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THE METHODS FOR DETERMINING AGROLANDSCAPE TYPICALITY FOR PROJECTS OF WATER SUPPLY CONSTRUCTION

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Abstract

The scientific paper presents the experimental data obtained in the course of the environmental and reclamation monitoring of the hydro-geological and reclamation condition of irrigated soils in the southern steppe of Ukraine, their chemical composition is determined. On the basis of the analysis of water and salt regime of the soils in the areas under study for reclamation and water supply construction, on the basis of many years' research, the study suggests the method for determining agrolandscape typicality considering the properties of soil chemical composition. The basis of this method is the following principle: the confidence intervals of neighboring regression lines coincide (overlap) on a certain interval of values, so they are typical on this interval of values. The study establishes that according to this method the landscapes of Kherson Prysyvashshia and Askania steppes are typical by the specificity of the formation of soil chemical composition by 83.5% that makes it possible to compare the research results obtained on both landscapes and proves the typicality of the field experiment.

Key words: *agrolandscape, chemical composition, mathematical statistics, regression, water and salt regime.*

INTRODUCTION

The need of agrolandscapes for irrigation reclamation in the South of Ukraine is caused by their location in the area of insufficient moisture, where periodical droughts lead to a decline in crop yields and crop death if irrigation is not applied.

It is necessary to use a complex of eco-friendly reclamation measures reducing a negative impact of unfavorable weather conditions and increasing soil fertility. The main efficient method for increasing dark chestnut soil fertility is irrigation in combination with agro-technical measures, aimed at accumulation or storage of humus in soil and maintenance of project water and salt, air and nutritional regimes of soils. However, more than 50% of all irrigated lands in the world are inclined to secondary salinization, alkalization and waterlogging (Sabagh et al., 2019).

Under conditions of Kherson and Crimean Prysyvashshia, a favorable eco-friendly mode in project exploitation of irrigation and drainage networks provides horizontal drainage with the distance between drains of 220-240 m and the depth of laying drains - 2.5-3.5 m, maintaining the water table (WT) at the depth of more than 1.5 m during the irrigation season, reducing the WT to the depth of more than 2 m at the end of the year.

Substantiation of optimal irrigation modes and drainage parameters must be based on the evaluation of the conditions of the formation of water and salt regimes of soils. At the same time, an optimal irrigation mode results in average annual declining resultative flow of moisture, contributing to soil desalinization, and it can be implemented only on the basis of efficient drainage.

Hydro-technical reclamation should be always combined with amelioration and agro-technical measures into a single system of reclamation measures (Liu et al., 2016; Jones & Rowe, 2017).

However, systems of integral management of soil regimes ensuring maximum utilization of biological potential in crop production and ecological sustainability of agricultural landscapes have not been developed yet and are still hypothetical reclamation systems of the future. A complex of agricultural techniques decelerates the degradation period of soil development, but it is not capable of eliminating general regressive tendencies of soil formation entirely. The main task of soil ecological forecasting is to determine the degradation stage at which this soil development will cease and how much time it will take (Kumara et al., 2015).

MATERIALS AND METHODS

In order to reduce the level of manifestation of negative changes on previously irrigated lands and avoid them on reclaimed territories, especially on poorly drained and territories without drainage, including Kherson and Crimean Prysyvashshia and the steppes of Kherson region, it is necessary to optimize reclamation modes of irrigated lands and to develop quantity criteria for the state of irrigated agrolandscapes. In this case the choice of a reclamation mode is a primary task in the aspect of maintaining favorable water and salt regime of soils (Wang et al., 2014).

Water and salt regime of soils is determined by complex processes of mass transfer occurring under the influence of different natural and artificial factors. But management of water and air, water and salt regimes of soils by means of irrigation and drainage, and maintenance of an optimal reclamation mode in combination with agro-technical techniques should prevent secondary salinization of soils and ensure desalinization of primary saline soils and increase their fertility (Dukhovny & Stulina, 2010).

Currently new methods of examining water and salt regime of soils in the zone of aeration have been thoroughly developed. They are based on the study of the mode of moisture transfer through the zone of aeration by the data of hydro-physical observations. However, calculations of salt transfer have just become common practice of hydro-geological and reclamation research, therefore their methods cannot be considered as developed enough. In order to substantiate these calculations, it is certainly necessary to search for new methods for further improvement of theoretical models of salt transfer that consider physical and chemical properties of the processes of soil salinization and desalinization, rock and soil structure and plant impacts (Ushkarenko et al., 2018; Lavrenko et al., 2018).

At present the regularities of salt distribution in soils are mainly examined by a vertical profile. The regularities of horizontal distribution of salt composition and concentration in the zone of soil aeration, especially within certain soil areas have not been studied thoroughly; moreover, the role of capillary leakage, diffusive migration, osmotic filtration and other processes related to ion transport is not clear yet (Lendering et al., 2015).

The experience of regulating water and salt regime on low- and medium-salinized meadow-chestnut and chestnut-meadow alkaline soils under proximity of highly-mineralized (8-20 g/dm^3) groundwater in Kherson and Crimean Prysyvashshia proves that the correlation of the total water supply (600-800 mm per year) and water removal by means of horizontal drainage (15-20% of water supply) maintains fertility of irrigated lands, ensures security against secondary soil salinization and maintains project crop productivity.

General direction of the rise and fall of groundwater in different seasons of the year is characteristic of undrained and drained territories, but the height of the rise and the duration of ground water lying at a certain depth are different. The values of acceptable levels must be based on the main factors that have an impact on water and salt balances of the zone of aeration (Wang et al., 2016). These are lithological conditions of the zone of aeration affecting the height and velocity of capillary rise and irrigation-climate indexes determining the wetting of the zone of aeration, the potential of forces influencing the movement of substances. The depth of groundwater, the average for the growing season, is closely connected with the evaporation coefficient.

For instance, the balance of moisture is close to zero on virgin dark chestnut soils in the South of Ukraine, and it is negative at the depth of more than 200 cm, i.e. this thickness adds no moisture and, on the contrary, has a certain tendency for a progressive loss of moisture and the loess stratum under virgin vegetation has humidity of 12.0-15.6%. On irrigated lands, the limits of moisture regulation in the soil layer containing roots depending on the size of the soil-absorbing complex for dark chestnut and chestnut soils is 0.6-0.8 of the soil moisture threshold.

Salt regime of irrigated lands is mainly determined by natural features of the region under study, the quality of irrigation water, the depth of ground water lying and mineralization (Lisetskii et al., 2015).

Salinized lands occupy 92.8 thousand hectares, including medium-salinized and highly-salinized - 18.3 thousand hectares in the steppe of Ukraine. Lands with secondary salinization occupy 30% of the territory of salinized farmlands, while lands with primary salinization occupy 70% of the territory. The highest priority tasks of managing salt regimes of soils in the dry steppe zone are mainly related to creating conditions of even moisturizing by the area and depth, maintaining highly fertile and unsalinized 1 m of the topsoil, stabilizing natural salt reserves in deep layers of the zone of aeration and applying high-quality water for irrigation (Jiménez-Aguirre et al., 2018; Feizi et al., 2010). Irrigation considerably affects the formation of a salt profile not only in the zone of aeration, but has an impact on deeper layers.

The specificity of salt regime of soils in the dry steppe zone is in the following facts: calcium carbonates and sulfates are washed away to the depth of 0.5-0.7 m in automorphic conditions; water-soluble salts, including a great number of sodium sulfates are available at the depth of 0.7-2.0 m. The direction and intensity of the processes of changes in soil-reclamation conditions (under deep-lying ground water) in chestnut soils of the southern steppe region is mainly determined by the content and chemical composition of salts and the quality of irrigation water; mineralization and chemism of ground water play an important role under its proximity.

Calcium ions (up to 50%) and hydro-carbonates (up to 60%) dominate in a liquid phase in unsalinized soils, and sodium ions (up to 70%), sulfate ions and chlorine ions dominate in salinized soils. If there is an increase in moisture resulting from intensification and cation-change processes, there is a rise in the relative concentration of sodium and potassium in the solution, and there is a decrease in the concentration of calcium and magnesium.

Salt regime of secondary hydromorphic soils under drainage is formed in the same way as the one without drainage. In cold seasons the topsoil undergoes salt depletion, while the subsoil accumulates salts, in warm seasons they reach the surface again, however, the intensity of salts in these soils is much lower than in secondary hydromorphic soils without drainage. They are characterized by more favorable composition of secondary salts in which calcium hydro-carbonates dominate (Asgari et al., 2018; Zhang et al., 2019).

Salt regime in soils beneath virgin vegetation is characterized by a seasonal circulation of water-soluble ions occurring in a small volume of soil and is determined by the depth of moisture circulation. The average annual loss of salts (0.0062%) of the layer of 0-50 cm was nearly equal to their gainful part for the growing season (0.0068%) in the research period.

There is an obvious necessity for improving the methods for evaluation of salt dynamics and the efficiency of reclamation of salinized soils. It is known that, even under total equality of all other conditions of reclamation, the intensity of salt occurrence in soils changes depending on the total amount of salts in the reclaimed layer. It is common in attempts of comparative evaluation of salt dynamics and comparison of the way of improvement on different lands with various hydro-geological, soil and farming conditions (Stupak, 2016).

Soil gradually loses the properties of its initial state under the influence of irrigation. It mostly refers to the distribution by the profile of humus, carbonates and gypsum. There are more similarities between cultivated soils of different regions than between natural soils of these regions. Therefore many soil scientists suggest distinguishing irrigated soils as special types (Golosov & Belyaev, 2013).

Currently the results of numerous field and production experiments and pre-project searches are often recommended to be used in practice without proper substantiation of "model" character of the experiment. In other words, the research results are spread only in a descriptive aspect (the reference to a possible identity of soil, hydro-geological and climate characteristics inevitably requiring a widespread use of stochastic methods and evaluations), but not in terms of quantity. It does not allow a widespread use of the research results in practice. It causes the necessity to develop the methods for determining agrolandscape typicality considering the properties of soil chemical composition.

RESULTS AND DISCUSSIONS

We consider the typicality of a field experiment as the correspondence of its conditions to natural, climatic, agro-technical and water management conditions.

The idea of production modeling is taken as a principle of choosing a typical plot for experiments. The research plot should be a model of the territory where the research results will be spread.

This method allows determining the area to which the research results will be spread.

In order to establish the features of the formation of water and salt regime of soils under conditions of long-term irrigation with artificial drainage, we conducted research on the territory of the following landscapes: Kherson (Henichesk district of Kherson region, 46°23'44.66"N 324°38'59.37"W) and Crimean (Dzhankoi district of Crimea, 45°41'20.19"N 325°15'38.34"W) Prysyvashshia, Askania steppe (the farms of Chaplynka district of Kherson region, 46°24'55.83"N 326°06'22.31"W) and the virgin lands of the biosphere reserve "Askania-Nova" (46°29'23.63"N 326°04'49.01"W).

Different hydro-geological conditions of Kherson Prysyvashshia and Askania steppes do not allow determining their typicality using the available methods for determining agrolandscape typicality (Ladychuk et al., 2018). Therefore we suggest an alternative method for determining agrolandscape typicality considering the properties of soil chemical composition. The following principle is assumed as a basis of this method: if the confidence intervals of the neighboring lines of regression determining the dependence of one of the major ions (hydro-carbonate ions, chlorides, sulfates, calcium, magnesium, sodium + potassium) on the sum of salts in soil, constructed for each of the compared agrolandscapes, coincide (overlap) on a certain interval of values, they are typical on this interval of values.

The initial data in our method for determining landscape typicality are the following: 1) soil salinity, %; 2) chemical compositions of soils, m-eq per 100 g of soil.

1. Graphical dependence of the major ions on the sum of salts in soil of each research object (landscape) in a linear correlation is determined for each of these ions (HCO_3^-, Cl^-, SO_4^{2-}, Na^+, Ca^{2+}, Mg^{2+}) (Figure 1).

2. It is necessary to calculate the parameters of the regression lines, their confidence intervals, correlation coefficients and errors for each linear dependence ($y = кx + в$, $к_1$, $к_2$, $в_1$, $в_2$, r_1, r_2, Sr) (Figure 2).

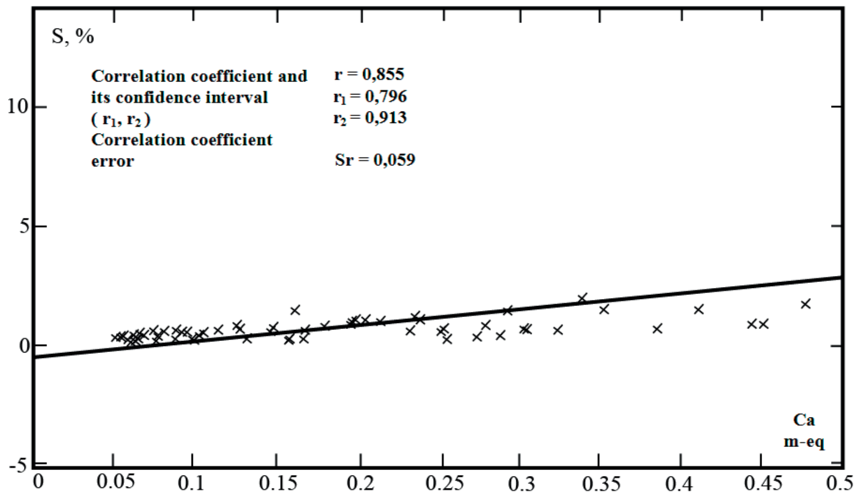

Figure 1. Dependence of the ion-content Ca^{2+} (m-eq) on the sum of salts (S, %) in soil

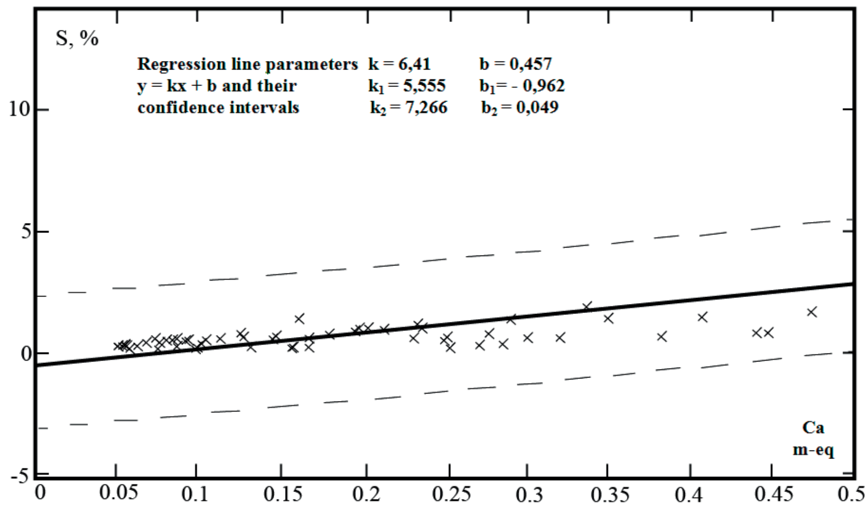

Figure 2. Confidence intervals of linear dependence of the ion content Ca^{2+} (m-eq) on the sum of salts(S, %) in soil

3. The regression lines for the landscapes should be shifted to one coordinate plane of the chosen scale with determining confidence intervals for each of them.
4. We use the principle that confidence intervals of the neighboring regression lines coincide (overlap) on a certain interval, therefore they are typical on this interval of values, and find the points of intersection of the confidence intervals.
5. If we connect these points (the nearest ones by the line of a confidence interval), we determine the confidence region where the research (compared) landscapes are typical by the content of a certain ion.
6. The correlation coefficient shows the closeness of association of the factors and, if its values approximate 1.0, the confidence interval of the regression line becomes narrower and the accuracy of determining the confidence region increases when such neighboring confidence intervals overlap.
7. We register the boundary values of the projections of the regression lines onto the scale S, % within which the regression lines of each research landscape are typical or are confined to the confidence region of typicality (Table 2).
8. We determine the difference between the boundary values for each ion by the formula[1]:

$$^{1}\quad \Delta BV = BV_k - BV_h,$$

where Δ(BV) is the difference between the boundary values of the regression and the confidence region.
9. We calculate percentage of the relative difference (PRD, %) by each of the ions between the research agro-landscapes by the formula[2]:

$$^{2}\quad PRD = \frac{\Delta BV_i - \Delta BV_n}{\Delta BV_i} \bullet 100,\%,$$

where: $\Delta(BV)_i$ is the difference between the boundary values of the landscape-i; $\Delta(BV)_n$ is the difference between the boundary values of the landscape-n; i and n are the symbols corresponding only to a certain landscape. (large values in comparison to other values are used as the first (Δ(BV)i).
10. It is necessary to subtract the percentage of relative difference and the typicality percentage (TP, %) from 100% for the compared landscapes by each ion.
11. The total (final) typicality percentage (T(F)TP) of the compared landscapes is determined as the average between the typicality percentage by each ion, and T(F)TP allows determining typical areas in hectares by the formula[3]:

$$^{3}\quad T(F)TP = \frac{TP(HCO_3) + TP(Cl) + TP(SO_4) + TP(Ca) + TP(Mg) + TP(Na)}{6}$$

Notes: 1) the more values of the total content of salts and the content of this or that ion in soils are used when determining their interdependence, the more accurate the values of the regression lines and their statistical characteristics are, that affects the ultimate result of determining typicality; 2) only soils of the same type and granulometric composition can be compared.
Practical realization of the suggested method is described below.

The research plot located on the virgin land of the reserve "Askania-Nova", chosen for the research as a basic variant of natural soil fertility, for evaluation of the changes in soil formation processes in the research landscapes under the influence of anthropogenic factors - irrigation and drainage. In order to make a more correct shift from the virgin landscape of Askania steppes to the irrigated landscape with horizontal drainage of Kherson Prysyvashshia while determining typicality, we chose two research plots irrigated for a long time, one of them being typical for Kherson Prysyvashshia by the basic parameters, the other one being typical for Askania steppes.

The ultimate result of the grapho-analytical determination of the research agro-landscapes typicality is given in Tables 1 and 2 and in Figures 3-6, presenting the areas of typicality of the landscapes under study by the content of each of the major ions. The boundaries of soil salinization, from which the research landscapes are typical by each of the major ions, are given in Table 1.

Table 1. Statistical characteristics of the dependence of the content of the major ions on the sum of salts in soil in determining landscape typicality

Ion	№ of the object	The regression equation of the y=ax+b	Confidence intervals of the regression lines				Correlation coefficients (r) and their error
			К1	В1	К2	В2	
HCO_3^-	1	y=0.014x+0.603	-0.079	0.553	0.106	0.653	0.025 ±0.058
	2	y=0.384x+0.576	-0.097	0.473	0.865	0.679	0.276 ± 0.107
	3	y=10.053x-0.308	7.742	-0.592	12.364	-0.023	0.860 ± 0.032
	4	y=0.147x+0.893	-0.421	0.600	0.715	1.185	0.127 ± 0.148
Cl^-	1	y=2.058x+0.209	1.485	-0.102	2.631	0.519	0.524 ± 0.042
	2	y=6.740x-0.343	5.442	-0.620	8.037	-0.066	0.882 ± 0.026
	3	y=0.012x+0.155	-0.269	0.120	0.292	0.189	0.016 ± 0.123
	4	y=2.007x-0.010	1.021	-0.518	2.993	0.498	0.710 ± 0.075
$S0_4^{2+}$	1	y=13.555x-0.968	13.060	-1.236	14.050	-0.700	0.978 ± 0.003
	2	y=8.808x-0.402	5.576	-0.665	10.041	-0.139	0.932 ± 0.015
	3	y=2.535x+0.295	-0.049	-0.023	5.118	0.613	0.355 ± 0.108
	4	y=13.329x-1.280	12.014	-1.958	14.644	-0.602	0.981 ± 0.006
Ca^{2+}	1	y=7.061x-0.460	6.397	-0.820	7.725	-0.100	0.877 ± 0.013
	2	y=2.382x+0.256	0.963	-0.047	3.802	0.559	0.517 ± 0.085
	3	y=1.016x+0.361	-0.197	0.212	2.229	0.510	0.309 ± 0.111
	4	y=2.060x+0.078	1.296	-0.315	2.825	0.472	0.800 ± 0.054
Mg^{2+}	1	y=3.400x-0.011	3.076	-0.187	3.724	0.164	0.874 ± 0.014
	2	y=3.796x-0.061	3.036	-0.223	4.557	0.102	0.874 ± 0.027
	3	y=0.169x+0.487	-2.157	0.201	2.496	0.774	0.028 ± 0.123
	4	y=2.720x+0.099	2.163	-0.188	3.277	0.386	0.924 ± 0.022
Na^++K^+	1	y=5.038x+0.348	4.325	-0.038	5.750	0.734	0.771 ± 0.024
	2	y=9.753x-0.364	7.869	-0.767	11.637	0.038	0.881 ± 0.026
	3	y=14.086x-0.971	11.704	-1.264	16.468	-0.678	0.916 ± 0.020
	4	y=10.225x-0.341	8.932	-1.007	11.519	0.326	0.969 ± 0.009

Table 2. Typical boundaries of soil salinization (%) for the research landscapes

The research agrolandscape	Ions					
	HCO_3^-	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^++K^+
Kherson Prysyvashshia (irrigation + drainage)	0.05-0.60	0.05-0.60	0.05-0.25	0.05-0.34	0.05-0.52	0.05-0.39
Kherson Prysyvashshia (irrigation)	0.05-0.60	0.06-0.24	0.05-0.39	0.05-0.47	0.05-0.48	0.05-0.37
Askania-Nova (irrigation)	0.06-0.16	0.05-0.44	0.05-0.24	0.05-0.60	0.05-0.25	0.06-0.41
Askania-Nova (virgin lands)	0.05-0.60	0.05-0.60	0.05-0.33	0.05-0.60	0.05-0.60	0.05-0.42

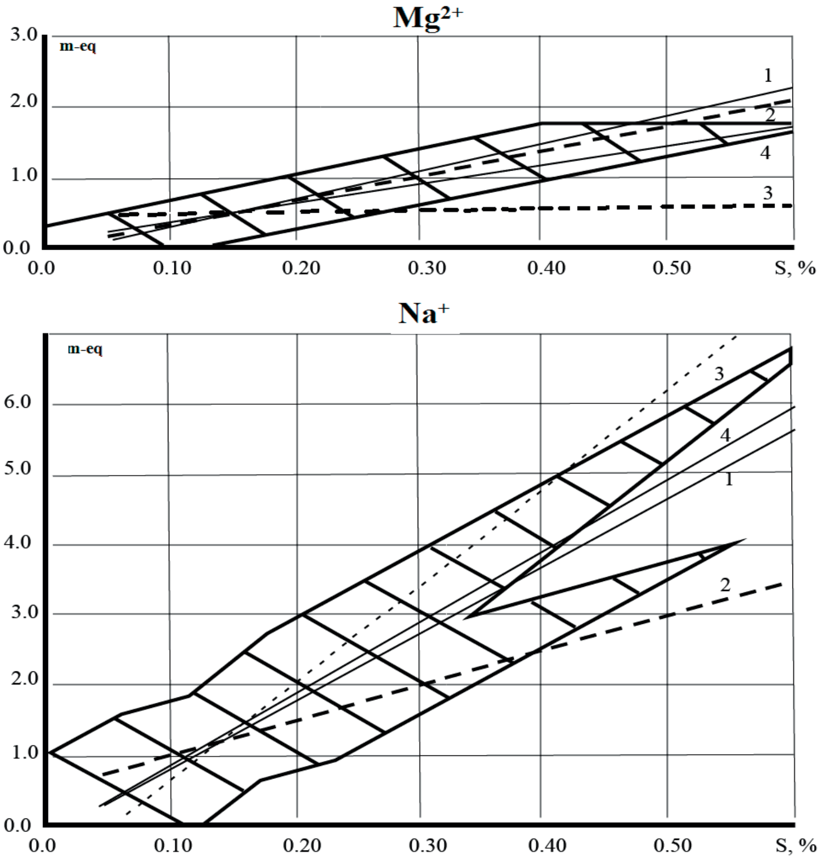

Figure 3. Determination of landscape typicality using the dependence of the ion content Mg^{2+} and Na^{+} on the sum of salts (S, %) in soil: 1 - Kherson Prysyvashshia (irrigation); 2 - Kherson Prysyvashshia (irrigation + drainage); 3 - Askania-Nova (irrigation); 4 - Askania-Nova (virgin lands)

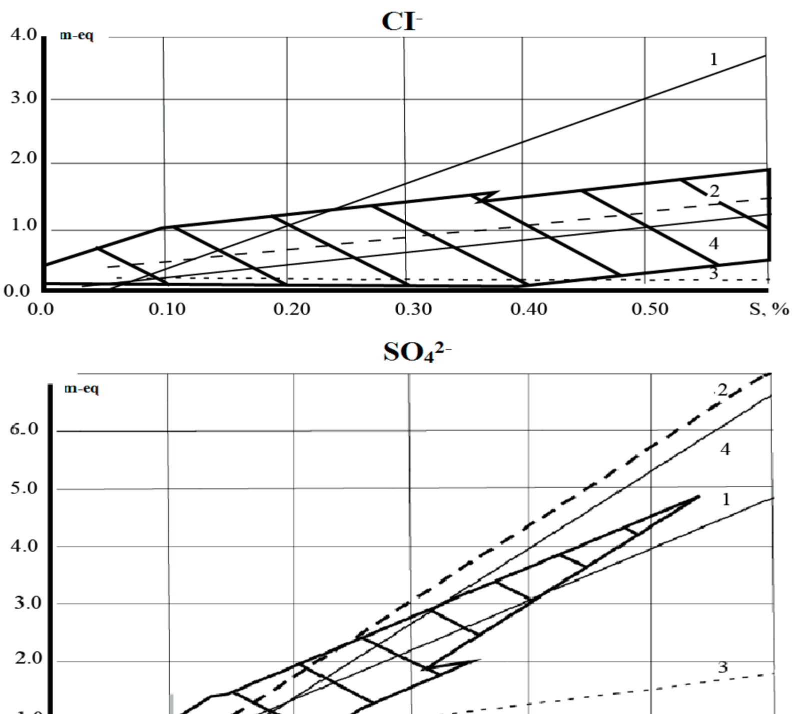

Figure 4. Determination of landscape typicality using the dependence of the ion content Cl^{-} and SO_4^{2-} on the sum of salts (S, %) in soil: 1 - Kherson Prysyvashshia (irrigation); 2 - Kherson Prysyvashshia (irrigation + drainage); 3 - Askania-Nova (irrigation); 4 - Askania-Nova (virgin lands)

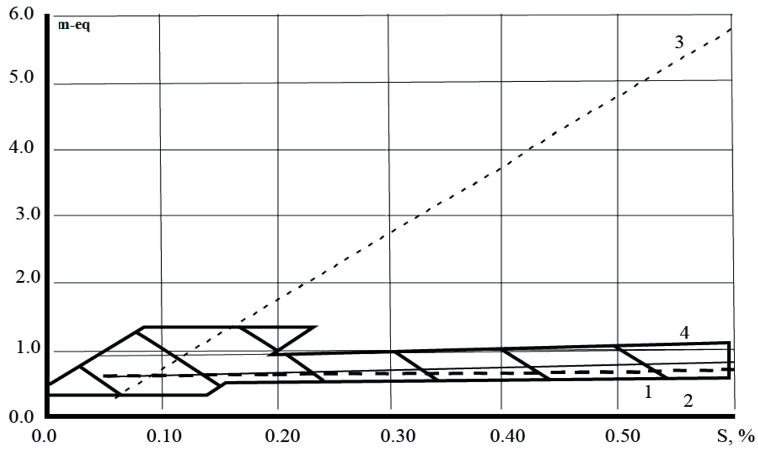

Figure 5. Determination of landscape typicality using the dependence of the ion content HCO_3^- on the sum of salts (S, %) in soil: 1 - Kherson Prysyvashshia (irrigation); 2 - Kherson Prysyvashshia (irrigation + drainage); 3 - Askania-Nova (irrigation); 4 - Askania-Nova (virgin lands)

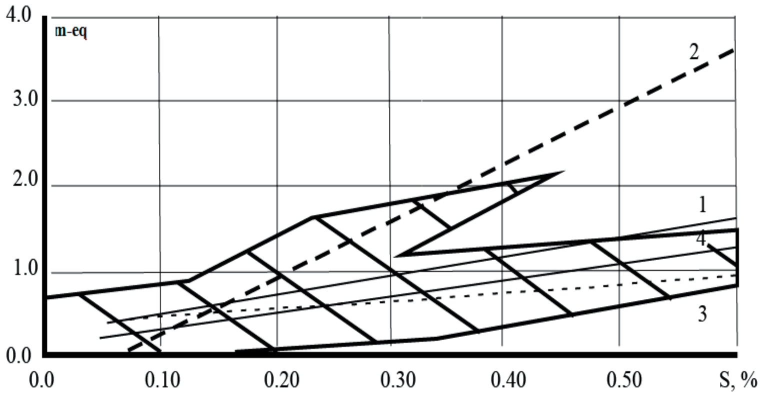

Figure 6. Determination of landscape typicality using the dependence of the ion content Ca^{2+} on the sum of salts (S, %) in soil: 1 - Kherson Prysyvashshia (irrigation); 2 - Kherson Prysyvashshia (irrigation + drainage); 3 - Askania-Nova (irrigation); 4 - Askania-Nova (virgin lands)

Therefore, the typical boundaries of soil salinization for the research plots with drainage in Kherson Prysyvashshia and in the virgin steppe of the biosphere reserve “Askania-Nova” entirely coincide by the distribution of hydro-carbonate-ions and chlorides. There are slight differences by the distribution of sodium + potassium and magnesium - 8 and 15%. There are essential differences by the distribution of sulfates and calcium - 29 and 47%. Thus, the research agro-landscapes are entirely typical by the distribution of hydro-carbonate-ions and chlorides (100%), they are essentially typical by the distribution of sodium + potassium and magnesium (92 and 85%) and their typicality is medium by the distribution of sulfates and calcium (71 and 53%).

Therefore, the research landscapes of Kherson Prysyvashshia and Askania steppes are typical in the properties of soil chemical composition by the distribution of the major ions by 83.5%.

CONCLUSIONS

Irrigation often affects the formation of a salt profile not only in the zone of aeration, but occupies deeper layers.

Under the influence of irrigation, soil gradually loses the properties of its initial state. It mainly refers to the distribution by the profile of humus, carbonates and gypsum. Between the cultivated soils of different regions there is much more similarity, than between the natural soils of these regions. Therefore many soil scientists suggest distinguishing irrigated soils as a special type.

Our method allowed establishing that the landscapes of Kherson Prysyvashshia and Askania steppes are typical by the properties of the formation of soil chemical composition by 83.5% that makes it possible to compare the research results obtained on both landscapes and proves the typicality of the field experiment.

REFERENCES

Asgari, N., Ayoubi, Sh., Dematte Jose, A.M. (2018). Soil drainage assessment by magnetic susceptibility measures in western Iran. *Geoderma Regional*, 13, 35-42. doi.org/10.1016/j.geodrs.2018.03.003.

Dukhovny, V.A., Stulina, G.V. (2010). Water and food security in Central Asia. *Proceeding of the NATO Advanced Reseach Workshop on Socio-Economic Stability and Water Productivity: Water and food security in Central Asia. Series C: Environmental Security*, 1-23. doi: 10.1007/978-90-481-9974-7_1.

Feizi, M., Hajabbasi, M.A., Mostafazadehfard, B. (2010). Saline irrigation water management strategies for better yield of safflower (*Carthamus tinctorius* L.) in an arid region. *Australian Journal of Crop Science*, 4(6), 408-14. doi: 10.21475/ajcs.

Golosov, V., Belyaev, V. (2013). The history and assessment of effectiveness of soil erosion control measures deployed in Russia. *International Soil and Water Conservation Research*, 1(2), 26-35. doi.org/10.1016/S2095-6339(15)30037-X.

Jiménez-Aguirre, M.T., Isidoro, D., Usón, A. (2018). Soil variability in La Violada Irrigation District (Spain): I Delineating soil units for irrigation. *Geoderma*, 311, 78-90. doi.org/10.1016/j.geoderma.2017.04.025.

Jones, D.L., Rowe, E.C. (2017). Land Reclamation and Remediation, Principles and Practice. Reference Module in Life Sciences. *Encyclopedia of Applied Plant Sciences (Second Edition)*, 3, 304-10. doi.org/10.1016/B978-0-12-394807-6.00014-9.

Kumara, P., Sarangi, A., Singh, D.K., Parihar, S.S., Sahoo, R.N. (2015). Simulation of salt dynamics in the root zone and yield of wheat crop under irrigated saline regimes using SWAP model. *Agricultural Water Management*, 148 (31), 72-83. doi.org/10.1016/j.agwat.2014.09.014.

Ladychuk, D.O., Shaporinska, N.M., Voloshin, M.M., Ladychuk, V.D. (2018). Method of determining the typology of anthropogenically altered landscapes for land reclamation projects in the steppe zone of Ukraine. *Science and education a new dimension. Natural and Technical Sciences,* 158(18), 69-71.

Lavrenko, N., Lavrenko, S., Revto, O., Lykhovyd, P. (2018). Effect of Tillage and Humidification Conditions on Desalination Properties of Chickpea (*Cicer arietinum* L.). *Journal of Ecological Engineering*, 19(5), 70-5. doi: 10.12911/22998993/91265.

Lendering, K.T., Jonkman, S.N., P.H.A.J.M. van Geldera Peters, D.J. (2015). Risk-based optimization of land reclamation. *Reliability Engineering & System Safety*, 144, 193-203. doi.org/10.1016/j.ress.2015.07.025.

Lisetskii, F., Stolba, V.F., Marinina, O. (2015). Indicators of agricultural soil genesis under varying conditions of land use, Steppe Crimea. *Geoderma*, 239-240, 304-16. doi.org/10.1016/j.geoderma.2014.11.006.

Liu, X., Feike, T., Chen, S., Shao, L., Sun, H., Zhang, X. (2016). Effects of saline irrigation on soil salt accumulation and grain yield in the winter wheat-summer maize double cropping system in the low plain of North China. *Journal of Integrative Agriculture*, 15(12), 2886-98. doi.org/10.1016/S2095-3119(15)61328-4.

Sabagh, A.E.L., Hossain, A., Barutçular, C., Islam, M.S., Ratnasekera, D., Kumar, N., Meena, R.S., Gharib, H.S., Saneoka, H., Teixeira da Silva, J.A. (2019). Drought and salinity stress management for higher and sustainable canola (*Brassica napus* L.) production: a critical review. *Australian Journal of Crop Science*, 13(01), 88-97. doi: 10.21475/ajcs.19.13.01. pp. 1284.

Stupak, N. (2016). Impact of Agricultural Transition on Soil Protection in Ukraine: The Role of Institutional Change. *Land Use Polic*, 55, 86-97. doi.org/10.1016/j.landusepol.2016.03.022.

Ushkarenko, V.O., Dementieva, O.I., Pryimak, V.V., Lavrenko, S.O., Lavrenko, N.M., Shepel, A.V., Siletska, O.V. (2018). Rice (*Oryza sativa* L.) Yields Depending on Cultivars and Quality of Irrigation Water. *Research Journal of Pharmaceutical, Biological and Chemical Sciences (RJPBCS)*, 9(5), 1772-1777. doi: 10.33887/rjpbcs.

Wang, Q., Huo, Z., Zhang, L., Wang, J., Zhao, Y. (2016). Impact of saline water irrigation on water use efficiency and soil salt accumulation for spring maize in arid regions of China. *Agricultural Water Management*, 163(1), 125-38. doi.org/10.1016/j.agwat.2015.09.012.

Wang, W., Liu H., Li, Y., Su, J. (2014). Development and management of land reclamation in China. *Ocean & Coastal Management*, 102(B), 415-25. doi.org/10.1016/j.ocecoaman.2014.03.009.

Zhang, T., Dong, Q., Zhan, X., He, J., Feng, H. (2019). Moving salts in an impermeable saline-sodic soil with drip irrigation to permit wolfberry production. *Agricultural Water Management*, 213(1), 636-45. doi.org/10.1016/j.agwat.2018.11.011.