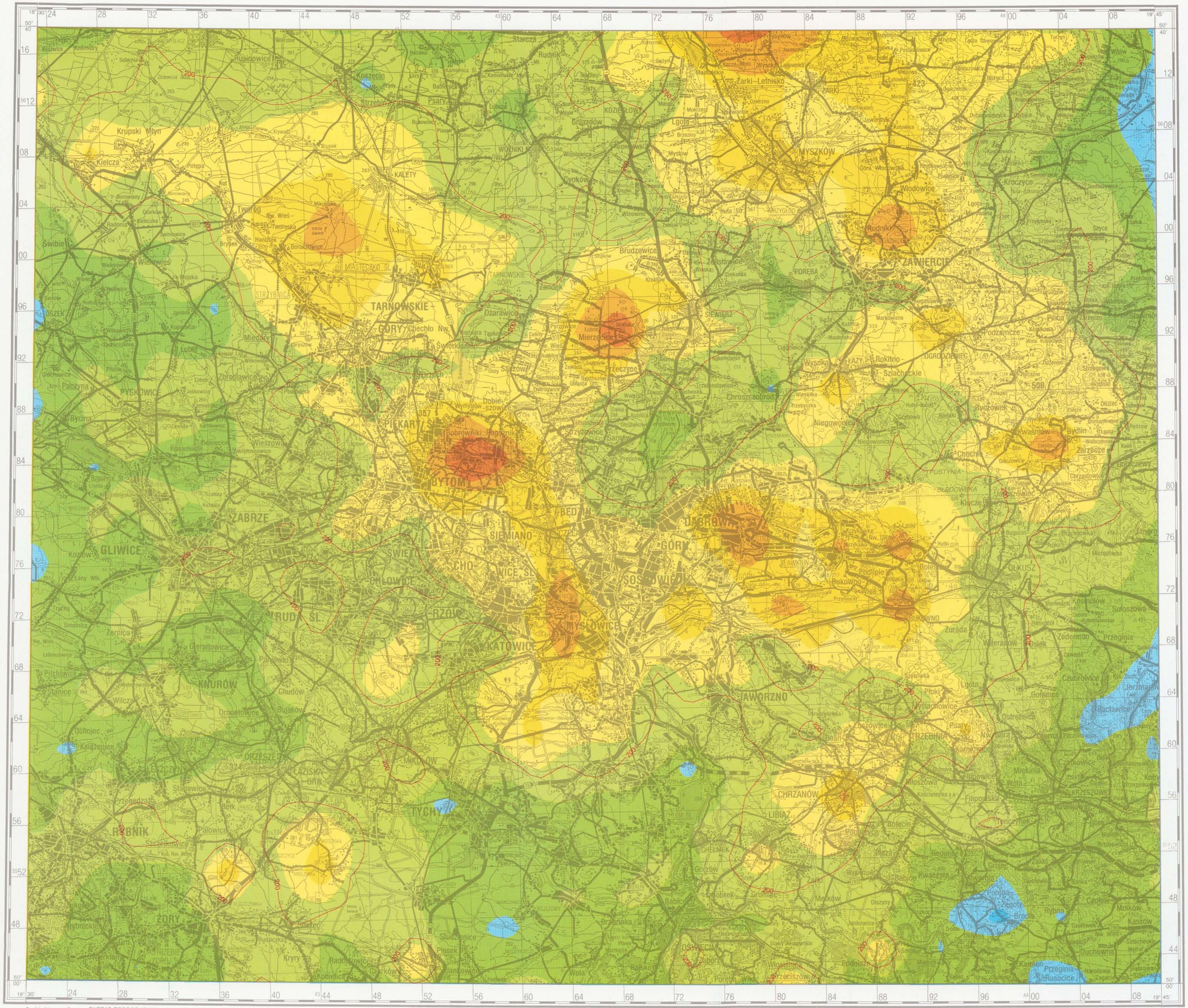
800 Wartość graniczna dla tła wód powierzchniowych Polski
Limit value for background of surface waters of Poland



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000

Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500



Podkład topograficzny – ZARZĄD TOPOGRAFICZNY SZTABU GENERALNEGO W.P. – 1992 r.

1:200 000

Druk POLSKA AGENCJA EKOLOGICZNA – 1995 r.
Zlec. D-3 4/95 Egz. 500

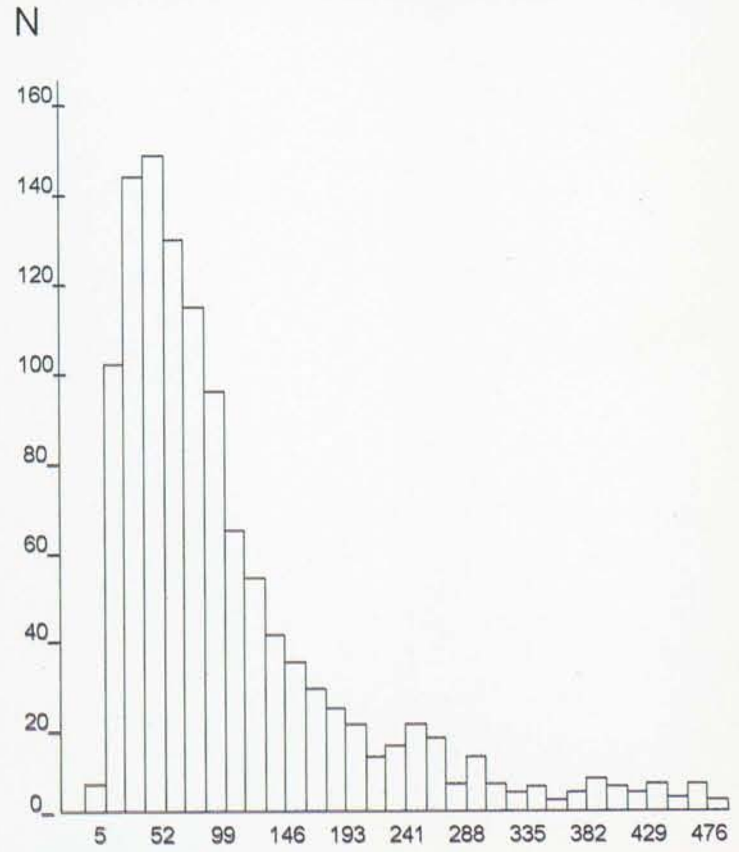
WODY POWIERZCHNIOWE
SURFACE WATERS

TABLICA 65
PLATE

Zn CYNK ZINC

PARAMETRY STATYSTYCZNE
STATISTICS PARAMETERS
ppb = µg/l

Liczba próbek	1188	Number of samples
Minimum	5	Minimum
Maksimum	13198	Maximum
Średnia arytm.	208	Arithmetic mean
Średnia geom.	96	Geometric mean
Mediana	86	Median
Granica wykrywalności	5	Detection limit



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	30	60	120	250	500	1000	3000

—— 200 —— Wartość graniczna dla I klasy czystości wód powierzchniowych
Limit value for I class purity of surface waters