Analysis of methodological approaches to evaluation of land quality in ukraine

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Abstract. The paper analyzes methodological approaches to evaluation of the quality of land in Ukraine. It was determined that, depending on the purpose and methods of assessment there are several types of land evaluation in Ukraine: soil rating (bonitet), economic and pecuniary evaluation, where the quality of the land affects the results of evaluation. There are many methodological approaches to qualitative assessment of the land. It was highlighted both many individual and integrated indicators, but there is no uniform system of their evaluation.

Works on soil rating of agricultural lands in Ukraine have been carried out in accordance with "Methods of soil rating in Ukraine." Under the present conditions of the regulation of land relations, the question as for more precise specification of limits of agro-industrial groups of soils has arisen.

On the basis of experimental researches, it was found that using a variety of methodological approaches to qualitative assessment of soil, there is inexactitude in the formation of soil maps, and hence in soil rating. Thus, it is necessary to adopt and uphold a single methodology for the qualitative assessment of land.

Key words: soil rating (bonitet), land evaluation, environmental and agrochemical certification of fields, agrochemical passport of a land plot, agro-industrial group of soils.

PROBLEM STATEMENT

The issues of land quality at all stages of society were particularly relevant. Because of the diversity of functions of land its quality is evaluated by different criteria. The quality of the land affects the results of land assessments.

Depending on the purpose and methods there are several types of land evaluation in Ukraine: soil rating (bonitet), economic and pecuniary evaluation which is divided into normative and expert. Each of them has its practical application and each uses appraisal that reflects the natural properties of soil oriented on criteria for potential fertility as well as for crop yield. In these conditions the value of reliability of bonitet data is growing, since it is the basis for the definition of :indices of economic evaluation of soil used in the analysis of the efficiency of land use, economic suitability of land for growing crops; normative pecuniary evaluation of a particular land plot, which is the basis for determining the amount of land tax and rent; peer review of land plots during the alienation, insurance, mortgage and determining the investment contribution to the implementation of the investment project on land improvement.

ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

The famous soil scientist V.V. Dokuchaiev is considered to be the founder of soil rating. In Ukraine, the first attempts to solve issues of soil rating related to researches of V.P. Kuzmychov, S.S. Soboliev, A.I. Zrazhevsky, I.I. Karmanov, then it was much improved by A.I. Siryi, V.V. Medvediev, T.M. Laktionova, L. Ya. Nowakowski, O.P. Kanash, etc. However, in existing methods of soil rating physical parameters were used not enough and not impartially. Since the physical properties is an important component of soil fertility, their indices are gaining popularity in foreign concepts of soil quality and evaluation of agricultural lands: Russia (I.I. Karmanov and joint authors, 2002), France (D. De la Rosa, 1982), USA (F. Steiner, 1987; B.P. Warkentin, 1995), Canada (D.E. Romig and oth., 1995), India (D.P.S. Divakar, R.N. Sing, 1993), Bulgaria (B. Heorhiyev, 1994), New Zealand (G.P. Sparting, L.A. Schipper, 2002), etc.

A significant number of methodological approaches to qualitative assessment of the land can be found in the literature. It has been highlighted both many individual and integrated indexes, but there is no unified system.

STATEMENT OF THE PROBLEM

To analyze the methodological approaches to qualitative land evaluation.

THE MAIN MATERIAL

Since 1993, all agricultural lands in Ukraine have been embraced by soil rating, which is based on materials of large-scale soil surveys or selective surveys.

According to Article 199 of the Land Code of Ukraine [10] and Article 1 of the Law of Ukraine "On Land Valuation" [11] soil rating is the comparative evaluation of quality of soils based on their key natural characteristics that have stable character and substantially affect yields of agricultural crops grown in specific geographic and climatic zones.

The object of soil rating were accepted the units of the soil cover, which were distinguished on the maps of soils and combined into agro-industrial groups of soils in accordance with the "Classification of agro-industrial groups of soils Ukrainian SSR" (Kyiv, 1978).

The criterion of soil rating is soil qualitative indicators obtained in soil surveys that are sustainable and have a significant impact on the yield of crops grown in specific climatic conditions, and fully reflect the fertility of the soil.

Evaluation of soil quality is given in relative values – soil is rated on a 100-point scale worked out for some crops, which include winter wheat, winter rye, barley, oats, corn and grain, sunflower, sugar beet, potatoes and flax. Scales of soil bonitet are calculated for each natural agricultural area. The highest rating is given to soils that have the better characteristics and the highest natural productivity.

Works on soil rating of agricultural lands of Ukraine have been carried out in accordance with "Methods of soil rating in Ukraine", which was considered and approved at the meeting of the Department of Agriculture of the Ukrainian Academy of Agrarian Sciences 10.03.1992 (protocol number 2) and "Methodological guidelines on soil rating" [9], which were reviewed and approved by the scientific methodical Council on the soil rating in Ukraine on 21.01.1993.

In Ukraine the soil rating is conducted following three main natural features like depth of humus horizons, humus content and the content of physical clay.

Calculation of the score of soil rating (B_i) is based on a formula (1):

$$B_i = \frac{y_i}{y_e} * 100, \quad (1)$$

where: y_i - the value of the soil characteristic, for which the score is determined, y_e - the value of the soil characteristic, taking by 100points.

Thus within the land area estimated for each of these characteristics, their share impact on crop yield is determined, taking into account the determination coefficient (K_d) calculated by the formula (2):

$$K_{dij} = r_{ij}^2, \quad (2)$$

where: r_{ij}^2 - the correlation coefficient between the yield of j-crop and individual i coefficient of soils properties in scores.

Taking into account a share impact of each characteristic on crop yield in each agro-industrial group of soils of land-estimated area it was defined the total score of soil rating (bonitet) by the formula (3):

$$B_{zj} = \frac{B_{1ij} * B_{d1ij} + B_{2ij} * B_{d2ij} + ... + B_{nij} * B_{dnij}}{K_{d1ij} + K_{d2ij} + ... + K_{dnij}}, \quad (3)$$

where: B_{zj} - total score of bonitet of i's agro-group of soils, $B_{1ij}, B_{2ij}, ... B_{nij}$ - score of bonitet of soils by individual properties of i's group, $K_{d1ij}, K_{d2ij}, ... K_{dnij}$ - coefficients of determination by individual properties of soils of i's crop.

As correction coefficients such indicators like soil acidity, content of sodium, salinity, gleying are used.

The main purpose of soil rating is to determine the relative quality of soils by their fertility, that is, establishing how many times each soil is better or worse than the other one in its natural and sustainably acquired properties.

Since the last soil rating of agricultural lands according to mentioned methods more than twenty years have passed. Despite the fact that the Law of Ukraine "On Land Valuation" [11] soil rating must be conducted at least once every 7 years.

Under the present conditions of regulation of land relations there is the question as for specification of limits of agro-industrial groups based on the Law of Ukraine "On Land Protection", "On state control over land use and protection", the Decree of the President of Ukraine of December 2, 1995 , №1118 "On complete agrochemical certification of agricultural lands", the Decree of the Ministry of Agrarian Policy and Food of Ukraine "On Approval of the Order of keeping of agrochemical passports on a field and a land plot" of October 11, 2011, №536 [10], which define the procedure for obtaining qualitative soil characteristics, with the help of which specification of limits of agro-industrial groups of soils is conducted.

Methods for environmental and agrochemical certification of fields and land plots have been considered and approved by the Academic Council of the Institute of Agroecology and Biotechnology UAAN on December 28, 1994 and by the Technical Council of the Ukrainian public association on execution of agrochemical works "Ukragrohim» on January 24, 1995 [3].

In Ukraine, there are many scientific and practical institutions operating in the field of agrochemical certification, but, unfortunately, the results of their performance are not coordinated. These are regional production engineering centers dealing with the protection of soil fertility of the Ministry of Agrarian Policy, a system of observation stations of the State Committee for Hydrometeorology; hydrogeology and

reclamation expeditions, regional sanitary-and-epidemiological stations etc. Basic indicators of soil fertility, which given institutions use, belong to the category of individual ones:

1. pHsaline - potentiometrically (DSTU ISO 10390-2001).
2. The humus content – according to Tiurin (GOST 26213-91).
3. The content of alkali and hydrolyzed nitrogen - according to Cornfield.
4. The content of physical clay - according to Kaczynski (DSTU ISO 11277: 2005).
5. Mobile forms of phosphorus and exchangeable potassium - according to Kirsanov (DSTU 4405-2005) and Machyhin (DSTU 4114-2002).
6. The sum of absorbed bases - according to Kappen-Hilkovits (GOST 27821-88).
7. The content of calcium and magnesium –by the trylonometrical method (GOST 26487-85).
8. Hydrolytic acidity - according to Kappen in modification of ЦІНАО (GOST 26212-91).
9. Trace elements – atomic and absorption spectrophotometer method C - 115 M1.
10. Salts of heavy metals - according to RD 52.18.289-90.
11. DDT and its metabolites - according to the "Methodical reference on level control and studying of dynamics of pesticides content in soils and plants. - M.: Agropromizdat, 1985."

Following a given set of indicators, we can adequately assess the current state of the soil, diagnose all kinds of degradation and predict changes for the near or even distant future. However, a large amount of data gained by various organizations, often without following unified standardized (certified) techniques, and especially not in accredited laboratories, cannot provide a complete picture of the quality of land in different regions in particular and the country as a whole.

Well-founded algorithm of calculation of qualitative soil evaluation is described in the Methods of ecological and agrochemical certification of agricultural lands [3]. However, the number of correction coefficients in establishing this evaluation also is not clearly stipulated, that greatly affects the final result. Furthermore, among the indicators included in the agrochemical passport of a field and a land plot, parameters characterizing physical and chemical properties of soils, and their nutrient regime and pollution were dominant, but almost no physical parameters are taken into account [15].

According to indices of qualitative assessment of land soil maps of the area are formed. Soil maps of Ukraine of different scales, which were made on the basis of large-scale soil survey during 1957 - 1961, are significantly outdated and many of them have the low-quality information for the following reasons: 1) taking the prescription of soil maps; 2) materials were processed in the absence of topographic maps or aerial photographs; 3) there was a change of soil cover due to its radical reclamation or intensive erosion processes, etc.; 4) changes in the boundaries of land use and so on.

Experimental data obtained by the State institution "Oblderzhrodyuchist" indicate significant differences between boundaries of agro-industrial groups of soils with different methodological approaches. For example, let's consider how to change the boundaries of agro-industrial soils groups of the land plot of 24.4371 hectares, which belongs to Borschovychi (03) natural and agricultural region of the western steppe zone.

Figure 1 shows the boundaries of agro-industrial soils groups of the given area, which have been formed according to the data of the large-scale soil survey during 1957 - 1961.

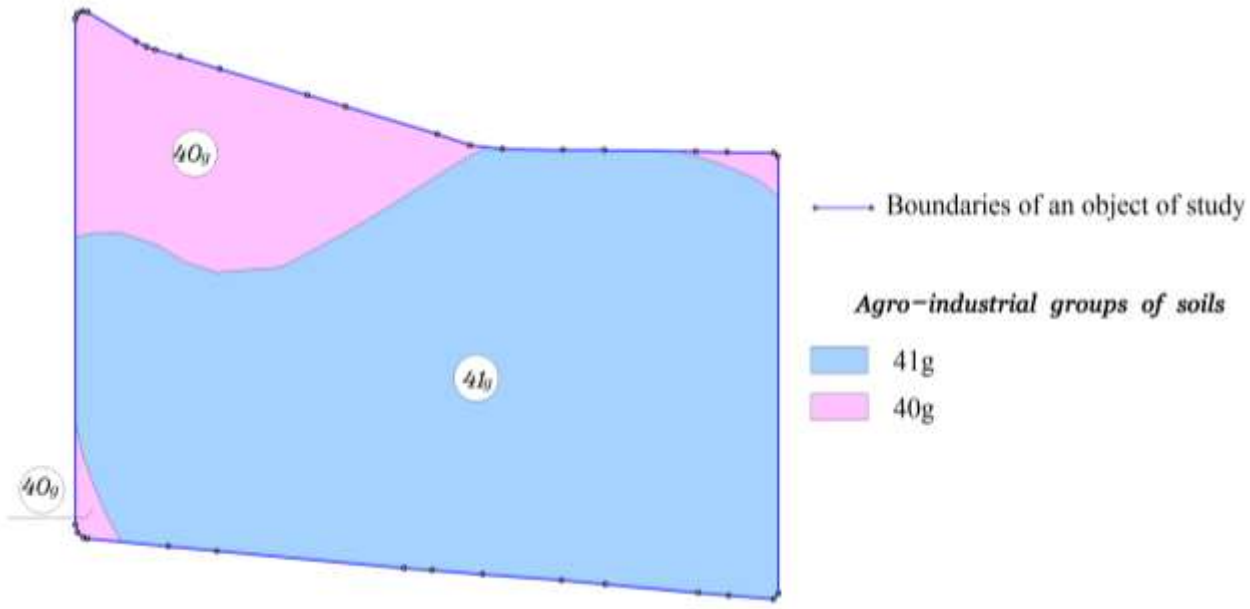

Fig. 1. Soil map of the investigated area, which is formed according to the data of the large-scale soil survey since 1957 till 1961

It has been determined that within the survey area the following types of soils prevail: 40g - dark gray podzolic light loamy soils on loess loams, occupying an area of 4.8479 hectares and 41g – black earth podzolic light loamy soils on loess loams, occupying an area of 19.5892 hectares.

According to the results of soil agrophysical and agrochemical properties investigation on the investigated area by the Methods of ecological and agrochemical certification of agricultural lands, we obtained data presented in Table 1.

On the basis of field and analytical investigations and in accordance with the nomenclature list of agro-industrial groups in Ukraine and the scale of soil rating in Lviv region we revealed that within the investigated area following soils prevail:

1. Dark gray podzolic light loamy soils on loess deposits that cover an area of 6.1235 hectares of arable land, and belong to 40g agro-group, the score of soil rating is 66.
2. Black earth-meadow gley of medium-depth soils on loess diluvium that cover an area of 1.9164 hectares of arable land, and belong to 134g agro-group , the score of soil rating is 61.
3. Dark gray podzolic gley light loamy soils on loess deposits that cover an area of 16.3972 hectares of arable land, and belong to 46g agro-group , the score of soil rating is 27.

Figure 2 shows the soil map of the investigated area, which is formed on the basis of Methods of ecological and agrochemical certification of agricultural lands.

Table 1. The results of soil agrophysical and agrochemical properties investigation

№ of a sample	Code of an agro-group	Depth of sampling	Results of investigation					
			Humus, %	pH saline	The amount of fraction of physical clay less 0,01 mm, %	Nitrogen alkaline mg / kg	Phosphorus, mg / kg	Potassium, mg / kg
1-1	40g	0-28	2,61	4,81	25,52	112,9	60,0	32,0
2-1	134g	0-44	2,51	5,73	27,07	102,7	205,3	63,7
3-1	46g	0-34	2,54	5,62	25,97	132,9	156,7	45,0

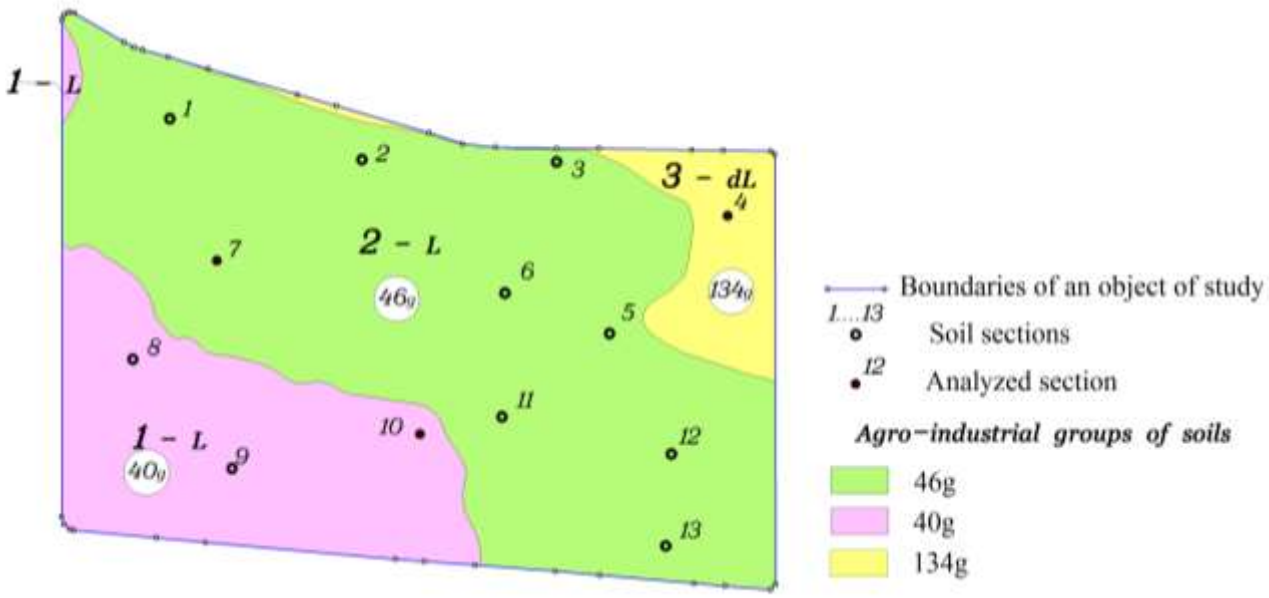

Fig. 2. Soil map of the investigated area, which is formed on the basis of Methods of ecological and agrochemical certification of fields and land plots

According to the data of two methodological approaches for the qualitative assessment of land we have formed a comparative explication of agro-industrial groups of soils (Table 2).

Table 2. Comparative explication of agro-industrial groups of soils on the investigated area

Name of the methodological approach to evaluation of the land quality	*Agro-industrial groups of soils prevailing on a plot*	*Area of agro-industrial group of soils,*
Large-scale soil survey during 1957 -1961	*40g*	*4,8479*
	41g	*19,5892*
Methods of agrochemical certification of agricultural lands	*40g*	*6,1235*
	134g	*1,9164*
	46g	*16,3972*

Thus, using a variety of methodological approaches to qualitative assessment of soil, there is inexactitude in making soil maps, and hence in determination of the score of soil rating.

Today soil rating is important for the SLC because it provides information about the qualitative assessment of soil, which in turn is the basis for the economic valuation of land and
thus - normative pecuniary evaluation of land. However, the legislation governing the procedure for this type of evaluation is very limited; even there is no normative act that would define such a procedure.

Therefore, we can conclude that at the present stage of development of land relations legal regulation of soil rating needs to be improved.

CONCLUSIONS

Thus, in general terms, the problem is to define a common methodology and a set of indicators to assess soil quality adequately. Development of a system of indicators should be done taking into consideration the possibility of information use from existing services that control the state of the soil cover, soil fertility and health of soil. We also should take into account the need in spreading information from researches based on the modern technical base and advanced techniques.

REFERENCES

1. **Bulyhin S.Ya. 2005.** Land quality evaluation: methodical recommendations / S.Ya. Bulyhin, A.V. Barvinsky, K.S. Karabach. – K.: NAU. – 37.
2. Ecological and agrochemical certification of fields and land plots: methodological guidelines / M.V. Kozlov, M.V. Medvediev, A.G. Serdiuk. - Kyiv: Agrarian opinion, 1996. – 34. (in Ukraine).
3. Ecological and agrochemical certification of fields and land plots: methodological guidelines. - Kyiv: Agrarian science, 1996. – 37.
4. **Hirzheva K.B. 2006.** Role of physical indicators in the regional pedotransfer assessed models // Herald of Agricultural Science. - № 11. - pp. 72-74. (in Ukraine).
5. **Kanash O.P. 2008.** Soil rating: changes are being proposed, what are they worth? / O.P. Kanash // Land management Herald. - № 5. - 46-50. (in Ukraine).
6. **Koshovyy V., Alokhina O., Skierucha W., Wilczek A., Pastuszka T. and Cymerman J.** 2013. Peculiarities of soil moisture and temperature dynamics based on TDR-measurement results for 2008-2012 in the western Polesie territory of Ukraine. Acta Agrophysica, 20(4), 577-593. (in Ukraine).
7. Land Code of Ukraine. - K .: Information of Verkhovna Rada of Ukraine, 2002. - № 3 - 4 – 27.
8. **Medvedev V.V. 2008.** Criteria, standard and spatial units in soil rating / V.V. Medvediev, I.V. Plisko // Herald of Agrarian Science. - № 8. - 9-15. (in Ukraine).
9. Methodical guidelines on soil rating. – K .: UAAS, 1993. - 96.
10. On approval of the procedure of keeping an agrochemical passport of a field and a land plot: Decree of the ministry of agrarian policy and food of Ukraine on October11, 2011 № 536 [electronic resource]. - Mode of access: http: // zakon4.rada.gov.ua/laws/show/z1517-11.
11. On land evaluation:the Law of Ukraine on December 9, 2012 № 1378-15 [electronic resource]. - Mode of access: http: // zakon4.rada.gov.ua/laws/show/1378-15.
12. **Panas R.M. 2012.** Soil rating: educational manual / R.M. Panas. - Lviv: Novyi Svit, - 319. (in Ukraine).
13. **Skierucha W. 2006.** Temperature influence on the reflectometric measurement of soil moisture. Acta Agrophysica, 122, 1-88. (in Ukraine).
14. Soil rating : methodical recommendations / A.I.Siryi, N.A. Dubrovina, V.A. Lapanova, N.V. Kozlov, V.G.Krykunov. - K .: UAA, 1986 – 75p.
15. **Sokhnych A.Ya. 1997.** Land monitoring / A.Ya. Sokhnych. - Lviv, – 127. (in Ukraine).
16. **Yershova K. B. 2004.** Experience in the use of physical parameters in soil rating/ K. B. Yershova, K.B. Hirzheva //Herald of KHNAU. - № 6. - 133-136. (in Ukraine).