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Qualitative Assessment of Soils in Dolyna District of Ivano-Frankivsk Region

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ABSTRACT

The article presents the results of agrochemical survey of soils of the Dolyna territorial community of Ivano-Frankivsk region. The agro-productive grouping of all soils of the district was carried out. There are five agro-productive soil groups within the district: sod-podzolic soils on ancient alluvial, water-glacial deposits, moraine, and eluvium of magmatic rocks; sod-podzolic and podzolic-sod surface-gleyed medium-loamy soils; deep non-gleyed and gleyed medium-loamy sod soils and their podzolized variants on ancient alluvial, water-glacial deposits, moraine, and eluvium of magmatic rocks; brown-podzolic, sod-brown-podzolic, brown mountain-forest podzolized gleyed and surface-gleyed non-eroded and slightly eroded heavy loamy and light clayey soils; sod gleyed soils; sod-brown and meadow-brown gleyed soils on alluvial and deluvial deposits, medium-loamy stony soils.These soils exhibit acidic pH, are moderately deficient in available phosphorus, and have medium levels of potassium. They are potentially fertile but require liming and the application of organic-mineral fertilizers.

Keywords: soil, agricultural production groups, acidity, humus, nitrogen, phosphorus, potassium, qualitative assessment, soil fertility, soil degradation.

INTRODUCTION

Soil is the most valuable asset and an important natural resource used for agricultural activities. Over time, due to the use of various methods of cultivation, it becomes polluted, loses fertility and degrades (Polupan et al., 2015; Medvedev, 2011). Ukraine's soil cover is extremely diverse. According to large-scale surveys conducted in 1957–1961, more than 800 soil types were identified, with podzolic, typical, ordinary, and southern black soils dominating, with a total share of over 60%. Meadow-chernozem and meadow soils (7.1%), gray forest soils (6.4%), sod-podzolic and soddy podzolic soils (6.1%), dark gray podzolic soils (4.6%), dark chestnut and chestnut saline soils (3.0%), and peat soils (1.5%) are also widespread. These soils are very diverse in their properties: the humus content in the topsoil varies from 0.6–1.5% in sod-podzolic sandy loam soils to 5.0–6.0% in typical heavy loam and light clay loam chernozems, the humus reserves in the profile range from 30–60 t/ha to 550–600 t/ha, and the thickness of the humified profile ranges from 15–25 cm to 120–150 cm or more. Overall, Ukraine's soils have the agro-soil potential for effective fertility to produce more than 60 million tons of grain, but to realize this potential, it is necessary to prevent soil cover deterioration. After a large-scale survey was completed and adjusted, the soil cover has changed, and its actual condition can only be assessed by repeating a large-scale survey (Medvedev 2015; Achasov et al., 2019). Ukraine's soils are well studied, but this has not prevented the intensive development of degradation processes. About one third of the arable land has been eroded, 30% of organic matter has been lost, almost all arable soils in the subsoil are compacted, nutrient reserves are significantly reduced, and numerous problems are observed on reclaimed land (Tymchenko et al., 2014; Hryhoriv et al., 2024).

A comprehensive agrochemical survey of land solves a number of important issues related to soil and agrochemical monitoring, soil fertility restoration, efficient use of agrochemicals, increased agricultural productivity, and environmental protection. The determination of agrochemical parameters allows to establish the state of soil fertility and its changes, as well as to develop agricultural measures to protect soils from degradation processes (Rishuk et al., 2003; Baliuk and Kucher, 2019; Pozniak et al., 2019). Based on the results of the agrochemical soil survey, technologies for the effective application of mineral fertilizers, optimization of doses, timing, and methods of their application are developed and implemented. Additionally, design and estimate documentation for chemical amelioration with liming of acidic soils is created. Soil analysis for trace elements helps to develop recommendations for the use of microfertilizers. Based on the results of soil analysis, cartograms of nutrient content and levels of contamination with heavy metals and radionuclides are drawn up (Veremeenko and Trusheva, 2010; Grading of soils of Ukraine, 1993; Dmytruk and Semenchuk, 2021). It should be noted that the land reform did not take into account the issue of soil fertility, which further exacerbated the problem of land degradation. The new landowners are not aware of the quality of their land and cannot control its condition when leasing it out. Many tenants of land plots do not have the necessary knowledge and skills to apply modern crop cultivation technologies and preserve soil fertility (Buiak et al., 2019; Kasperevych, 2018). The reduction in the use of organic and mineral fertilizers and ameliorants in recent years has led to soil acidification, a decrease in humus and nutrient content, as well as an overall deterioration in soil properties and regimes (A reference book, 1994; Tavares et al., 2022; Tarariko et al., 2016). Modern agricultural production is characterized by uncertainty in the ratio of agricultural lands, an imbalance of biochemical substances and energy in agrolandscapes, the imperfection of anti-erosion soil protection systems, and land resource monitoring. This leads not only to a decrease in potential soil fertility, but also to a violation of environmental sustainability and a decrease in agricultural land productivity. Overall, the current use of land resources in Ukraine does not meet the requirements of sustainable natural resource management (Primak et al., 2010; Osman, 2018; Thorsøe et al., 2019; Adeyolanu and Ogunkunle, 2016). In scientific literature that examines soil monitoring issues, special attention is paid to the indicators of soil properties as a biokosnoe (bio-abiotic) body. Soil monitoring in this context involves observing changes in soil properties over space and time in permanent plots that have state status and reflect natural diversity and all types of their economic use (Truskavetskiy and Tsapko 2003; Tsapko 2004; Gobat et al., 2004; Hegeret et al., 2012).

Agrochemical principles of soil quality assessment are becoming extremely relevant under conditions of extensive and irrational economic activities by agricultural producers. The scientists strive to reflect existing soil diversity in a generalized and systematic manner, highlighting the commonality of soils within defined classes (groups) and the differences between them belonging to different classes. They aim to demonstrate the relationships between soil diversity and the diversity of their genesis. Today, soil classification serves as the scientific basis for accounting for global soil resources, their conservation, and rational utilization across various sectors of human activity (Smaga 2012; Yatsuk et al., 2021; Mugiyo et al., 2021).

Thus, conducting agroecological assessment of soil conditions within administrative-territorial units of Ukraine, followed by agroecological zoning of the country's territory, is extremely important. This will serve as the basis for a strategy of environmentally sustainable land use. Purpose of the research was to conduct a survey of agricultural lands, determine indicators of nutrient regime, analysing the results of eco-agrochemical survey, and perform a comprehensive qualitative assessment of the agroecological state of soils within Dolyna territorial community of Ivano-Frankivsk region.

MATERIALS AND METHODS

The materials were soils of the Dolyna territorial community of Ivano-Frankivsk region used in agriculture, as well as their quality condition in terms of ecological and agrochemical indicators. The research methods included field and laboratory methods. The routes for the soil survey on the territory of the respective territorial community were planned in office conditions using topographic maps at a scale of 1:10,000. On the cartographic materials, routes were identified with precise identification of starting, ending, and intermediate points for soil digging and soil sampling. The route planning was conducted in such a way as to encompass the morphological and morphometric characteristics of all elements and forms of relief from the watershed to the river valley. This allowed for identifying the main patterns of distribution of various types and varieties of soils and collecting samples from predominant relief features. The points of survey (digging) with soil sampling were geodetically tied to the points of the state geodetic network using GPS receivers. The surveyed soils are represented by agricultural lands. During the soil survey of agricultural lands that were previously poorly studied (so-called "white spots"), a standard methodology for large-scale soil research and generally accepted research methods were used (Methodology of. 1994). All planned studies were conducted according to the methods specified in the methodology for agrochemical passportization of agricultural lands (Methodology for. 2013).

RESULTS AND DISCUSSION

Within Dolyna territorial community, 5 types of soils were identified. They were grouped into one agro-industrial group based on the following criteria: genetic similarity and agronomic properties; common agricultural use and similar productivity; uniformity of relief and hydrological conditions; similar granulometric composition; approximately the same physical properties, water, air, and thermal regimes; similarity of indicators characterizing the nutrient regime; uniformity of physicochemical properties; similar physical-mechanical properties; analogous composition, concentration, and dynamics of soil solution; similar need for reclamation; presence of substances harmful to plants; and similar nature and intensity of erosion and deflation processes (Patuka, Tarariko, 2002).

According to the obtained results, an agro-industrial grouping of soils was conducted (Rishuk et al., 2003) in the Dolyna territorial community of Ivano-Frankivsk region, and soil types were identified:

1. Sod-podzolic and podzolic-soddy surface-gleyed medium loamy soils (agro group code 18 d).
2. Soddy deep unclayey and gleyey medium loamy soils and their podzolized variants (agro group code 176 d).
3. Shallow soddy gley light loamy soils (agro group code 177 g).
4. Brown-podzolic, soddy brown-podzolic, brown mountain-forest podzolized gley and shallow-gleyed, non-eroded and slightly eroded, heavy loamy and light clayey soils (agro group code 183 e).
5. Soddy brown and meadow brown gley soils on alluvial and deluvial deposits, medium loamy stony (agro group code 186 dk).

We identified five agricultural soil groups (Table 1). They are dominated by brown-podzolic, soddy brown-podzolic, brown mountain-forest podzolized gley and shallow-gleyed, non-eroded and slightly eroded, heavy loamy and light clayey soils with an area of 273.06 hectares, which belong to the 183rd agricultural production group, as well as sod-podzolic and podzolic-soddy surface-gleyey medium loamy soils with an area of 160.45 hectares and Soddy brown and meadow brown gley soils on alluvial and deluvial deposits, medium loamy stony soils – 90.29 hectares. It was found that, compared to the surveys conducted in 2011, the areas of these agricultural production groups decreased by 4.18–8.20 hectares, and this trend of area reduction is observed in all agricultural groups. Our results coincide with the studies conducted by Polichko et al. (2022), who examined the soils of the Transcarpathian region. There were also downward changes in the areas of agricultural soil groups in the region. In the surveyed area, 5 agricultural production soil groups were identified, formed on loamy terraces and slopes of varying steepness. These soils are potentially quite fertile but require liming and application of organic and mineral fertilizers. According to the soil survey data in the studied area, the largest area is occupied by brown-podzolic, soddy brown-podzolic, and brown mountain-forest

Table 1. Explication of agricultural production groups of soils of the Dolyna territorial community of Ivano-Frankivsk region

Agricultural production groups of soils		Total area, ha	In percentage terms
Code	Name		
177 g	Shallow soddy gley light loamy soils	0.79 * / 0.79	0.1
176 d	Soddy deep unclayey and gleyey medium loamy soils and their podzolized variants	54.83 / 56.97	9.5
18 d	Sod-podzolic and podzolic-soddy surface- gleyed medium loamy soils	160.45 / 168.65	27.7
183 e	Brown-podzolic, soddy brown-podzolic, brown mountain-forest podzolized gley and shallow-gleyed, non-eroded and slightly eroded, heavy loamy and light clayey soils	273.06 / 276.24	47.1
186 dk	Soddy brown and meadow brown gley soils on alluvial and deluvial deposits, medium loamy stony	90.29 / 90.54	15.6
Total:		579.42	100
V, %		6.0	

Note: * Denominator data from 2021, numerator data from 2011.

soils, which account for approximately 50%. These are predominantly arable lands and natural fodder lands located on flat and undulating terrain. In terms of the granulometric composition of the upper horizon, the brown-podzolic, shallow-gleyed soils are mostly heavy loamy and light clayey, with varying amounts of hard rock fragments in the profile. The determination of the physical properties of agricultural soils in the territory of Dolyna territorial community showed that they are different (Table 2). The data in Table 2 indicate that the content of fine sand fractions (size 0.25–0.05 mm) in the 0–20 cm soil layer of sod-podzolic surface-gleyed, sod gleyed podzolized, and meadow brown soils (agrogroup codes 18d, 176d, 186dk) varies from 18.8% to 55.9%. The total content of the physical sand fraction ranges from 50.9% to 79.9%. This fraction is characterized by high water permeability, lack of swelling, plasticity, absorption capacity, and coagulation effect. In terms of mineral composition, the physical sand is represented by quartz and is considered a passive fraction of the soil's granulometric composition. Based on the granulometric composition, these soils are classified as medium loam. It should be noted that in the 0–20 cm soil layer of shallow sod gley, brown podzolic, and podzolized gley non-eroded soils (agrogroup codes 177g, 183e), the content of fine sand fractions (size 0.25–0.05

Table 2. Physical properties of soils in Dolyna territorial community

Code	Name of the soil agro group	No. of the section	Sampling depth, cm	Particle size, mm, number of particles, %.						
				sand		dust		sludge		Sum of particles < 0.01
				> 0.25	0.25–0.05	0.05–0.01	0.01–0.005	0.005–0.001	< 0.001	
18 d	Sod-podzolic surface-gleyed soils	6	0–20	55.8	23.1	3.1	4.8	3.7	9.5	18.0
			35–45	46.6	32.6	2.1	3.6	5.9	8.6	18.1
176 d	Sod gleyed podzolized soils	7	0–20	18.77	59.05	12.60	5.30	1.00	3.28	9.58
			35–45	16.34	64.57	4.45	11.34	0.70	2.60	14.64
177 g	Shallow soddy gley soils	8	0–20	45.96	37.92	8.06	0.25	2.77	5.04	8.06
			35–45	14.18	68.40	6.31	2.28	2.52	6.31	11.11
183 e	Brown-podzolic, podzolized gley soils	9	0–20	47.3	28.6	3.5	2.2	12.6	5.8	20.6
			35–45	50.12	32.48	7.34	1.53	3.21	5.32	10.06
186 dk	Meadow brown gley soils	10	0–20	28.64	45.6	8.04	7.2	4.66	6.22	18.08
			30–40	26.14	47.6	6.54	9.16	5.6	4.96	19.72

mm) ranges from 28.6% to 37.9%. These soils are classified as light loam.

It is known that intensive agricultural use of soils leads to a decrease in their fertility due to compaction (especially in chernozems), loss of cloddy-granular structure, reduction in water permeability, and aeration capacity, which results in numerous negative environmental consequences and soil degradation. This view is supported by authors such as Thorsoe et al. (2019), who emphasize the importance of preventing soil compaction to preserve soil functions and ecosystems overall. Soil compaction occurs nearly continuously, reducing crop yields and increasing greenhouse gas emissions and the leaching of pollutants. However, preventing compaction is a challenging task because the risk of soil compaction is dynamic. The authors investigated the factors of soil degradation and discussed the opportunities and obstacles to sustainable soil management using the example of soil compaction in Danish agriculture (Thorsoe et al., 2019). Our conclusions are further supported by the Baliukand Kucher (2019), which indicates that soil degradation is a significant issue for Ukraine's soil resources. According to their findings, the most characteristic processes of soil degradation include: loss of humus at a rate of 0.42–0.51 tons per hectare per year and nutrients such as phosphorus and potassium; erosion losses of the upper fertile layer; soil compaction, destruction of soil structure, formation of clods and crusts; and soil acidification, particularly in the Polissya and Carpathian regions. On the territory of

Table 3. Qualitative indicators of agricultural production groups of soils of Dolyna territorial community

Sampling depth, cm	Humus, %	pH KCl	Hydrolytic acidity, mg equivalent /100 g of soil	Nutrients, mg/kg soil			Sum of absorbed bases Ca^{2+} Mg^{2+}, mg equivalent/100 g
				N	P_2O_5	K_2O	
Agrogroup 18 e							
Sod-podzolic soil							
0–25	1.53 * / 1.61	4.4 / 4.7	13.8 / 11.6	67 / 74	24 / 32	91 / 114	10.0 / 11.2
25–46	1.46 / 1.54	4.6 / 5.0	12.7 / 10.0	58 / 64	21 / 26	80 / 92	15.0 / 17.3
Agrogroup 176 d							
18–40	1.34 / 1.40	5.5 / 5.7	1.81 / 1.73	90 / 107	51 / 64	134 / 140	15.0 / 18.0
Agrogroup 177 d							
Shallow soddy gley soils							
0–15	1.67 / 1.75	5.0 / 5.3	1.83 / 1.67	55 / 67	44 / 51	76 / 83	17.1 / 18.5
15–33	1.25 / 1.37	4.9 / 5.1	0.79 / 0.66	49 / 54	40 / 46	71 / 78	14.0 / 16.2
Agrogroup 183 e							
Brown-podzolic, podzolized gley soils							
0–20	1.94 / 2.01	4.0 / 4.4	10.13 / 9.63	45 / 5	15 / 24	150 / 16	17.0 / 18.2
20–42	0.90 / 0.97	4.0 / 4.2	9.82 / 8.61	35 / 42	22 / 28	140 / 154	20.0 / 21.2
Agrogroup 186 dk							
Meadow brown gley soils							
0–18	3.14 / 3.41	5.0 / 5.4	15.1 / 13.11	64 / 72	69 / 74	171 / 186	19.2 / 20.3
18–37	1.55 / 1.67	5.1 / 5.4	21.10 / 18.74	56 / 63	74 / 82	162 / 170	18.6 / 19.3
HIP_{05}				1.4	3.2	2.0	

Note: * Denominator is 2017 data, numerator is 2011.

Dolyna territorial community, there are sod-podzolic surface-gleyed soils (agro group code 18d). They are characterized by a very low humus content of 1.53%, which is mainly found in the humus-eluvial horizon.

Sod-podzolic soils are characterized by low saturation with exchangeable Ca and Mg ions and acidic pH. As a result of podzolization, the upper genetic horizons become depleted in bases while enriching in exchangeable hydrogen and aluminum ions, as indicated by hydrolytic acidity indices (Table 3). The agrochemical balance is determined at levels of 48, 49, and 49, while the agro-ecological balance stands at 47, 38, and 47 points respectively, correlating with yields of 19.26 t/ha, 19.67 t/ha, and 19.26 t/ha. It's worth noting that compared to 2011, the amount of organic matter in the soil has decreased, attributed to intensive agricultural cultivation and the export of nutrients from fields, compounded by the absence of organic fertilizers. We observe a similar trend with all quality indicators, which have declined compared to 2011. The surveyed area contains 5 agricultural soil groups formed on clayey terraces and slopes of varying steepness under the influence of sod and podzolic soil formation processes. These soils exhibit acidic pH, are moderately deficient in available phosphorus, and have medium levels of potassium. They are potentially fertile but require liming and the application of organic-mineral fertilizers.

CONCLUSIONS

In the study area, 5 agro-productive soil groups were identified, with a total area of 579.42 hectares, which decreased by 5.01% compared to 2011.

The largest area is occupied by brown-podzolic, soddy brown-podzolic, brown mountain-forest podzolized gley and shallow-gleyed, non-eroded and slightly eroded, heavy loamy and light clayey soils (47.1%). From the total agricultural land area, 62.7% is occupied by brown podzolic, soddy brown gley soils, 27.7% by sod-podzolic and podzolic-soddy surface-gleyed soils, and 9.6% by soddy unclayey and gleyey soils, including their podzolized variants. The soil solution reaction is acidic, although there are small areas with slightly acidic to near-neutral soils. These soils are moderately deficient in available phosphorus (16–69 mg/kg) and have medium levels of potassium (78–171 mg/kg).

The results of the analysis indicate an increasing rate of degradation: decreasing organic matter and nutrient reserves, compaction, erosion, acidification, among other factors, totaling approximately 17 types of degradation processes. The main causes of soil degradation include a deficit of organic and mineral fertilizers, reduced chemical reclamation efforts, inadequate protection of soils through agroforestry and meliorative measures, as well as a lack of interest from land users in preserving and restoring soil fertility.

REFERENCES

1. Adeyolanu O.D., Ogunkunle A.O. 2016. Soil quality assessment for sustainable land use and management. International Journal of Plant & Soil Science, 13(6), 22136.
2. Achasov A.B., Achasova A.A., and Titenko A.V. 2019. Determination of soil erodibility by assessing hydrothermal conditions of its formation. Global Journal of Environmental Science and Management, 5, 12–21. https://doi.org/10.22034/gjesm.2019.SI.02
3. A reference book is from the agrochemical and agroecological state of soils of Ukraine, 1994, Edited by G. Ya. Chesnyka, Kyiv, 121.
4. Baliuk S.A., Kucher A.V. 2019. Spatial features of the soil cover as the basis for sustainable soil. Ukrainian geographical journal, 3, 3–14. https://doi.org/10.15407/ugz2019.03.003 (In Ukrainian).
5. Buiak L., Pryshliak K., Bashutska O. 2019. Features of assessment of agricultural lands. Bulletin of the Khmelnytskyi National University, 6(1), 242–248. (in Ukrainian) http://journals.khnu.km.ua/vestnik/wp-content/uploads/2021/01/46-5.pdf
6. Dmytruk Y., Semenchuk V. 2021. Soil monitoring and conservation as a component of the system of sustainable management of agro-ecosystems at the local level. Agrochemistry and soil science, 92, 24–31. (in Ukrainian) https://doi.org/10.31073/acss92-03
7. Gobat J.-M., Aragno M., Matthey W. 2004. The Living Soil. Fundamentals of Soil Science and Soil Biology. Science Publishers, 602.
8. Grading of soils of Ukraine: Grading scales of soils of arable lands of Ukraine. 1993. Kyiv: Institute of land use of the Ukrainian Academy of Agrarian Sciences. (in Ukrainian)
9. Heger J., Imfeld G., Mitchell E. 2012. Bioindication in Soil Ecosystems European. Journal of Soil Biology, 49, 1–118.
10. Hryhoriv Ya., Butenko A., Solovei H., Filon V., Skydan M., Kravchenko N., Masyk I., Zakharchenko E., Tykhonova O., Polyvanyi A., 2024, Study of the Impact of Changes in the Acid-Base Buffering Capacity of Surface Sod-Podzolic Soils. Ecological Engineering, 25(6), 73–79 https://doi.org/10.12911/22998993/186928

11. Kasperevych L. 2018. Features of agricultural lands assessment in the conditions of market relations. Agrosvit, 19, 3–10. (in Ukrainian) https://10.32702/2306-6792.2018.19.3
12. Medvedev V. 2011. Soil grading in Ukraine: results and prospects. Bulletin of Kharkiv National Agrarian University: Series Soil Science, Agrochemistry, Agriculture, Forestry, Soil Ecology, 1, 22–28.
13. Methodology for Conducting Agrochemical Passportization of Agricultural Lands: Guiding Regulatory Document / Edited by I.P. Yatsuk, S.A. Baliuk. Kyiv, 2013, 10.
14. Methodology of the continuous ground-agrochemical monitoring of agricultural lands of Ukraine, 1994, Edited by O. O. Sazonova, Kyiv, 162.
15. Mugiyo H., Chimonyo V.G.P., Sibanda M., Kunz R., Masemola C.R., Modi A.T., Mabhaudhi T. 2021. Evaluation of land suitability methods with reference to neglected and underutilised crop species: a scoping review. Land 2021, 10(2), 125. https://doi. org/ 10.3390/land10020125
16. Osman K.T. 2018. Management of Soil Problems, XX. https://doi.org/10.1007/978-3-319-75527-4
17. Patuka V.P., Tarariko O.G, 2002, The agroecological monitoring and passport system of agricultural earth, Kyiv, Fitosotsiotsentr, 295.
18. Polichko V.S., Palamarchuk S.O., Matvienko Z.M., 2022, Qualitavite assessment of Soils in the Uzhhorod districtof the Zakrpattia Region. Soil Conservation. 14, 111–115.
19. Polupan M.I., Velychko V.A., Solovej V.B. 2015. Development of Ukrainian agronomical pedology: genetic and production aspects. Kyiv, 400. [In Ukrainian].
20. Pozniak S.P., Havrysh N.S. 2019. The role of soils in social development of society. Ukrainian geographical journal, 2, 57–61. https://doi.org/10.15407/ugz2019.02.057 (In Ukrainian).
21. Primak I.D., Man'ko YU.P., Ride N.M., Mazur V.A., Gorshchar V.I., Konoplev O.V., Palamarchuk S.P., Primak A.I. 2010, Ecological problems of agriculture, Edited by I. D. Prymak, Kyiv, Center of educational literature, 456.
22. Rishuk S.M., Lysovuy M.V., Bencarovskiy D.M., 2003. Methodology of the agrochemical passport system of earth of the agricultural setting, Kyiv, Ahrarna nauka, 64.
23. Smaga I. 2012. The state and prospects for the development of the agro-ecological direction in the credit assessment of soil and climatic conditions. Biological systems, 4(1), 91–94. http://ibhb.chnu.edu.ua/uploads/ f iles/vb/BS_T4_V1_2012/4_C_91-94_Smaga.pdf
24. Soil Fertility: Monitoring and Management; edited by V. V. Medvedev. Kyiv: Urozhai, 1992, 248.
25. Tarariko O.H., Ilienko T.V., Kuchma T.L. 2016. Sustainable land use management and soil conservation: urgency and challenges in modern conditions. Ukrainian geographical journal, 3, 56–60. https://doi.org/10.15407/ ugz2016.03.056 (In Ukrainian).
26. Tavares V., Tavares F., Santos E. 2022. The value of farmland and its determinants – the current state of the art. Land, 11(11), 1908. https://doi.org/10.3390/land11111908
27. Thorsoe M.H., Noe E.B., Lamandé M., Frelih-Larsen A., Kjeldsen C., Zandersen M., Schjønning P. 2019. Sustainable soil management – Farmers' perspectives on subsoil compaction and the opportunities and barriers for intervention. Land Use Policy, 86, 427–437. https://doi.org/10.1016/j.landusepol.2019.05.017
28. Truskavetskiy R.S., Tsapko Yu.L. 2003. Assessment indicators of soil acidity-buffering capacity. Agrochemistry and Soil Science. 64, 12–16.
29. Tsapko Yu.L. 2004. Scientific monitoring of soils based on graphical models of buffering capacity. Bulletin of V.V. Dokuchaev Kharkiv National Agrarian University. 1, 114–117.
30. Tymchenko D., Havryliuk V., and Koliada V. 2014. Deflation Processes of the Volyn Polissya of Ukraine: Soil Aspect / FOP Hrytsak S. Yu., Kharkiv, Ukraine.
31. Yatsuk I., Dmytruk Y., Cherlinka V., Den D. 2021. Status and Problems of Normative Monetary Valuation of Land in Ukraine. In: Dmytruk, Y., Dent, D. (eds) Soils Under Stress. Springer, Cham. https://doi.org/10.1007/978-3-030-68394-8_2