Acta Sci. Pol.
Formatio Circumiectus 24 (4) 2025, 69–89
ENVIRONMENTAL PROCESSES
www.acta.urk.edu.pl ISSN 1644-0765 DOI: http://dx.doi.org/10.15576/ASP.FC/215809
ORIGINAL PAPER Accepted: 18.12.2025

GEOINFORMATION ANALYSIS OF THE SOIL COVER IN KHARKIV OBLAST BASED ON THE RESULTS OF THE 10TH ROUND OF AGROCHEMICAL SURVEYS OF AGRICULTURAL LANDS

Roman Palamarchuk[1] 0000-0002-5965-1305, Olena Hryshchenko[1] 0000-0002-1241-7183, Bohdanna Zaiachkivska[2]✉ 0009-0003-0962-5998, Mykhailo Hunchak[1] 0000-0002-3521-8531, Viktoriia Hryshchenko[1] 0009-0003-8550-2033

[1] State Institution "Soils Protection Institute of Ukraine", Ukraine
[2] National University of Life and Environmental Sciences of Ukraine, Ukraine

ABSTRACT

Aim of the study
The study aims to assess soil quality in the Kharkiv Oblast using results from the 10th round of agrochemical surveys, and to develop and present geospatial data layers and thematic maps for monitoring changes in soil properties, in accordance with the requirements of the NSDI and the INSPIRE Directive.

Material and methods
This article uses materials from the study of the results of the 10th round of agrochemical soil surveys of the Kharkiv Oblast, conducted and prepared in the format of a geospatial database by the State Institution "Soils Protection Institute of Ukraine." Soil surveys, laboratory tests, classification of results, and visualization were performed in accordance with the approved methodology (Yatsuk and Baliuk, 2019).

Cartographic and geospatial data for soil cover analysis were prepared and processed in a geographic information system (GIS) environment. All digital maps created in this study used the international coordinate system of WGS 84. All operations, including vectorization, spatial analysis, and the preparation of final layouts, were performed using QGIS (version 3.32.1).

Results and conclusions
Using geoinformation technologies, an assessment of the qualitative (agrochemical and eco-toxicological) indicators of the soils of the region's agricultural lands was conducted based on data from the 10th round of agrochemical studies. Thematic maps were constructed to reflect the spatial distribution of agrochemical parameters according to the approved gradations of agrochemical indicators, and the soil cover was characterized based on the results.

Keywords: agricultural land, humus content, monitoring of soil quality indicators, soil map, thematic field maps

✉e-mail: b_zayachkivska@nubip.edu.ua

INTRODUCTION

Fulfilling the commitments of the European Community on its path toward European integration, Ukraine is actively implementing the principles and requirements of the Directive of the European Parliament of 14 March 2007 on the establishment of an Infrastructure for Spatial Information in the European Community (INSPIRE) (European Parliament, 2007). In accordance with the provisions of the Directive, the National Spatial Data Infrastructure (NSDI) was established on the basis of the Law of Ukraine "On the National Spatial Data Infrastructure" of April 13, 2020 No. 554-IX (Verkhovna Rada of Ukraine, 2020a) and the Resolution of the Cabinet of Ministers of Ukraine "On Approval of the Procedure for the Functioning of the National Spatial Data Infrastructure" of May 26, 2021 No. 532 (Cabinet of Ministers of Ukraine, 2021b). Pursuant to these regulatory legal acts, the custodians of information on soils, genetic soil types, agro-industrial soil groups, natural-agricultural zoning, parent rocks, stratigraphic units, genetic types of Quaternary deposits, particle-size distribution, stoniness, erosion, average slope angle, and potential moisture capacity are: the State Service of Ukraine for Geodesy, Cartography and Cadastre (StateGeoCadastr), the State Enterprise "Centre for State Land Cadastre," and the State Forest Resources Agency of Ukraine.

According to Annex 2 to the Procedure for the Functioning of the National Spatial Data Infrastructure, the State Institution "Soils Protection Institute of Ukraine," within its competence, is to participate in the development and provision of: data on environmental monitoring services, the results of observations and measurements of the state of the environment, as well as other ecosystem parameters in the part concerning soil monitoring; data on the level of emergencies and their registration; data on zones of environmental emergency and degraded lands, in particular: land plots whose surface has been disturbed as a result of earthquakes, landslides, karst formation, floods, extraction of minerals, and other factors; land parcels with eroded, waterlogged, acidic, or saline soils; land parcels contaminated with chemical substances, and others (Cabinet of Ministers of Ukraine, 2021a).

Agrochemical surveying of agricultural lands in Ukraine has been conducted for more than 60 years, with a periodicity of once every five years. The State Institution "Soils Protection Institute of Ukraine" and its regional centers, as the executor of these works at the state level, conduct agrochemical research of the soil cover, assessing its properties and ecological condition (Prysiazhniuk et al., 2010; Yatsuk, 2015, 2020; Romanova et al., 2023). To date, eleven full rounds of such surveys have been conducted.

Soil research in the Kharkiv Oblast has also been conducted by experts of the Institute for Soil Science and Agrochemistry Research named after O.N. Sokolovsky (based in Kharkiv). The main areas of activity of this Institute include: the agrochemical characterization of soils of the Left-Bank Forest-Steppe, including the assessment of their fertility, physicochemical properties, and suitability for cultivating major agricultural crops; the reclamation of solonetzic and degraded soils of Kharkiv Oblast using chemical, agrotechnical, and biological methods; monitoring of the humus status and the content of macro- and microelements in soils; determining the potential for conservation and accumulation of organic carbon in the soil cover of the region.

T. Hrynchenko and V. Desenko performed the fifty-year monitoring of the comprehensive assessment of soil fertility in Kharkiv Oblast (1966–2015). Their research included the analysis of key agrochemical parameters, namely: soil reaction (pH), humus content, mobile forms of phosphorus, and exchangeable potassium (Hrynchenko et al., 2007, 2018). The problems of the ecological condition of soils in Kharkiv Oblast, in particular the impact of industrial and agricultural factors on degradation processes, water and wind erosion, as well as contamination with heavy metals, petroleum products, and pesticides, were studied by L.M. Shevchenko, O.V. Kruhlov, V.P. Koliada, O.O. Domkin, and others (Shevchenko et al., 2016).

Special attention has been given to the development of the Regional Program for Soil Protection and Fertility Improvement in Kharkiv Oblast, prepared with the support of the United States Agency for International Development (USAID) within the framework of the "Agricultural and Rural Development Support" project. The program defined strategic objectives, conceptual foundations, and mechanisms for implementing a set of measures aimed at: preserving the soil cover and preventing its degradation; increasing the productivity of land resources; adapting land use systems to climate change; and integrating modern technologies for monitoring and managing land resources into agricultural production. An important aspect of the program was the consideration of the regional characteristics of the soil cover of Kharkiv Oblast, including areas affected by erosion, salinization, acidification, and contamination with heavy metals and pesticides. The program recommended a combination of agrotechnical, biological, and chemical methods for restoring fertility, as well as the introduction of a system of regular soil monitoring in accordance with the requirements of the National Spatial Data Infrastructure (NSDI) (Baliuk and Miroshnychenko, 2018).

Thus, comprehensive research and programmatic documents have laid the foundation for the transition from fragmented control of soil conditions to an integrated land resource management system in Kharkiv Oblast. The effective land resource management system can be achieved with the aid of technology, such as geographic information systems and geodatabases, as it provides not only the collection and storage of large volumes of data, but also that data's spatial modeling, visualization, and operational analysis.

MATERIALS AND METHODS

The 10th round of agrochemical surveys is of particular importance, as it covered the largest areas of agricultural land and provided for the laboratory determination of a record number of indicators compared to previous rounds. Since soil sampling is carried out exclusively with the voluntary consent of land users, the survey results contain so-called "white spots" − territories where the soil scientists of State Institution "Soils Protection Institute of Ukraine" did not conduct surveys.

The data from the 10th round of agrochemical surveys became a baseline source for ensuring the monitoring of soil quality indicators in accordance with the requirements and obligations of the National Spatial Data Infrastructure (NSDI).

Based on the results of the eleven rounds of agrochemical surveys, State Institution "Soils Protection Institute of Ukraine" has formed and populated the soil indicator databank. To improve the efficiency of monitoring soil quality indicators, there arose a need to introduce modern approaches to mapping and the automation of calculations. For this reason, work was initiated on transforming cartographic and tabular materials into a unified dataset, along with the creation of a geographic information system and database.

After soil samples are collected, the laboratories of State Institution "Soils Protection Institute of Ukraine" carry out the determination of agrochemical and ecological indicators and their subsequent analysis. The final results of the studies are:

- absolute indicators for elementary parcels;
- weighted average indicators for fields, agro-industrial soil groups, agricultural enterprises, administrative districts, and others;
- thematic maps.

Thematic maps are created based on the grouping of soils by the concentration of elements in the soil. According to the methodology (Yatsuk and Baliuk, 2019), the weighted average values are classified:

- according to pH content, subdivision into 10 groups: very strongly acidic: (0–4.1); strongly acidic (4.1–4.5); average acidic (4.6–5.0); sightly acidic (5.1–5.5); close to neutral (5.6–6.0); neutral (6.1–7.0); weakly alkaline (7.1–7.5); average alkaline (7.6–8.0); strongly alkaline (8.1–8.5) and very strongly alkaline (> 8.5);
- according to easily hydrolysable nitrogen content determined using the Cornfield method (State Standards of Ukraine, 2015a), subdivision into 4 groups: very low (0–101 $mg \cdot kg^{-1}$); low (101–150 $mg \cdot kg^{-1}$); average (151–200 $mg \cdot kg^{-1}$); elevated (> 200 $mg \cdot kg^{-1}$);
- according to other indicators, subdivision into six groups (Table 1).

The content of microelements in soil was determined using the following extracting solutions:

- for manganese, zinc, cobalt, and copper, an ammonium-acetate buffer solution with a pH of 4.8 was used;
- for molybdenum, an oxalate buffer solution with a pH of 3.3 (Grigg's extract) was used;
- for boron, the extracting solution used was water (H_2O).

When they exceed certain content standards, mobile compounds of trace elements act as pollutants. The gradation of the content of trace elements-pollutants is given in Table 2. Manganese, zinc cobalt and copper are extracted using ammonium acetate buffer solution (pH 4.8). Molybdenum is determined using the Grigg oxalate extraction method.

The tabular data contain numerical values of the indicators, while the cartographic materials reflect the classification of lands according to the relevant gradations, from low to high levels (Yatsuk and Baliuk, 2019).

This article presents an example of creating a geospatial data layer within the territory of Kharkiv Oblast, as well as the results of analysis and mapping for selected agrochemical indicators.

Kharkiv Oblast is one of the largest administrative-territorial units of Ukraine, located in the east of the country. It borders Luhansk, Donetsk, Dnipropetrovsk, Poltava, Sumy oblasts, and the russian federation. The region lies within the Left-Bank Forest-Steppe Upland, where clay and loess deposits predominate. Approximately half of the region's territory is situated in the Left-Bank Forest-Steppe Province, and the other half, in the Left-Bank Steppe Province (Fig. 1) (Martyn et al., 2015).

According to the Kharkiv Oblast Council, the area of the region is 31.415 thousand square km (Kharkiv

Table 1. Grouping of soils according to element content

Groups	Humus, %	Mobile phosphorus, mg · kg^{-1}	Mobile potassium, mg · kg^{-1}	Mobile sulphur, mg · kg^{-1}	Boron, mg · kg^{-1}	Mobile manganese, mg · kg^{-1}	Mobile zinc, mg · kg^{-1}	Mobile cobalt, mg · kg^{-1}	Mobile copper, mg · kg^{-1}	Mobile molybdenum, mg · kg^{-1}
Very low	0–1.1	0–21	0–21	0–3.1	0–0.15	0–5.1	0–1.1	0–0.071	0–0.11	0–0.05
Low	1.1–2.0	21–50	21–40	3.1–6.0	0.15–0.22	5.1–7.0	1.1–1.5	0.071–0.10	0.11–0.15	0.05–0.07
Average	2.1–3.0	51–100	41–80	6.1–9.0	0.23–0.33	7.1–10.0	1.6–2.0	0.11–0.15	0.16–0.20	0.08–0.10
Elevated	3.1–4.0	101–150	81–120	9.1–12.0	0.34–0.50	10.1–15.0	2.1–3.0	0.16–0.20	0.21–0.30	0.11–0.15
High	4.1–5.0	151–200	121–180	12.1–15.0	0.51–0.70	15.1–20.0	3.1–5.0	0.21–0.30	0.31–0.50	0.16–0.22
Very high	>5.0	>200	>180	>15.0	>0.70	20.1–49.9	>5.0	0.30–0.49	0.51–0.99	0.22–0.29

Table 2. Grouping of soils according to the content of mobile forms of polluting elements

Groups	Mobile manganese, mg · kg^{-1}	Mobile zinc, mg · kg^{-1}	Mobile cobalt, mg · kg^{-1}	Mobile copper, mg · kg^{-1}	Mobile molybdenum, mg · kg^{-1}
Low pollution level	50–99	5–9	0.5–0.9	1–1.9	0.3–0.4
Moderate pollution level	100–149	10–14	1.0–1.4	2–2.9	0.5–0.9
Average pollution level	150–199	15–19	1.5–1.9	3–3.9	1–1.4
Elevated pollution level	200–249	20–24	2.0–2.4	4–4.9	1.5–1.9
High pollution level	250–299	25–29	2.5–2.9	5–5.9	2–2.4
Very high pollution level	300	30	3.0	6	2.5

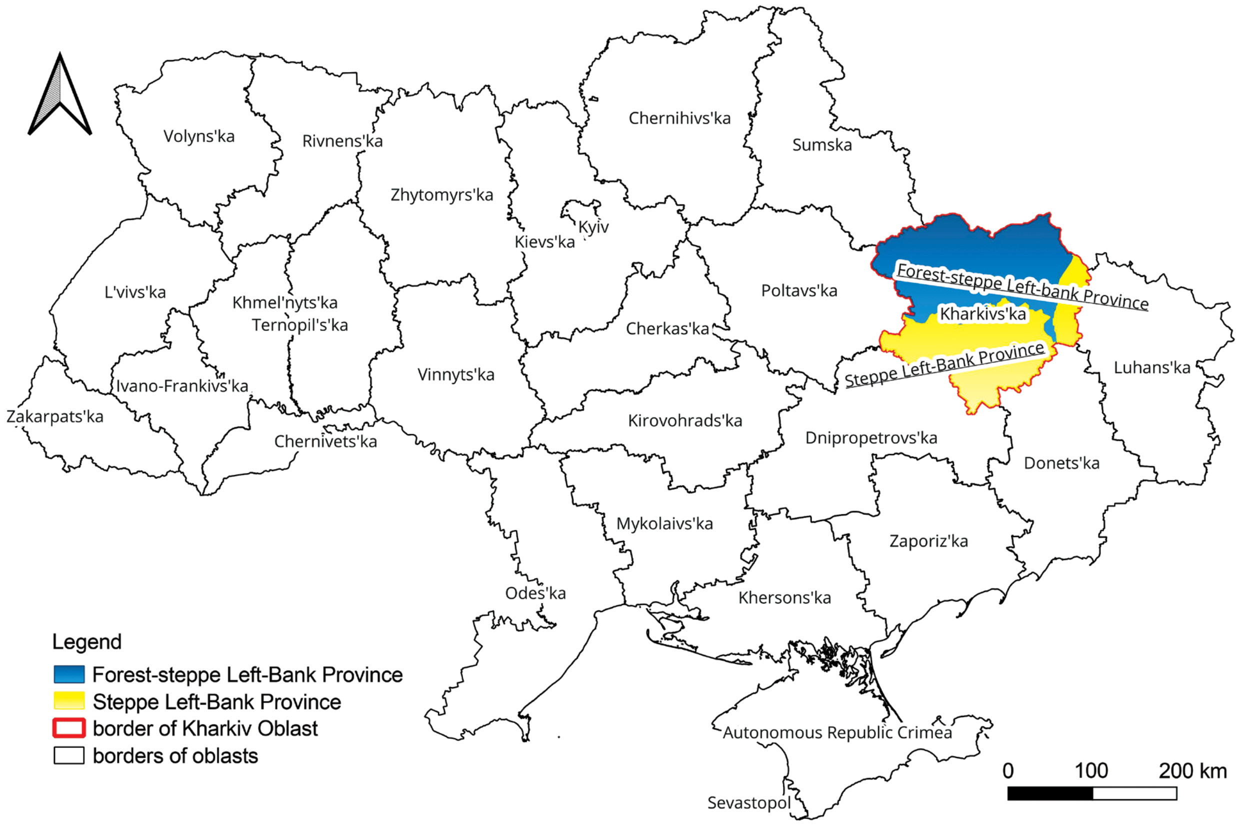

Fig. 1. Location and natural-agricultural zoning of Kharkiv Oblast (Source: own elaboration)

Oblast Council, 2020). Before 2020 the Kharkiv Oblast included 27 districts: Balakliis'kyi (I), Barvinkivs'kyi (II), Blyzniukivs'kyi (III), Bohodukhivs'kyi (IV), Borivs'kyi (V), Chuhuivs'kyi (XXVI), Derhachivs'kyi (X), Dvorichans'kyi (IX), Iziums'kyi (XIV), Kehychivs'kyi (XV), Kharkivs'kyi (XXV), Kolomats'kyi (XVI), Krasnohrads'kyi (XVII), Krasnokuts'kyi (XVIII), Kupians'kyi (XIX), Lozivs'kyi (XX), Novovodolaz'kyi (XXI), Pecheniz'kyi (XXIII), Pervomais'kyi (XXII), Sakhnovschyns'kyi (XIV), Shevchenkivs'kyi (XXVII), Valkivs'kyi (VI), Velykoburluts'kyi (VII), Vovchans'kyi (VIII), Zachepylivs'kyi (XI), Zmiivs'kyi (XII) and Zolochivs'kyi (XIII). In accordance with the Resolution of the Verkhovna Rada of Ukraine "On the Formation and Liquidation of Districts" No. 3650, July 17, 2020, seven administrative districts were established within the oblast: Bohodukhivskyi, Iziumskyi, Krasnohradskyi, Kupianskyi, Lozivskyi, Kharkivskyi, and Chuhuivskyi (Verkhovna Rada of Ukraine, 2020b). In 2024, Krasnohradskyi District was renamed Berestynskyi (Fig. 2).

According to the State Land Cadastre as of October 1, 2019, the area of agricultural land in Kharkiv Oblast amounted to 2.381 thousand ha, of which 1.937 thousand ha were arable land, 395 thousand ha were pastures and hayfields, 42 thousand ha were perennial plantations, and 8 thousand ha were fallow land (Land Directory of Ukraine, 2020).

The climate of Kharkiv Oblast is moderately continental, with warm, sometimes hot summers and moderately cold winters. The average annual temperature is about +7 to +8°C, the average temperature in July is +20 to +22°C, and in January –6 to –8°C. Annual precipitation ranges from 480 to 550 mm, with the majority falling during the warm period of the year. The spring–summer season is characterized by short-term but intense downpours, which cause significant surface runoff and activate water erosion

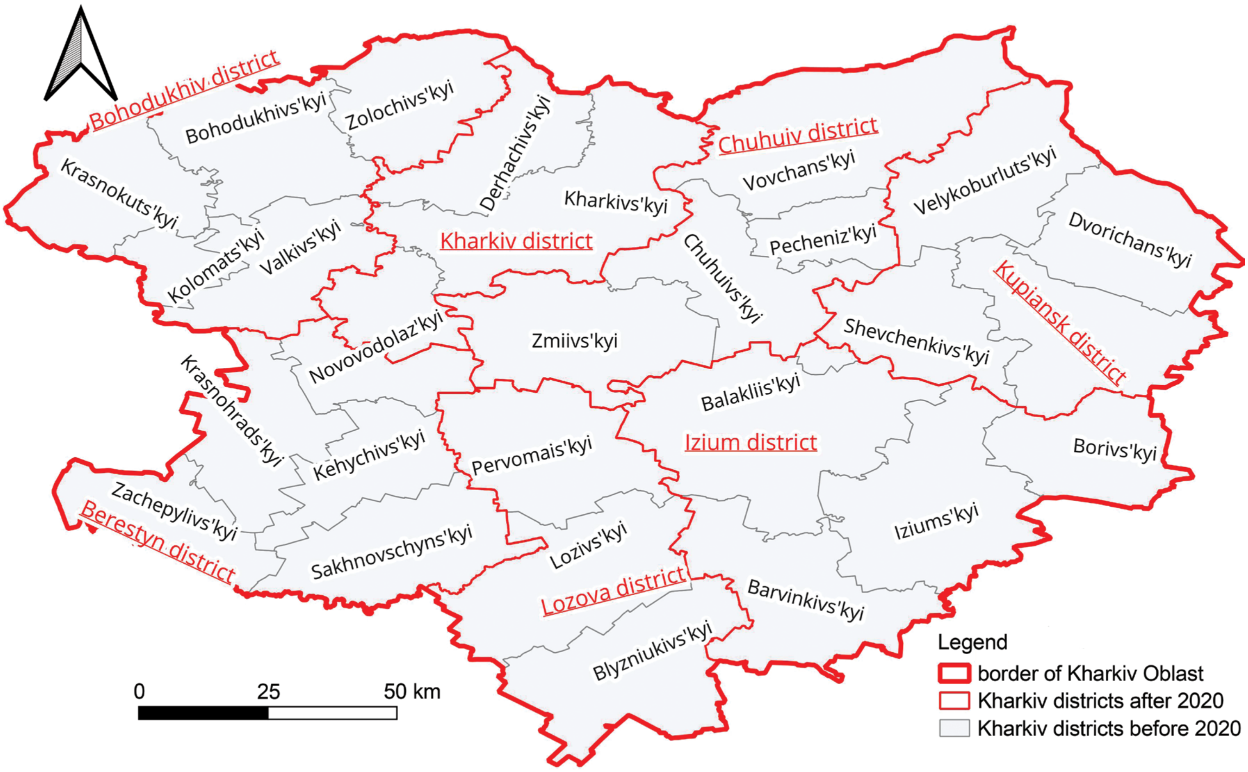

Fig. 2. Administrative districts of Kharkiv Oblast (Source: own elaboration)

processes, especially on slopes (Kharkiv Oblast Military Administration, n.d.).

Relief features complicate the environmental situation in the region. A significant part of the territory has an undulating-hilly surface dissected by numerous river valleys, gullies, and ravines, formed mainly as a result of water erosion. Ravines develop in erosion-prone areas with degraded vegetation cover and steep slopes (3–5°), where surface water concentrates, causing soil washout (Stetsiuk and Kovalchuk, 2005). According to Bairak (2018), medium-depth ravines (5–15 m) and deep ravines (20–25 m) are widespread within the region. The formation of erosion structures is intensified in areas with weakened vegetation cover, significant precipitation, and unstable clay or loess deposits. For this reason, the western and central parts of the region are characterized by a dense network of gullies and ravines.

Elevation differences and water erosion contribute to the loss of the fertile topsoil, especially in open and ploughed areas. Accelerated surface runoff due to significant elevation changes washes away soil in zones with insufficient vegetation cover. In the western and central parts of Kharkiv Oblast, a complex system of erosion forms is widespread, including ravines (up to 10–20 m deep) and shallow ravines. The densest ravine networks are located to the southwest of Kharkiv, particularly near the Lopan River and its tributaries. Significant erosion formations are also observed in the western part of the region near the Zmiiv Reservoir and in the Pechenihy valley. Erosion-unstable relief exacerbates soil degradation in the region (Kharkiv Oblast Military Administration, 2023). Relief, hydrography, and forest cover of Kharkiv Oblast is visualized by open data sources SRTM, OpenStreetMap (Fig. 3).

Relief and the presence of numerous gullies influence soil cultivation, the formation of agricultural lands, and their configuration.

Based on the results of the 10th round of agrochemical surveys of agricultural lands within Kharkiv Oblast, more than 700 soil map-schemes were created, and indicators for over 18 thousand field contours were plotted on them (Fig. 4).

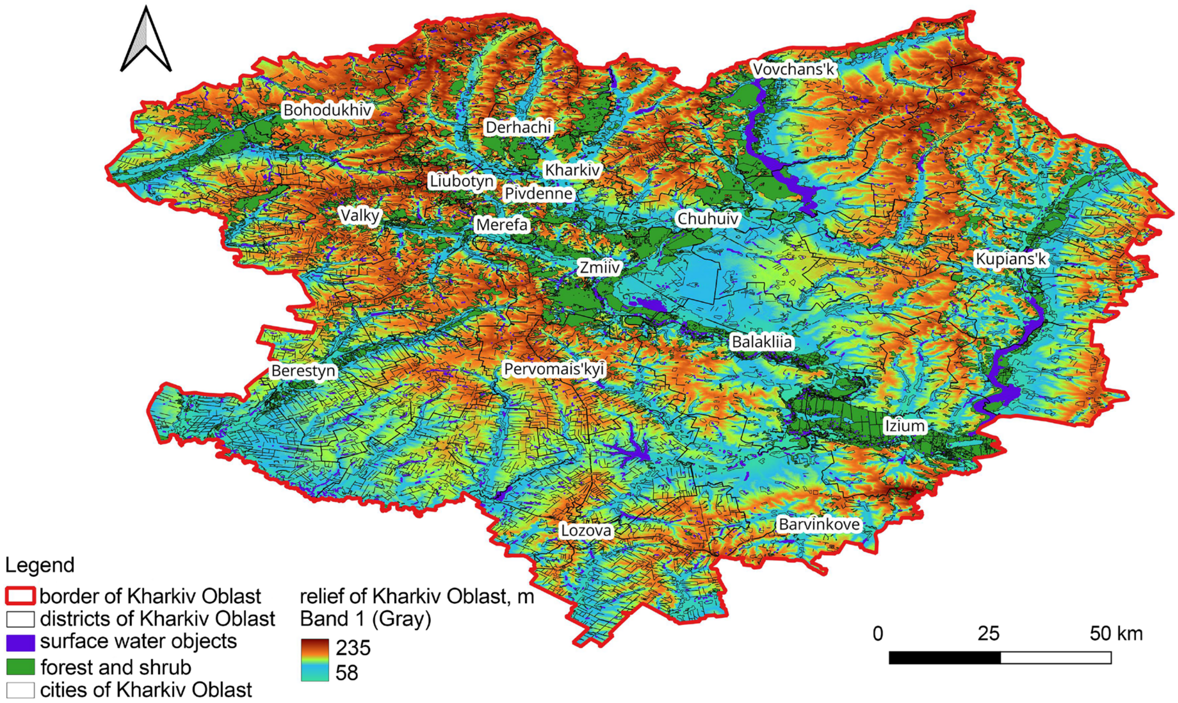

Fig. 3. Relief, hydrography and forest cover of Kharkiv Oblast (Source: own elaboration)

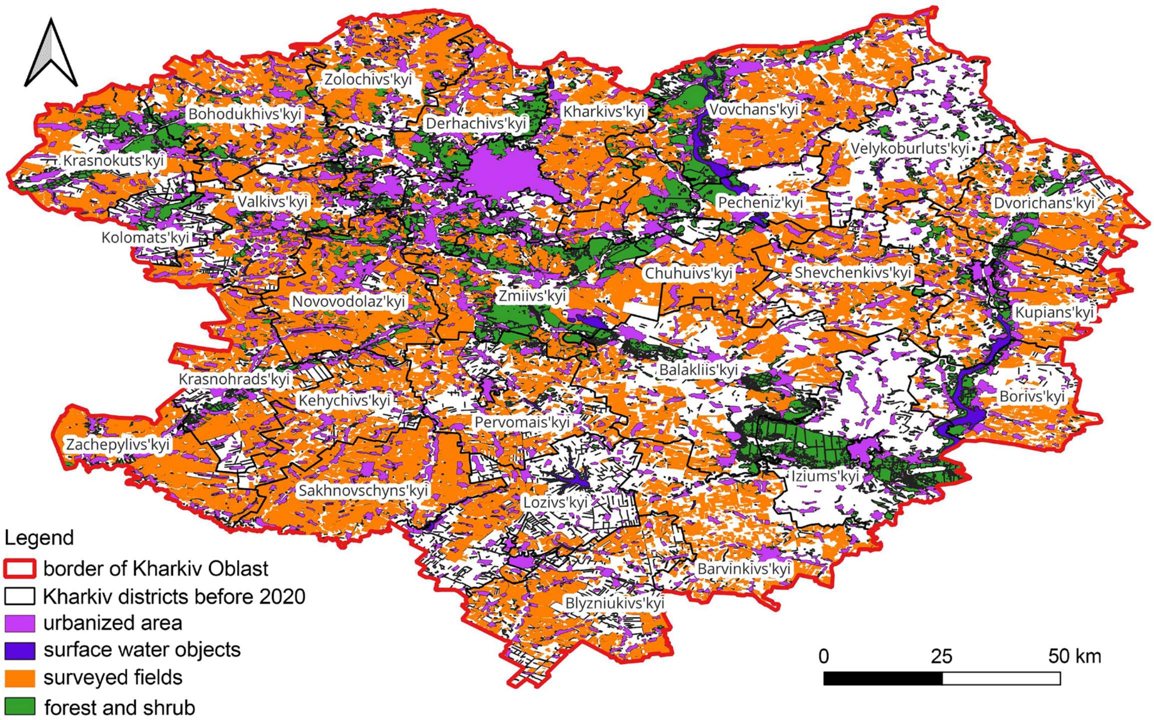

Fig. 4. Territorial coverage of the 10th round of agrochemical survey of agricultural lands in Kharkiv Oblast (Source: own elaboration)

The weighted average content of soil quality indicators is determined according to the Methodology for conducting agrochemical certification of agricultural lands (Yatsuk and Baliuk, 2019):

- humus – in accordance with SSU 4289:2004 (State Standards of Ukraine, 2004);
- soil solution reaction (pH) – in accordance with SSU ISO 10390:2007 (State Standards of Ukraine, 2007e);
- easily hydrolysable nitrogen – in accordance with SSU 7863:2015 (State Standards of Ukraine, 2015a);
- mobile phosphorus and potassium compounds – in accordance with SSU 4115–2002 (State Standards of Ukraine, 2002);
- mobile sulphur – in accordance with SSU 8347:2015 (State Standards of Ukraine, 2015b);
- boron content – in accordance with SS 10150-88 (State Standard, 1988a);
- mobile manganese compounds – in accordance with SSU 4770.1:2007 (State Standards of Ukraine, 2007a);
- mobile zinc compounds – in accordance with SSU 4770.2:2007 (State Standards of Ukraine, 2007b);
- mobile cobalt compounds – in accordance with SSU 4770.5:2007 (State Standards of Ukraine, 2007c);
- mobile copper compounds – in accordance with SSU 4770.6:2007 (State Standards of Ukraine, 2007d) and Resolution "On approval of maximum permissible concentrations of hazardous substances in soils and the list of such substances" (Cabinet of Ministers of Ukraine, 2021a);
- mobile molybdenum compounds – in accordance with SS 10151-88 (State Standard, 1988b).

RESULTS

The districts marked in white on the maps were not investigated in 2011–2015 survey at all or by certain indicators.

The weighted average humus content, determined by districts, is predominantly at elevated and high levels (Fig. 5), indicating a significant fertility potential of the soil cover. An elevated level (3.1–4.0%) was recorded across most of Kharkivskyi District, nearly half of the territory of Bohodukhivskyi and Chuhuivskyi Districts, as well as in part of Izium District. Such a distribution of organic matter is an important indicator of the agro-ecological condition of the land and creates favourable conditions for efficient agricultural production. In the remaining surveyed areas of the region, a high humus content – 4.1–5.0% – predominates.

According to the results of determining soil solution reaction (pH), the soils of Kharkiv Oblast predominantly exhibit neutral or close-to-neutral values (Fig. 6), which create favourable conditions for cultivating a wide range of agricultural crops. In the central and north-western parts of the region, pH ranges from 5.6 to 6.0, corresponding to a slightly acidic or close-to-neutral reaction. In the rest of the territory, a neutral soil reaction (pH 6.1–7.1) predominates.

The weighted average content of easily hydrolysable nitrogen in the soils of districts within Kharkiv Oblast during 2011–2015 was at very low and low levels (Fig. 7), indicating insufficient soil supply of this element and necessitating the application of nitrogen fertilizers to increase the yield of agricultural crops. According to the survey results, the western part of Bohodukhivskyi District, as well as extensive areas of Kharkivskyi and Chuhuivskyi districts, were characterised by a very low weighted average nitrogen content – up to 101 $mg \cdot kg^{-1}$ of soil. In other areas of the region, the weighted average nitrogen content remained at a low level (101–150 $mg \cdot kg^{-1}$ of soil).

The study also established that the provision of soils in Kharkiv Oblast with mobile phosphorus compounds, as determined by the Chirikov method, ranges from average to elevated levels, and in some cases reaches high values (Fig. 8). Average values (51–100 $mg \cdot kg^{-1}$) predominate in the northern and eastern districts. In parts of Berestynskyi and Lozivskyi districts, a high phosphorus content (151–200 $mg \cdot kg^{-1}$) was recorded. In most of the region's territory, elevated values (101–150 $mg \cdot kg^{-1}$) are widespread.

The weighted average content of mobile potassium compounds in the soils of agricultural lands in Kharkiv Oblast ranges from medium to high levels (Fig. 9). The highest values (121–180 $mg \cdot kg^{-1}$) were recorded in certain areas of Berestynskyi, Kharkivskyi, and Kupianskyi districts. Elevated potassi-

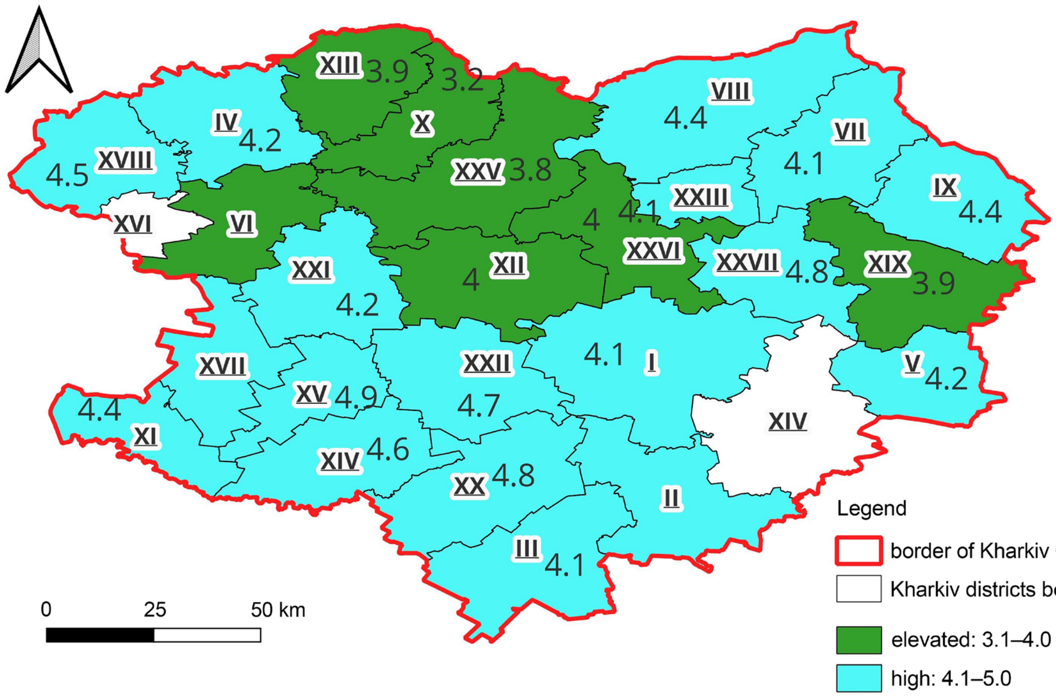

Fig. 5. Weighted average humus content (%) of agricultural land in districts of Kharkiv Oblast according to the results of the 10th round of agrochemical survey (2011–2015) (Source: own elaboration)

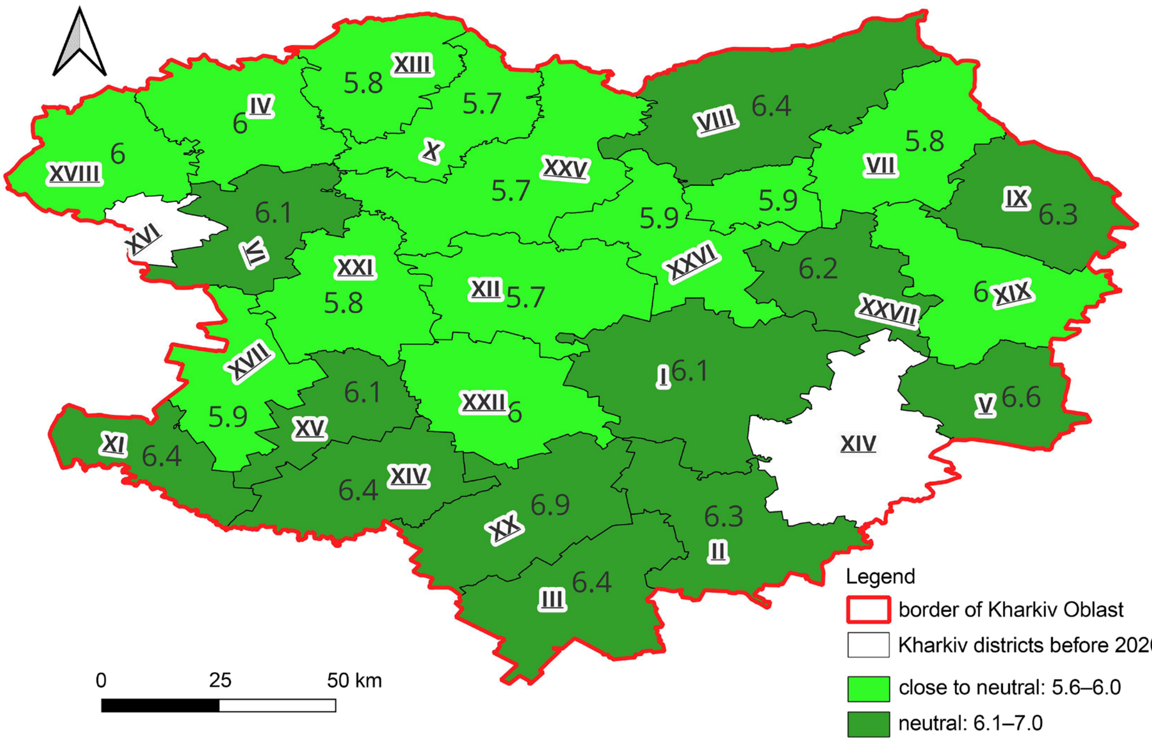

Fig. 6. Weighted average pH content of agricultural land in districts of Kharkiv Oblast according to the results of the 10th round of agrochemical survey (2011–2015) (Source: own elaboration)

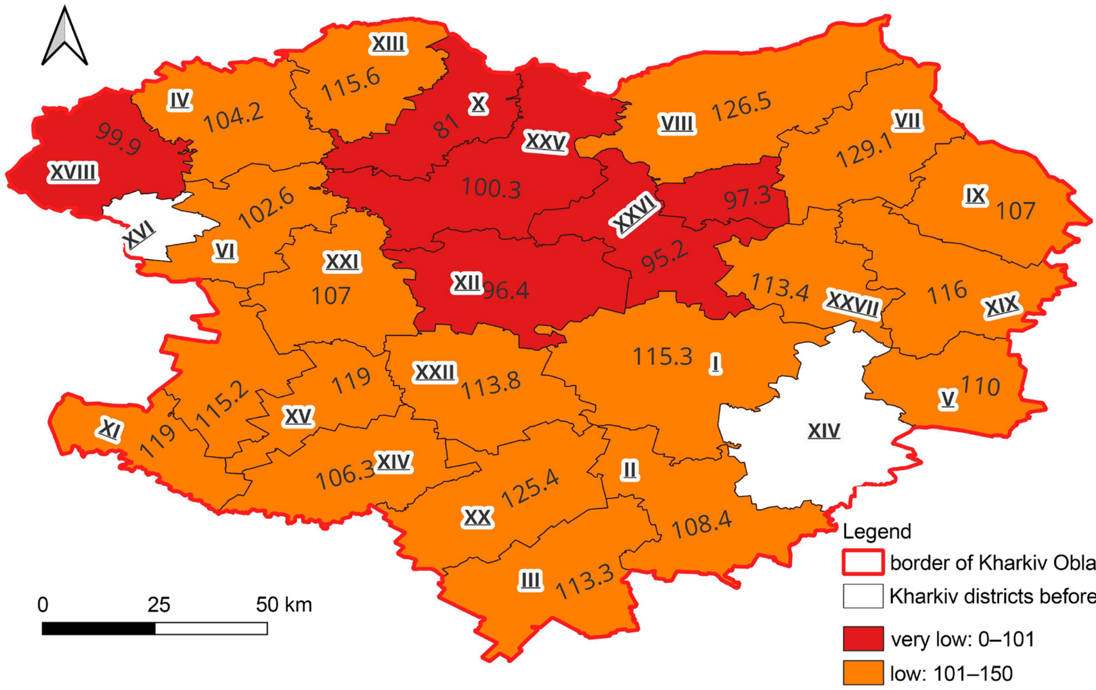

Fig. 7. Weighted average easily hydrolysable nitrogen content (mg · kg^{-1}) of agricultural land in districts of Kharkiv Oblast according to the results of the 10th round of agrochemical survey (2011–2015) (Source: own elaboration)

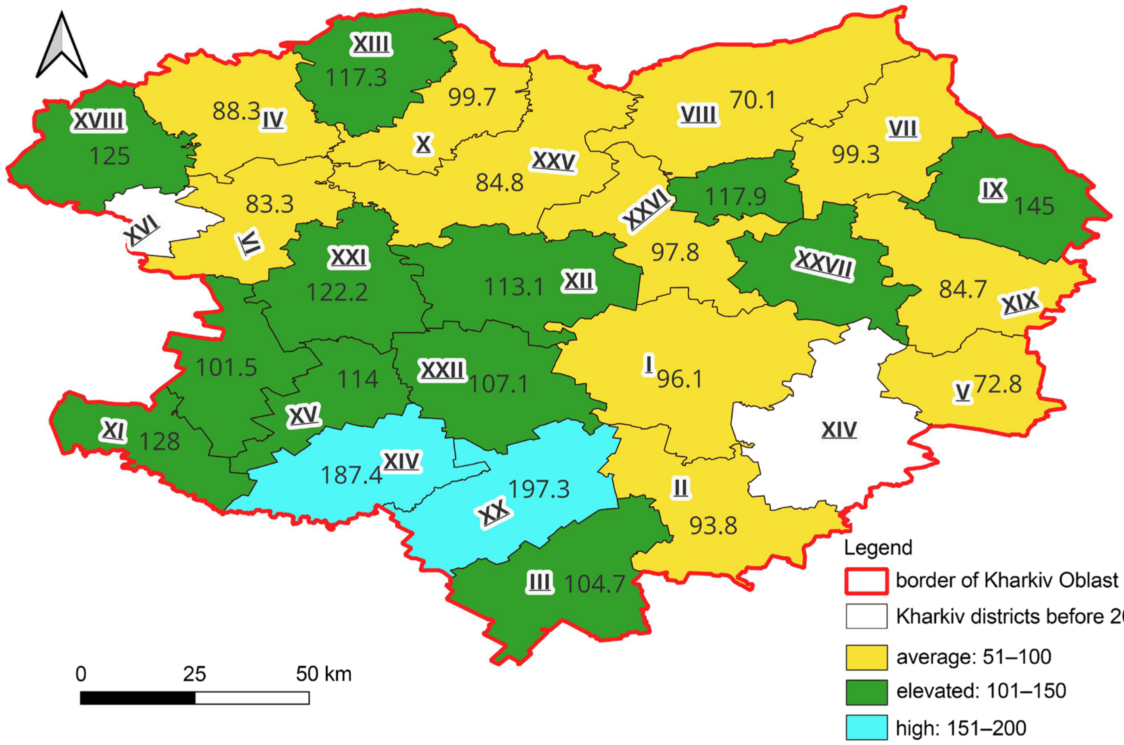

Fig. 8. Weighted average mobile phosphorus compounds content (mg · kg^{-1}) of agricultural land in districts of Kharkiv Oblast according to the results of the 10th round of agrochemical survey (2011–2015) (Source: own elaboration)

um content (81.0–120.0 mg · kg^{-1}) was observed in parts of Bohodukhivskyi, Chuhuivskyi, Kupianskyi, and Iziumskyi districts. In the remaining territories, a average potassium level (41.0–80.0 mg · kg^{-1}) predominates.

The weighted average content of mobile sulphur in the soils of Kharkiv Oblast varies widely − from medium to very high levels of supply. Average values (6.1–9.0 mg · kg^{-1}) ensure adequate plant nutrition with this element and support their normal development. At the same time, in certain areas, values exceeding 14.1 mg · kg^{-1} were recorded, corresponding to a very high level of supply. Such concentrations may result from both natural geochemical conditions and the prolonged application of sulphur-containing fertilizers (Fig. 10).

The weighted average boron content, determined using the Berger and Truog method, in the soils of Kharkiv Oblast predominantly falls within the average (0.23–0.33 mg · kg^{-1}) and low (0.15–0.22 mg · kg^{-1}) ranges (Fig. 11). In two districts of the region, an elevated boron level (0.34−0.50 mg · kg^{-1}) was recorded, and in one district − a high level (0.51−0.70 mg · kg^{-1}). Such concentrations may be associated with both natural soil-geochemical characteristics and local anthropogenic factors.

Mobile manganese compounds, determined in a buffered ammonium acetate extract at pH 4.8 using atomic absorption spectrophotometry, are present in the soils of Kharkiv Oblast across a wide range: from low to very high levels of supply. Despite the presence of areas with low manganese content, most of the region's territory is characterised by very high levels of this element (20.1–49.9 mg · kg^{-1} of soil) (Fig. 12).

The content of mobile zinc compounds, determined in a buffered ammonium acetate extract at pH 4.8 using the method of atomic absorption spectrophotometry, in the soils of Kharkiv Oblast is predominantly at a below-average level. According to the research findings, in the central and western parts of the region, the weighted average zinc content is low-ranging from 1.1 to 1.5 mg · kg^{-1} of soil. This points to the necessity of applying zinc-containing fertilizers, particularly for crops sensitive to zinc deficiency. In most of the territory of Kharkiv Oblast, the zinc concentration is very low, namely up to 1.1 mg · kg^{-1} of soil (Fig. 13).

The content of mobile cobalt compounds, determined in a buffered ammonium acetate extract at pH 4.8 using the method of atomic absorption spectrophotometry, in the soils of Kharkiv Oblast does not exceed the maximum permissible concentrations (> 0.5 mg · kg^{-1} of soil). However, the spatial distribution of this element is uneven: in the central part of the region, very high values are recorded, whereas in most of the territory the cobalt level corresponds to moderate pollution level (0.5–2.0 mg · kg^{-1} of soil) and average pollution level (1.5–1.9 mg · kg^{-1}) (Fig. 14).

The content of mobile copper compounds, determined in a buffered ammonium acetate extract at pH 4.8 using the method of atomic absorption spectrophotometry, is characterized by a very high level (0.51–0.99 mg · kg^{-1} of soil) across most of the territory of Kharkiv Oblast. In Lozivskyi District, a high copper level (0.31–0.50 mg · kg^{-1}) is observed, while in Kharkivskyi District the level is elevated (0.21– 0.30 mg · kg^{-1}). At the same time, in Bohodukhivskyi, Derhachivskyi, Pechenizkyi, Borivskyi, and Blyzniukivskyi districts, a low level of contamination with this micronutrient (1–1.9 mg · kg^{-1} of soil) has been recorded (Fig. 15).

The content of mobile molybdenum compounds was determined in a buffered ammonium acetate extract at pH 3.3 using the method of atomic absorption spectrophotometry. According to the research results, a low molybdenum level in the soils of Kharkiv Oblast is observed only in Derhachivskyi and Chuhuivskyi districts. In most of the territory, average, elevated, and high concentrations of this micronutrient predominate. In certain cases, particularly in Krasnohradskyi District, a average level of molybdenum contamination has been recorded, while the maximum permissible concentrations are not exceeded (Fig. 16).

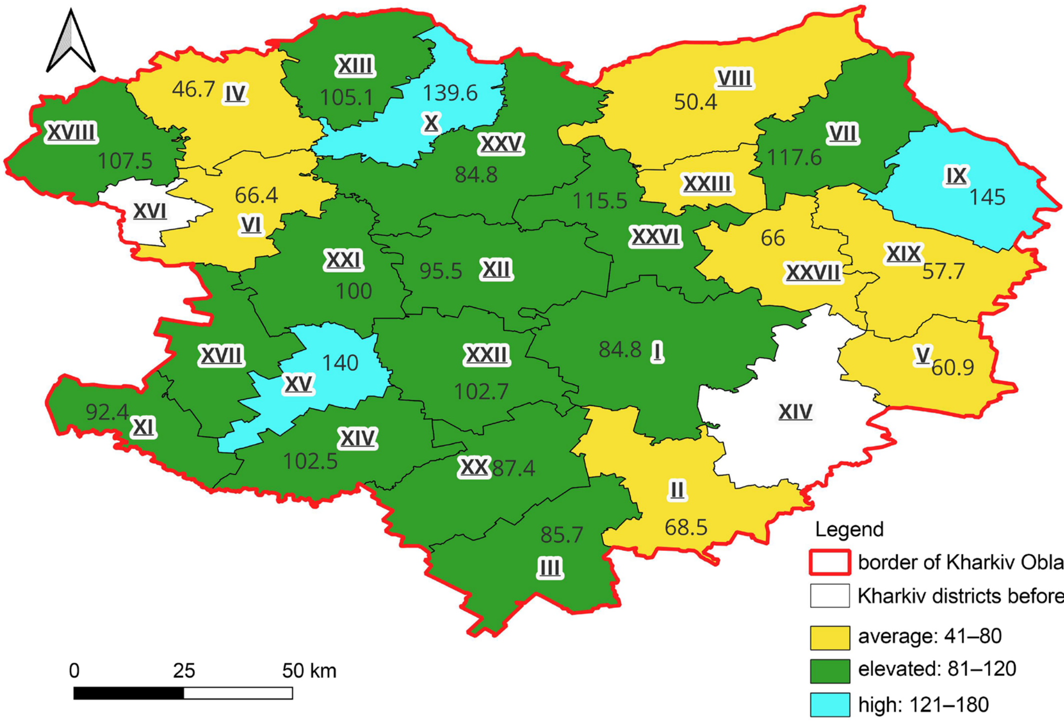

Fig. 9. Weighted average mobile potassium compounds content (mg · kg^{-1}) of agricultural land in districts of Kharkiv Oblast according to the results of the 10th round of agrochemical survey (2011–2015) (Source: own elaboration)

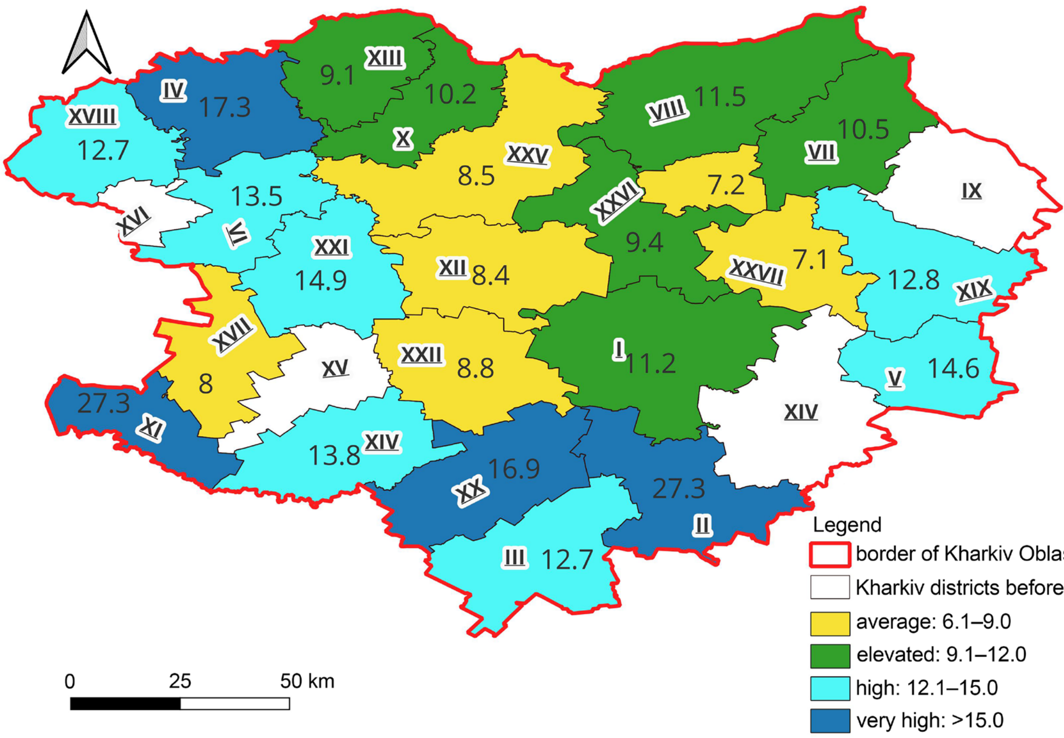

Fig. 10. Weighted average mobile sulphur content (mg · kg^{-1}) of agricultural land in districts of Kharkiv Oblast according to the results of the 10th round of agrochemical survey (2011–2015) (Source: own elaboration)

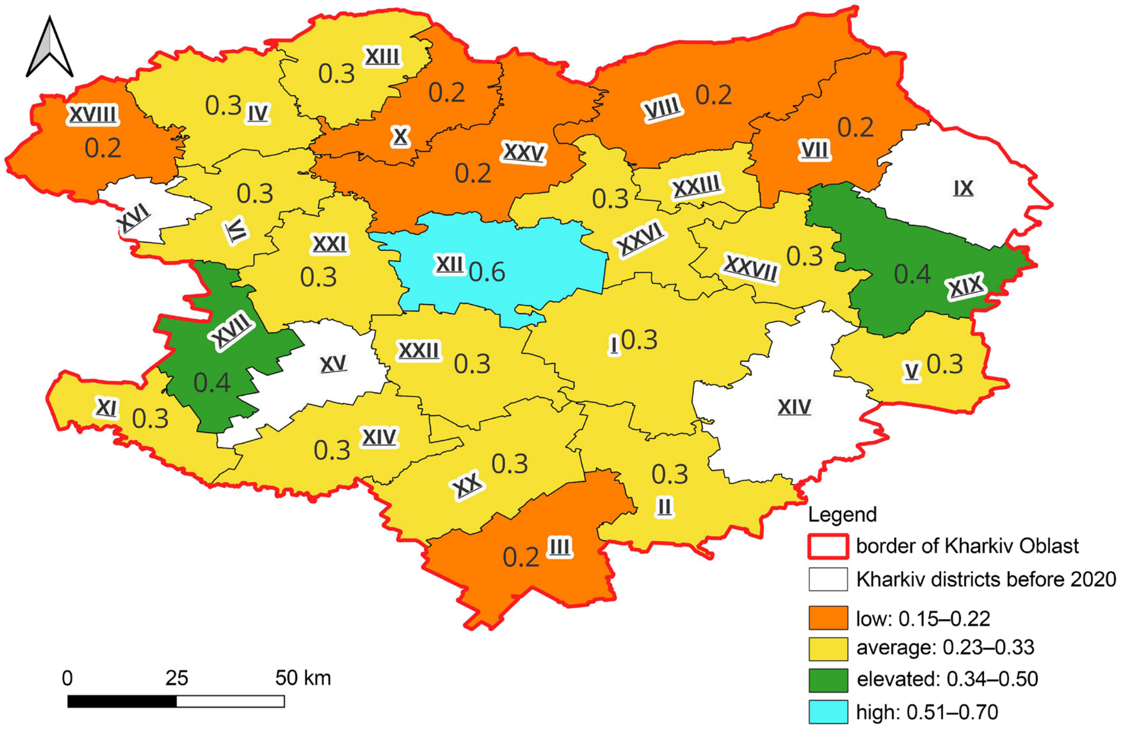

Fig. 11. Weighted average boron content (mg · kg^{-1}) of agricultural land in districts of Kharkiv Oblast according to the results of the 10th round of agrochemical survey (2011–2015) (Source: own elaboration)

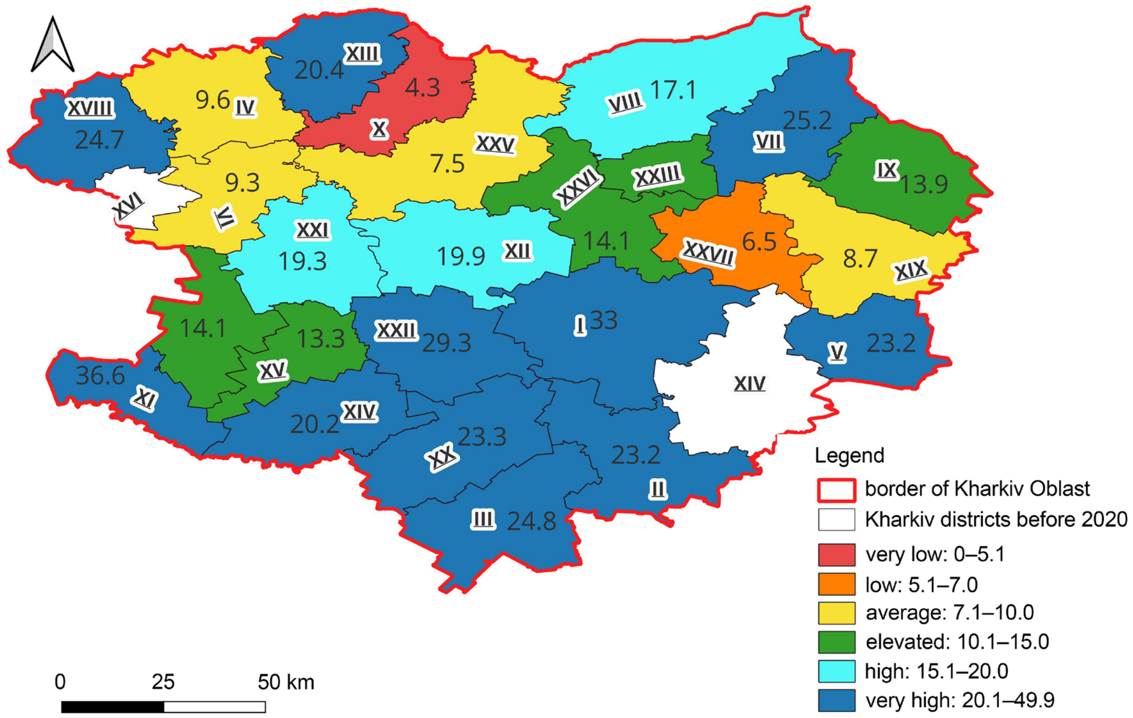

Fig. 12. Weighted average mobile manganese compounds content (mg · kg^{-1}) of agricultural land in districts of Kharkiv Oblast according to the results of the 10th round of agrochemical survey (2011–2015) (Source: own elaboration)

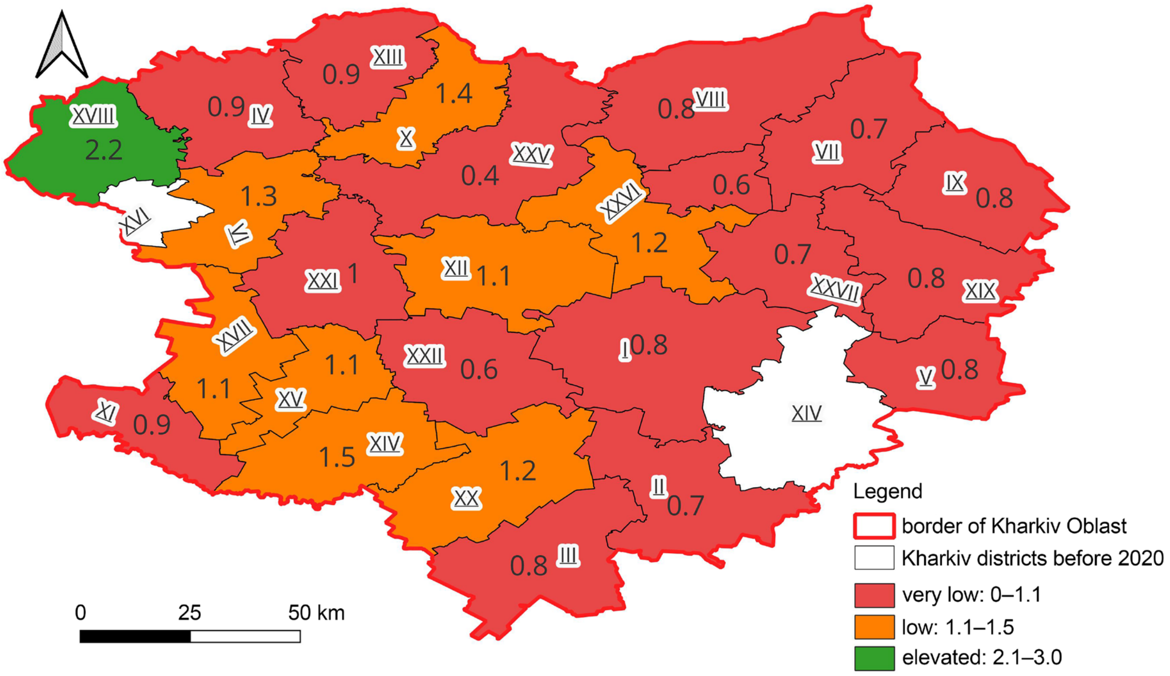

Fig. 13. Weighted average mobile zinc compounds content (mg · kg^{-1}) of agricultural land in districts of Kharkiv Oblast according to the results of the 10th round of agrochemical survey (2011–2015) (Source: own elaboration)

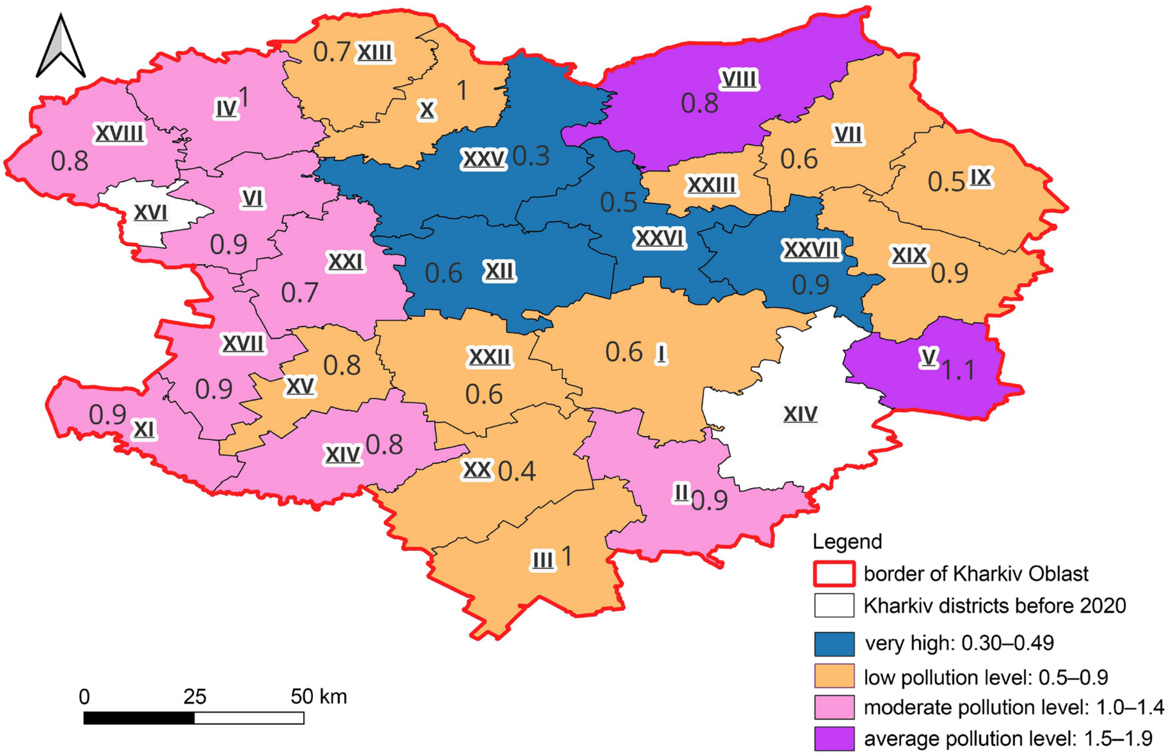

Fig. 14. Weighted average cobalt content (mg · kg^{-1}) of agricultural land in districts of Kharkiv Oblast according to the results of the 10th round of agrochemical survey (2011–2015) (Source: own elaboration)

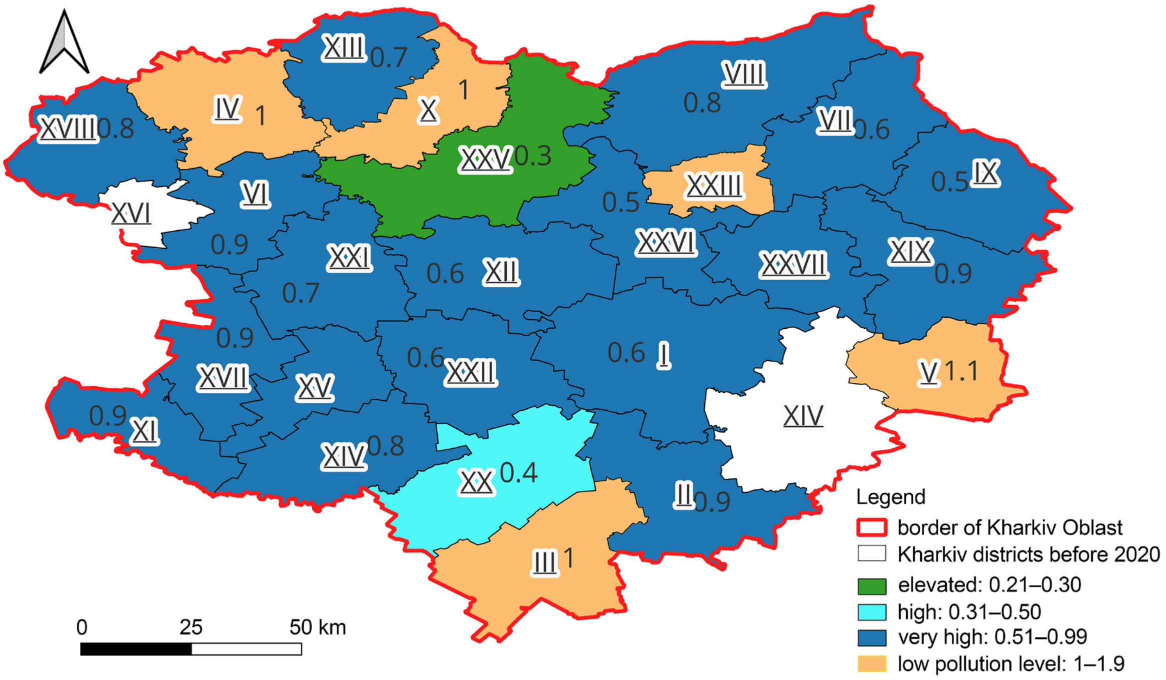

Fig. 15. Weighted average copper content (mg · kg[−1]) of agricultural land in districts of Kharkiv Oblast according to the results of the 10th round of agrochemical survey (2011–2015) (Source: own elaboration)

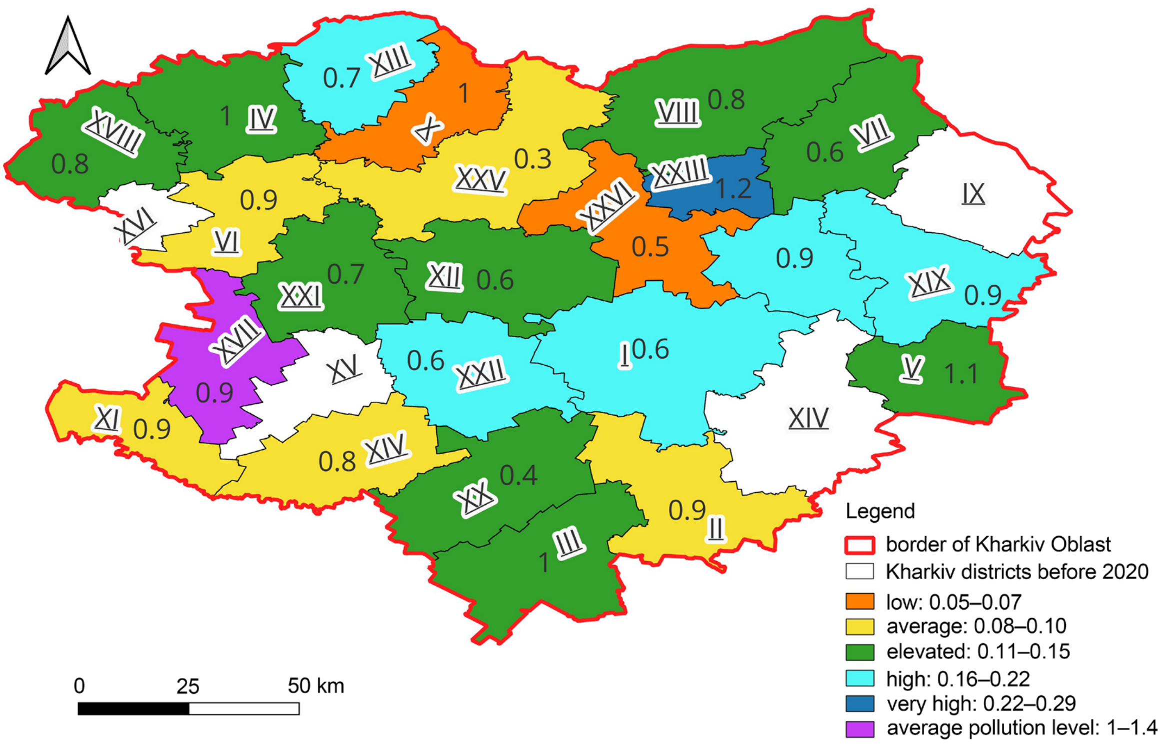

Fig. 16. Weighted average molybdenum content (mg · kg[−1]) of agricultural land in districts of Kharkiv Oblast according to the results of the 10th round of agrochemical survey (2011–2015) (Source: own elaboration)

DISCUSSION

The soil cover of the region's agricultural lands occupies 75.8% of the territory and is represented by 494 agro-industrial groups of soils, comprising nearly 72 thousand individual parcels. The most widespread among them are: 65l − ordinary weakly washed light-clay chernozems (12.5% of the total area) and 58l − ordinary medium-humus deep light-clay chernozems (8.9%). Other common agro-industrial groups include: dark-grey podzolized and regraded soils and podzolized and regraded weakly washed chernozems (49); typical low-humus chernozems and strongly regraded chernozems (53); typical medium-humus chernozems (54); typical chernozems and strongly regraded weakly washed chernozems (55); ordinary medium-humus deep chernozems and their residually and slightly solonetzic varieties (59); ordinary medium-humus and low-humus chernozems and their residually and slightly solonetzic varieties (60); and ordinary medium washed chernozems (66). The combination of these soils forms the basis of the region's agricultural potential, determining the directions of agricultural specialization and the level of its productivity (Table 3).

Of the total number of agro-industrial groups of soils, only 22 each exceed 1% of the area (ranging from 23.8 thousand ha to 297.4 thousand ha), together accounting for 79% of all identified soils. Another 88 groups each occupy from 0.1% to 1% (areas of 1.2–20.7 thousand ha), which together constitute 17.8%. The less common category includes 163 groups (2.9%), each with an area exceeding 100 ha but not reaching 1%. The remaining 221 groups occupy plots smaller than 100 ha. Overall, more than half (about 52%) of the agro-industrial groups of soils within the region consist of light clay loamy soils, which determine their physical-mechanical properties and agro-industrial potential. The high degree of arable land use indicates intensive exploitation of land resources, but at the same time increases the risk of degradation processes (Dobriak et al., 2009).

The uneven distribution of precipitation throughout the year leads to periods of soil moisture deficit, resulting in the drying of the arable layer, reduced yields, and an increased risk of wind erosion, particularly in open steppe areas. In dry years, the moisture deficit is further exacerbated by high temperatures and dry winds. At the same time, excessive precipitation during heavy summer downpours or in autumn can lead to over-moistening, temporary waterlogging, and erosion processes (Havryliuk, 2024). Thus, the climatic conditions of Kharkiv Oblast significantly affect the state and fertility of soils, determining both their productive potential and the risks of degradation.

A high humus content reflects the high capacity of soils to accumulate and retain nutrients and moisture, thereby ensuring optimal conditions for the development of agricultural crops. Moreover, a high humus level positively influences soil structure, enhances

Table 3. Predominant soil types by district of Kharkiv Oblast

Number	NameLATIN	Soil type	Number	NameLATIN	Soil type	Number	NameLATIN	Soil type
I	Balakliis'kyi	58, 59, 65	X	Derhachivs'kyi	49	XIX	Kupians'kyi	55, 65
II	Barvinkivs'kyi	58, 60, 65	XI	Zachepylivs'kyi	58, 59, 65	XX	Lozivs'kyi	58, 60, 65
III	Blyzniukivs'kyi	58, 60, 65, 66	XII	Zmiivs'kyi	59	XXI	Novovodolaz'kyi	49, 53, 55
IV	Bohodukhivs'kyi	53, 54, 55	XIII	Zolochivs'kyi	53, 54, 55	XXII	Pervomais'kyi	58, 65
V	Borivs'kyi	65	XIV	Iziums'kyi	58, 65	XXIII	Pecheniz'kyi	55
VI	Valkivs'kyi	49, 53, 55	XV	Kehychivs'kyi	58, 65	XXIV	Sakhnovschyns'kyi	58, 60, 65
VII	Velykoburluts'kyi	54, 55	XVI	Kolomats'kyi	53, 55	XXV	Kharkivs'kyi	54, 55
VIII	Vovchans'kyi	53, 54, 55	XVII	Krasnohrads'kyi	55, 58, 65	XXVI	Chuhuivs'kyi	53, 54, 55
IX	Dvorichans'kyi	54, 55	XVIII	Krasnokuts'kyi	53, 55	XXVII	Shevchenkivs'kyi	53, 54, 55

its water and air permeability, and contributes to the resilience of the ecosystem against erosion and other degradation processes. In view of this, areas with elevated and high humus content are of considerable importance for preserving land fertility, developing agricultural production, and maintaining ecological balance in the region.

Close to neutral reaction is optimal for crops that develop better in slightly acidic soils, while not limiting the cultivation of most other plants. A neutral soil reaction (pH 6.1–7.1) predominates, ensuring high solubility and availability of nutrients and, consequently, increasing land productivity. Overall, the acidity indicators attest to the stability of the soil system in Kharkiv Oblast and its high suitability for agricultural production. At the same time, local pH variations require consideration when selecting crops and planning agrotechnical measures.

A very low weighted average nitrogen content is critically deficient and points to a high demand for nitrogen fertilizer application to maintain soil fertility. A low level is somewhat higher, it still remains insufficient for the optimal growth of most crops without additional fertilization. Thus, the research findings indicate an overall need to enhance the nitrogen nutrition of soils in the region. This can be achieved through the rational application of mineral fertilizers, the use of green manure crops, and the incorporation of organic fertilizers. The implementation of such measures will contribute to improving soil quality, increasing yields, and reducing the risks of land resource degradation.

Medium-value phosphorus predominate is generally sufficient for most crops; however, for species with increased phosphorus requirements, additional fertilizer application may be necessary to achieve optimal growth conditions and yield formation. A high phosphorus content may be attributed both to natural soil-geochemical characteristics and to the prolonged application of phosphorus fertilizers. Such concentrations ensure reliable plant nutrition but require monitoring to avoid phosphorus excess, which could adversely affect ecosystems. Elevated values providing an adequate nutrient reserve and supporting high agrocenosis productivity. Overall, the spatial distribution of phosphorus in the region's soils reflects a combination of natural and anthropogenic factors that determine their fertility level. Regular monitoring and the rational application of mineral fertilizers remain important prerequisites for sustainable agricultural production and the preservation of soil quality in Kharkiv Oblast.

The highest-value potassium promotes active growth and development of most crops, enhances their resistance to stress conditions, and ensures the formation of high yields. Elevated potassium content a sufficient reserve of the element, which in most cases meets crop requirements, although in some instances it may require adjustment through fertilizer application. A medium potassium level predominates, providing basic conditions for plant growth but necessitating regular monitoring and, if required, additional nutrition to prevent deficiency. Overall, the spatial distribution of potassium in the soils of Kharkiv Oblast reflects a combination of natural factors and landuse characteristics. Rational management of crop potassium nutrition is a key factor in maintaining stable agricultural productivity and sustaining soil fertility in the region.

Mobile sulphur is a key microelement for the synthesis of proteins, enzymes, and vitamins in plants. Its optimal amount in the soil improves crop quality, increases resistance to diseases and stress factors. Considering spatial differences in sulphur supply is essential for developing effective fertilization systems and agrotechnical measures aimed at maintaining soil fertility and ensuring the sustainable development of agricultural production in Kharkiv Oblast.

Areas with low levels of this microelement are characterised by insufficient reserves, which may lead to slowed growth processes and reduced yields of crops particularly sensitive to boron deficiency (such as sugar beet, sunflower, and rapeseed). Medium values provide satisfactory nutritional conditions for most plants; however, for crops with increased boron requirements, additional application of micronutrient fertilizers may be necessary to achieve maximum productivity. Overall, the spatial distribution of boron indicates its limited availability in the soils of Kharkiv Oblast, which must be taken into account when planning fertilization systems. The rational use of boron-containing fertilizers can increase yields, improve the quality of agricultural products, and enhance crop resistance to adverse conditions.

Manganese is an essential microelement for plants, playing a key role in photosynthesis, respiration, enzyme activation, and overall metabolic activity. Its availability in the soil directly affects the condition of agrocenoses, growth efficiency, and crop productivity. Such high content indicates good manganese supply in soils, which supports optimal plant development and increased productivity.

At the same time, excessive manganese concentrations can be toxic to certain crops, especially in acidic soils where its mobility and availability increase. Therefore, to prevent negative effects, it is necessary to control the balance of this microelement in the soil, taking into account the types of cultivated crops, specific agrotechnical practices, and the condition of the soil environment. Based on weighted average indicators, manganese levels in most cases do not reach critical values, indicating the absence of technogenic contamination.

In general, the spatial distribution of manganese concentrations in the soils of Kharkiv Oblast reflects the geochemical characteristics of the area and must be considered when planning fertilization and crop nutrition systems. The implementation of a differentiated approach to micronutrient application makes it possible to increase the efficiency of agricultural production, avoid excessive manganese accumulation, and ensure the sustainable development of agroecosystems.

Zinc plays a key role in plants, as it participates in chlorophyll synthesis, enzyme activation, protein formation, and overall metabolism; its deficiency adversely affects crop growth and development. Very low zinc concentration may lead to slowed plant growth, reduced yields, and deterioration of product quality, as well as an increased risk of chlorosis and other pathologies associated with micronutrient deficiency.

Based on the obtained data, regular monitoring of zinc content in soils is recommended, along with the implementation of agronomic measures for plant supplementation with zinc-containing micronutrient fertilizers. This will not only enhance the productivity of agricultural crops but also maintain the fertility of soils in Kharkiv Oblast. At the same time, according to weighted average indicators, the zinc level in soils does not reach critical values and does not indicate technogenic contamination.

Cobalt is a micronutrient with a dual ecological significance. On the one hand, it is required in small amounts for the functioning of enzyme systems and for the development of leguminous crops (particularly in nitrogen fixation processes). On the other hand, its excessive concentration may lead to accumulation in the soil–plant system, potentially posing an environmental risk. Thus, the identified spatial variations in cobalt content reflect specific geochemical features of the territory of Kharkiv Oblast and should be taken into account in environmental monitoring and in the planning of agronomic measures.

Copper is an essential micronutrient for plants, participating in photosynthesis, respiration, enzyme activation, and chlorophyll formation. However, its excessive concentration in soil can be toxic to certain crops, particularly in acidic soils where copper mobility increases. The identified regional differences in copper content reflect the geochemical characteristics of Kharkiv Oblast and highlight the need for a differentiated approach to the application of micronutrient fertilizers and the planning of agronomic measures.

Molybdenum is an important micronutrient for plants, as it is involved in nitrogen fixation processes, enzyme activation, and protein synthesis. Insufficient content of this element may limit the development of leguminous crops and reduce the overall productivity of agrocenoses, whereas excessive molybdenum concentration in soil can be toxic to certain plant species. Thus, the identified spatial variations in molybdenum content in the soils of Kharkiv Oblast reflect the geochemical features of the region and should be taken into account when planning fertilization systems, applying micronutrient fertilizers, and ensuring the sustainable development of agroecosystems.

Comprehensive, systematic, and large-scale soil surveys of the Kharkiv Oblast are conducted exclusively by the State Institution "Soils Protection Institute of Ukraine." It is precisely this Institute that ensures full-scale monitoring, utilizing a representative sampling network, broad spatial coverage of territories, and a complete range of agrochemical, ecological-toxicological, and physical-chemical analytical determinations. Other scientific institutions and research groups that have conducted soil surveys in the Kharkiv Oblast have done so only point-wise, locally, or within limited areas. Such works do not ensure full spatial coverage, do not allow for the assessment of regional contamination patterns, and cannot be considered full-scale surveys. Thus, the Institute's results currently represent the sole source base for a broad-scale assessment of the soil condition in the Kharkiv Oblast following the impact of hostilities and anthropogenic factors.

CONCLUSIONS

The southern part of Kharkiv Oblast is characterized by higher weighted average values of humus, easily hydrolysable nitrogen, and mobile compounds of phosphorus and potassium compared to other districts, while the soils of this zone are predominantly neutral in reaction (pH). Such a combination of agrochemical indicators creates favorable conditions for the growth and development of agricultural crops, enhances soil fertility and its capacity to retain nutrients and moisture, thereby ensuring the stable productivity of agroecosystems.

However, in terms of micronutrient content, the territory of Kharkiv Oblast is marked by a heterogeneous, uneven distribution. For example, manganese predominates at medium-elevated and high levels, whereas zinc is mostly at low and very low levels, indicating the need for differentiated application of zinc-containing fertilizers. Cobalt does not exceed the maximum permissible concentrations; however, in the central part of the region, very high values are observed, while in most of the territory, the level corresponds to a medium degree of sufficiency. Copper is predominantly at high and very high levels, with localized zones of elevated and low content, whereas molybdenum in most districts occurs at medium, elevated, and high levels, with localized areas of low sufficiency.

Such a spatially heterogeneous distribution of micronutrients underscores the importance of a zonal approach to the planning of fertilization systems, crop supplementation, and monitoring of the potential toxicity of certain elements. In view of this, regional agroecosystems require regular monitoring of the chemical composition of soils and the application of differentiated agronomic measures, which makes it possible to optimize soil fertility, increase the productivity of agricultural crops, and ensure their resilience to adverse environmental impacts.

GIS technologies are an effective tool for spatial analysis and thematic mapping based on the results of agrochemical soil surveys. Quick access and effective data management are critically important for monitoring soil cover changes. Overlaying different thematic layers (relief, land use, climate data, etc.) significantly improves the quality of interpretation and understanding of spatial variability of soils and provides a scientifically sound basis for developing soil protection measures.

REFERENCES

Bairak, H. (2018). Methods of geomorphological research: Textbook. Lviv: Lviv National University by Ivan Franko, 292 p. https://geography.lnu.edu.ua/wp-content/uploads/2018/09/bayrak_metody_geom.pdf (accessed: 07.08.2025).

Balyuk, S.A., Miroshnychenko, M.M. (eds.) (2018). Regional program for soil protection and fertility in Kharkiv Oblast (goals, concept, means of implementation). FOP Brovin O.V., Kharkiv, 38 p. https://www.researchgate.net/publication/368010590_Regionalna_programa_ohoroni_gruntiv_ta_ih_.

Cabinet of Ministers of Ukraine (2021a). On approval of maximum permissible concentrations of hazardous substances in soils and the list of such substances, December 17, 2021. Government Courier, 243. https://www.kmu.gov.ua/npas/pro-zatverdzhennya-normativiv-granichno-dopustimih-koncentracij-nebezpechnih-rechovin-u-gruntah-takozh-pereliku-takih-rechovin-i151221-1325/

Cabinet of Ministers of Ukraine (2021b). On approval of the procedure for functioning of the national infrastructure of geospatial data No. 532, March 26, 2021. Official Bulletin of Ukraine, 44, art. 2701. https://zakon.rada.gov.ua/laws/show/532-2021-%D0%BF (accessed: 10.07.2025).

Dobriak, D.S., Kanash, O.P., Bambidra, D.I., Rozumnyi, I.A. (2009). Classification of agricultural lands as a scientific prerequisite for their environmentally safe use. Urozhai, Kyiv, 461 p. 449, 450, 455. https://files.znu.edu.ua/files/Bibliobooks/Inshi80/0059813.pdf (accessed: 10.07.2025).

European Parliament (2007). Directive of the European Parliament and of the Council of establishing an Infrastructure for Spatial Information in the European Community (INSPIRE) No. 2007/2/EC, March 14, 2007. https://zakon.rada.gov.ua/laws/show/984_002-07#Text (accessed: 10.07.2025).

Havryliuk, A. (2024). How climate change affects soil condition in Ukraine. Agrotimes, December 16, 2024. https://agrotimes.ua/agronomiya/yak-klimatychni-zminy-vplyvayut-na-stan-gruntiv-v-ukrayini/?utm_source=chatgpt.com.

Hrynchenko, T.O., Roman, B.V., Liepenina, I.I. (2007). Monitoring of the comprehensive assessment of soil fertility in Kharkiv Oblast, 1966–2005. In: T.O. Hrynchenko (ed.). Kharkiv, "13 Drukarnia", 212 p.

Hrynchenko, T.O., Vynnyk, O.F., Baliuk, S.A., Yatsuk, I.P., Romanova, S.A., Samokhvalova, V.L., Filon, V.I., Zhernova, O.S., Orel, O.Ye., Desenko, V.H. (2018). Atlas of 50-year monitoring of the comprehensive assessment of soil fertility in Kharkiv Oblast (1966–2015). In: T.O. Hrynchenko (ed.). Kharkiv, Pravo, 248 p.

Kharkiv Oblast Council. (2020). Administrative structure of Kharkiv Oblast, November 20, 2020. https://oblrada-kharkiv.gov.ua/administratyvnyj-ustrij-harkivskoyi-oblasti/ (accessed: 07.07.2025).

Kharkiv Oblast Military Administration (2023). Ecological passport of Kharkiv Oblast, 6–7. https://kharkivoda.gov.ua/content/documents/1282/128134/Attaches/ekologichniy_pasport_harkivskoyi_oblasti_2023_rik.pdf (accessed: 10.08.2025).

Kharkiv Oblast Military Administration. (n.d.). About Kharkiv Oblast. Geography. https://kharkivoda.gov.ua/pro-oblast/heohrafiya?utm_source=chatgpt.com (accessed: 06.08.2025).

Land Directory of Ukraine (2020). https://agropolit.com/spetsproekty/705-zemelniy-dovidnik-ukrayini--baza-danih-pro-zemelniy-fond-krayini.

Martyn, A.H., Osypchuk, S.O., Chumachenko, O.M. (2015). Natural-agricultural zoning of Ukraine: Monograph. Komprint Center, Kyiv, 328. https://nubip.edu.ua/sites/default/files/u18/monograph_natural_agricultural_zoning.pdf (accessed: 06.07.2025).

Prysyazhniuk, S.I., Melnyk, S.I., Zhylkin, V.A., Hrekov, V.O., Maistrenko, V.I., Melnyk, A.I., Kryvda, Yu. I., Panasenko, V.M., Kadiievskyi, I.I., Hulvanskyi, I.M., Demchyshyn, A.M., Zinchuk, M.I., Makarova, H.A., Morozov, O.V., Pasichniak, V.I., Trembitskyi, V.A., Boiko, L.V., Baliuk, S.A., Medvedev, V.V., ... Tonkha, O.L. (2010). Natsionalna dopovid pro stan hruntiv Ukrainy [National report on the status of soils in Ukraine]. TOV 'VIK PRYNT'. https://www.iogu.gov.ua/literature/periodically/1_2010.pdf.

Romanova, S.A., Palamarchuk, R.P., Hryshchenko, O.M., Broshchak, I.S., Hulvanskyi, I.M., Demchyshyn, A.M., Zhukova, Ya.F., Zhuchenko, S.I., Zapasnyi, V.S., Zinchuk, M.I., Koval, V.V., Kostenko, O.V., Krupko, H.D., Kulidzhanov, E.V., Shabanova, I.I., Yarmolenko, Ye.V., Yatsenko, Yu M. (2023). Naukovi doslidzhennia z monitorynhu ta obstezhennia silskohospodarskykh uhid Ukrainy za rezultatamy KhI turu (2016–2020 r.) [Scientific research on monitoring and survey of agricultural lands of Ukraine based on the results of the 11th round (2016–2020)]. Vik prynt. https://surl.lu/qxcbkw.

Shevchenko, L.M., Kruhlov, O.V., Koliada, V.P., Diomkin, O.O. (2016). Spatial distribution of soil erosion factors in Kharkiv Oblast. Bulletin of KhNAU named after V.V. Dokuchaiev. Series: Crop Production, Breeding and Seed Production, Vegetable and Fruit Growing and Storage, 2, 165–176.

SS 10150-88 (1988a). Methods of agrochemical analysis. Determination of mobile boron in soils according to Berger and Truog in CINAO modification.

SS 10151-88 (1988b). Methods of agrochemical analysis. Determination of mobile molybdenum in soils by Grigg method in CINAO modification.

SSU 4115-2002 (2002). Soils. Determination of mobile phosphorus and potassium compounds by the modified Chirikov method.

SSU 4289:2004 (2004). Soil quality. Methods for determination of organic matter. Official edition. Kyiv: Derzhspozhyvstandart, 14 p.

SSU 4770.1:2007 (2007a). Soil quality. Determination of mobile manganese content in soil in buffer ammonium-acetate extract with pH 4.8 by atomic absorption spectrophotometry. Official edition. Kyiv, Derzhspozhyvstandart, 14 p.

SSU 4770.2:2007 (2007b). Soil quality. Determination of mobile zinc content in soil in buffer ammonium-acetate extract with pH 4.8 by atomic absorption spectrophotometry. Official edition. Kyiv, Derzhspozhyvstandart, 14 p.

SSU 4770.5:2007 (2007c). Soil quality. Determination of mobile cobalt content in soil in buffer ammonium-acetate extract with pH 4.8 by atomic absorption spectrophotometry. Official edition. Kyiv, Derzhspozhyvstandart, 14 p.

SSU 4770.6:2007 (2007d). Soil quality. Determination of mobile copper content in soil in buffer ammonium-acetate extract with pH 4.8 by atomic absorption spectrophotometry. Official edition. Kyiv, Derzhspozhyvstandart, 4 p.

SSU 7863:2015 (2015a). Soil quality. Determination of easily hydrolyzable nitrogen by Cornfield method.

SSU 8347:2015 (2015b). Soil quality. Determination of mobile sulfur in modification by NSC IGA named after O.N. Sokolovskyi. Official edition. Kyiv, State Commit-

tee of Ukraine on Technical Regulation and Consumer Policy, 11 p.
SSU ISO 10390:2007 (2007e). Soil quality. Determination of pH. Official edition. Kyiv: Ministry of Economic Development of Ukraine, 8 p.
Stetsiuk, V.V., Kovalchuk, I.P. (2005). Osnovy heomorfolohii [Fundamentals of geomorphology]. Vyshcha Shkola, Kyiv, Ukraine.
Verkhovna Rada of Ukraine (2020a). On the National Infrastructure of Geospatial Data: Law of Ukraine No. 554-IX, April 13, 2020. Official Gazette, 37 (11.09.2020), p. 277.
Verkhovna Rada of Ukraine (2020b). On the formation and liquidation of districts. Resolution of the Verkhovna Rada of Ukraine No. 3650, July 17, 2020. https://zakon.rada.gov.ua/laws/show/807-20#Text. (accessed 07.07.2025).
Yatsuk, I.P. (ed.). (2015). Periodical report on the state of soils on agricultural lands of Ukraine: Results of the 9th round (2006–2010) of agrochemical survey. Vik Print, Kyiv, 118 p. https://www.iogu.gov.ua/literature/periodically/1_2010.pdf.
Yatsuk, I.P. (ed.) (2020). Periodical report on the state of soils on agricultural lands of Ukraine: Results of the 10th round (2011–2015) of agrochemical survey. Vik Print, Kyiv, 208 p. https://www.iogu.gov.ua/literature/periodically/3_2020.pdf.
Yatsuk, I.P., Balyuk, S.A. (eds.) (2019). Methodology for agrochemical certification of agricultural lands: Guiding regulatory document. Kyiv, 108 p. https://www.iogu.gov.ua/literature/instructions/1.pdf (accessed: 10.07.2025).

ANALIZA GEOINFORMACYJNA POKRYWY GLEBOWEJ OBWODU CHARKOWSKIEGO NA PODSTAWIE WYNIKÓW 10. TURY BADAŃ AGROCHEMICZNYCH GRUNTÓW ROLNYCH

ABSTRAKT

Cel pracy

Celem badania była ocena jakości gleby w obwodzie charkowskim z wykorzystaniem wyników 10. rundy badań agrochemicznych oraz opracowanie i przedstawienie warstw danych geoprzestrzennych i map tematycznych do monitorowania zmian właściwości gleby, zgodnie z wymogami NSDI i dyrektywy INSPIRE.

Materiał i metody

W niniejszym artykule wykorzystano materiały z analizy wyników 10. rundy agrochemicznych badań gleb obwodu charkowskiego, przeprowadzonych i opracowanych w formie bazy danych geoprzestrzennych przez Państwową Instytucję „Instytut Ochrony Gleb Ukrainy". Badania gleb, testy laboratoryjne, klasyfikacja wyników i wizualizacja zostały przeprowadzone zgodnie z zatwierdzoną metodyką (Yatsuk i Baliuk, 2019). Dane kartograficzne i geoprzestrzenne do analizy pokrywy glebowej zostały przygotowane i przetworzone w środowisku systemu informacji geograficznej (GIS). Mapy cyfrowe utworzone w ramach niniejszego badania wykorzystały międzynarodowy układ współrzędnych WGS 84. Wszystkie operacje, w tym wektoryzacja, analiza przestrzenna i przygotowanie ostatecznych układów, zostały wykonane z wykorzystaniem programu QGIS (wersja 3.32.1).

Wyniki i wnioski

Wykorzystując technologie geoinformacyjne, przeprowadzono ocenę wskaźników jakościowych (agrochemicznych i ekotoksykologicznych) gleb użytków rolnych regionu, bazując na danych z 10. tury badań agrochemicznych. Sporządzono mapy tematyczne, odzwierciedlające przestrzenny rozkład parametrów agrochemicznych zgodnie z zatwierdzonymi gradacjami wskaźników agrochemicznych, a na podstawie uzyskanych wyników scharakteryzowano pokrywę glebową.

Słowa kluczowe: grunty rolne, zawartość humusu, monitorowanie wskaźników jakości gleby, mapa gleby, tematyczne mapy terenowe