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SUSTAINABLE DEVELOPMENT OF IRRIGATION IN UKRAINE: SCIENTIFIC APPROACHES TO THE IRRIGATIONAL SOIL DEGRADATION ASSESSMENT AND THE MANAGEMENT OF IRRIGATED LANDS FERTILITY

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Statement of the problem. The present-day agrarian policy of Ukraine is aimed towards ensuring the guaranteed food security of the country, development of a competitive production sector of agricultural industry, and build-up and growth of exportable availabilities. As a whole, Ukrainian land and soil resources' potential, beside its ability to guarantee the national food security itself, can also turn Ukraine into one of the most important players on the global food market. However, more than half of the territory of Ukraine is located in the zones of insufficient and unstable moistening, furthermore, the protracted periods of droughts were increased in frequency. Food and resource support of the country, as many countries of the world, substantially depends on the availability, condition and efficiency of irrigated land usage [1-3]. The soil cover of the irrigated lands is extremely complex. Practically all types of the soils of the Ukraine are represented in its structure, but chernozem and dark-chestnut soils predominate [4].

By now, up to 16 kinds of soil-degradation processes, such as dehumification, nutrients-contents-reduction, overcompaction, structure- loss, erosion, pollution etc. appear in a wide scope - areas of degraded and poorly-productive lands covers from 5-6 to 10-12 mio ha [5-7].

Irrigation leads to the transformation of soils, correction of natural soil processes. From the large number of soils evolution directions during the irrigation we separate: cultivation, without the changes and the degradation of soils. The direction of the evolution of soils depends on the joint influence of the natural and anthropogenic factors on their natural properties and regimes and of the direction of changes in the functions of soils and their fertility. Irrigation creates conditions for a considerable increase in the productivity of land-utilization. Nevertheless, amelioration frequently becomes the cause for appearance and development of a number of degradation phenomena. Therefore the important task of irrigation is not only increasing of the productivity of the agricultural lands, but also conservation of inherent in ecological and social functions soil cover [8].

Therefore the important task is comprehensively characterized scientific approaches to the irrigation soil degradation assessment and the management of irrigated lands fertility, which are created with the author.

Material and Methods. The research were conducted in Forest-steppe and Steppe zones of Ukraine, where is disposed 98% irrigated lands. The Objects of our research were:

- irrigation water. For irrigation in Ukraine are used basically water of main river arteries and created on their base water storage's and ponds. In zones Forest-steppe and Steppe - waters of Dnieper's and cascade of Dnieper water storage, Dniester and others;
- irrigated soils. The area of irrigation in Ukraine forms 2,2 millions hectares. The structure of topsoil irrigated lands is presented basically by chernozems (typical, ordinary, southern and meadow-chernozemic) and dark-chestnut solonetz soils;
- agricultural plants, grown in conditions of irrigation (grains, vegetables, fodder's and technical cultures).

With the carrying out of this investigation there were used data of ecological-amelioration monitoring and own results of long-term field, micro-field, greenhouse and model experiments, and previously obtained data, presented in a number of papers [1, 4, 8]. Methodological basis of scientific investigation is made up of the modern methods of research: historical; systematic; statistical analysis.

Results and Discussion. Under "degradation of soils" we understand the natural and anthropogenic processes of worsening in the natural properties and

regimes of the soils, which produce steady negative changes in their functions, decrease stability and fertility.

The estimation of the soil degradation is achieved with the method of comparison of the parameters of the soils, which are fixed in the initial period of observations, or standard soils with the same parameters after the corresponding periods of the soil using. The criteria of evaluation of the development of degradation processes are worked out on the basis of these observations, the levels of their ecological danger and unprofitability are determined, the preventive and straight anti-degradation methods of using the ameliorated soils are proposed [8].

Under "Irrigational degradation", we mean the degradation of soils, which can be developed under the effect of irrigating ameliorations and causes an increase in the expenditures for the restoration of the project production level. We determine the degrees of irrigational degradation on the level of deviation from the optimum of the basic parameters of the soils, which are determining for the fertility formation:

- the soils without degradation: the soils, the properties and regimes of which are not worsened, which fulfill functions inherent in it, but productivity corresponds its natural fertility (deviation from the optimum to 5 %);
- the soils with low degree of degradation: deterioration of properties and regimes, negative changes in the functions, reduction in the productivity do not exceed 20 %;
- the soils with average degree of degradation: the average degree of the manifestation of negative changes in the soil properties and regimes, functions, reduction in the productivity in the range 20- 50 %;
- the soils with strong degree of degradation: the strong degree of the manifestation of unfavorable soil changes in the soil properties and regimes, functions, reduction in the productivity are more than 50 %.

The most common forms of the irrigational degradation of the soils are soil overcompaction, crustification; erosion; swamping and underflooding; pollution of soils with heavy metals, pesticides, radioactive nuclides; secondary salinization, solonetzization and alcalination [9]. They are developed after using for the irrigation waters of the not proper quality (suitable for determined limit and not suitable for the irrigation) and/or because of the low level of agriculture and insufficient resource investments - humus and nutritious elements losses. Let us pause at such forms of irrigational degradation as salinization, solonetzization and alkalinization.

Secondary salinization is accumulation in the soil of water-soluble salts, a change of the salt composition to increasing in sodium concentration and contraction is relation Ca:Na. The degree of salinization of soils is determined by the content of gross and/or toxic salts taking into account chemism of salinization (it's type). There are approximately 100 thousand ha of a secondary salinized soils (content of salts in the layer 0-100 cm) among the irrigated lands.

Secondary solonetzization is accumulation of sodium and potassium in the soil absorbing complex, which gives to soils unfavorable physical properties. Secondary solonetzization is the most common degradation process on the irrigated lands. The area of the irrigated solonetzic soils is approximately 700-800 thousand ha.

Alkalinization is increasing of the alkalinity of soil solution and the formation of soda, which occurs under the effect of secondary solonetzization, ground and irrigating waters, reducing of sulfates or other reasons. The regions in the Ukraine, where there is a danger of the formation of soda, are geographically separated. The greatest danger exists in the regions of the cultivation of rice in Kherson region and in the Crimea over the area more than 60 thousand ha.

The integral estimation of the irrigated soils according to the degree of irrigational degradation is developed (table 1). With the carrying out of this estimation were used data of ecological-amelioration monitoring and own results of long-term field, microfield, greenhouse and model experiments, and previously obtained data, presented in a number of papers [1-4, 7-8]. In recent years in Ukraine the areas of the irrigated lands are reduced more than twice (predominantly spontaneously, without control). The state of the basic lands withdrawn from the irrigation is satisfactory by the aquaphysical properties.

They are not irrigated only because of a deficiency in the material and technical or energy resources. Therefore, it can be used as nonirrigated, using the cultivation of all crops recommended for this zone corresponding to technology. It is also necessary to develop the mechanisms of the renewal of agriculture on irrigated soils, which are in a good and satisfactory ecologically-agroameliorative state, and water management complex as a whole. The general tendency of the evolution of the properties of soils after termination of its irrigation is the restoration of the parameters, characteristics for their nonirrigable analogs. Firstly, this concerns salt characteristics as desalinization and desolonetzization of soils. The irrigated lands, which do not pour on as a result of significant worsening in their ecologically-agroameliorative state should be used only simultaneously with the measures for an improvement in the soils. It is indispensably reckon in such degradation processes in them as salting, solonetzization and alkalinization and the level of ground water, the degree of its mineralization. In each specific case, it is necessary to consider the reasons, which led to worsening of the soil properties, and on what basis to use the measures for soils improvement.

Control of the fertility of the irrigated lands, directed to the formation of the models of steady, ecologically safe and economically effective agriculture, is impossible without:

1. Legislative and normative guarantee of soils protection. Further development and adoption are required to: Law of Ukraine on conservation of soils and protection of their fertility; Law on National (State) Program of Soils Protection and National Program of Use and Protection of Lands; Law (Decree) by the Cabinet of Ministers of Ukraine on establishment of State Service for Land and Soils Protection. Approval of these documents will contribute to implementing the State policies aimed at well-balanced soil-use and soil- protection in Ukraine, security of soil against depletion, degradation and pollution, while facilitating the food-, environmental, power-generating and social security policies of our country.

2. Creation of united soil-land service. The strategic and current national and regional tasks resolution concerning the soils protection and rational use is

laid just on this service. Just this service must be responded for the soils protection, the use of soil resources, and the preservation of their fertility.

Table 1 – The integral estimation of the irrigated soils according to the degree of the degradation

Indices	Soil without degradation	Degree of degradation		
		Low	Average	Strong
Salinization, 0-50 cm				
Toxic salts content, eCl^-, meqv/100 g of soil	less than 0,3	0,3-1,5	1,5-3,5	more than 3,5
Ca:Na in water extract	more than 2,5	2,5-1,0	1,0-0,5	less than 0,5
Solonetzization, 0-30 cm				
Na^++K^+, % from sum of cations, clay soils	less than 3	3-6	6-10	more than 10
Na^++K^+, % from sum of cations, sandy soils	less than 5	5-8	8-12	more than 12
aNa/√aCa	less than 1	1-3	3-7	more than 7
Factor of dispersivity by Kachinsky, %	less than 10	10-20	20-30	more than 30
Alkalinization, 0-30 cm				
pH_w.	less than 7,8	7,8-8,5	8,5-9,0	more than 9,0
HCO_3^--Ca^{2+}, meqv/100 g of soil	less than 0,5	0,5-1,0	1,0-2,0	more than 2,0
CO_3^{2-}, meqv/100 g of soil	less than 0,1	0,1-0,3	0,3-0,9	more than 0,9
pH-pNa	less than 4,0	4,0-5,0	5,0-5,5	more than 5,5
Humus state, 0-50 cm				
Decreasing of humus content, % from initial	0	0-10	10-20	more than 20
Agrophysical state, 0-30 cm				
Content of air-dry aggregates 0,25-10 mm	more than 70	60-70	40-60	less than 40
Content of water-proof aggregates > 0,25 mm	more than 45	35-45	25-35	less than 25
Equilibrium density of composition, g/sm^3, clay soils	less than 1,3	1,3-1,4	1,4-1,6	more than 1,6
Equilibrium density of composition, g/sm^3, sandy soils	less than 1,3	1,3-1,5	1,5-1,7	more than 1,7
Pollution, 0-100 cm				
Heavy metals content, in zinc equivalents, mg/kg of soil	less than 25	25-50	50-100	more than 100
Water-soluble fluorine, mg/kg of soil	less than 6	6-10	10-20	more than 20

3. New large-scale land survey and monitoring the soils, which will give adequate information about the soils of the country [5]. A Draft Project of "Large-Scale Observation of Soil Cover" State program has been prepared by the team of authors from National Scientific Center «Institute for Soil Science and Agrochemistry Research named after O.N. Sokolovsky», along with elaboration of the "Large-Scale Soil Observation Methodology" [7]. Authors believe that the observation actions must be implemented all over the territory of Ukraine, because relevant information on soil condition of 1/3d portion of Ukraine is absent. The Soil Observation program should thereby be combined with Agrochemical Passportisation and ekology-ameliorative monitoring; in other words, we speak about application of innovative soil-agrochemical methodology. Over there, each individual type of surveys shall complement the others, and taken altogether, they shall create a consistent Information System capable to solve the problems of assessment condition, forecasting, management, usage and protection of soil resources.

4. Increasing of the irrigation effectiveness due to the complex application of all kinds of amelioration and modern agro-technologies. Currently, only 600.000 to 700.000 ha (from the total 2.170.000 ha of irrigated land) are irrigated, whereas the rest of lands is removed from irrigation temporarily or permanently; hence, the major task in present-day conditions is to reconstruction the irrigation and to cut unproductive losses of water from these lands. These initiatives would require:

- assessment of soils applicability, selection of zones, and shifting zones of agricultural crops cultivation towards west-Ukrainian and west-Dnieper-bank provinces;

- agrotechnical methods of moisture accumulation and retention, methods of cultivation, crop rotation, modern agricultural technologies, including conservative, precise, no-tillage and other types of soil tillage;

- phased recovery of irrigation on area of 1.5 - 2.0 million ha, in the longer term to gain 4.0 million irrigated hectares.

5. Essential certification of the agricultural lands, firstly, irrigated. It is only on basis of current information of soil cover condition that we can speak about formation of sustainable land management during optimization of land resources'.

For the achievement of stated goal, the normative-methodical base (more than 300 normative documents) of soil investigations realization, agrochemical certification of the agricultural lands, ecological-ameliorative monitoring of the lands and monitoring of the soils is already created [10]. To further develop and improve the normative-methodical support system in fields of soil science, agro-chemistry and soils protection, coordinated efforts of scientific institutions, ministries and agencies.

Food and resource support of the country, as many countries of the world, substantially depends on the availability, condition and efficiency of irrigated land usage. A necessary condition for highly effective, environmentally safe of irrigated land usage is the working out and implementing the complex of measures to manage the fertility of irrigated land,

improve their agro-ecological condition and level of use [11]. This complex must constantly adapt to the variability of natural and anthropogenic factors in order to obtain the highest possible profit subject to the requirements of resource conservation, soil protection and maintain of natural processes balance both within agromeliorative landscapes and in the biosphere as a whole. The main elements of this complex of measures:

- reconstruction and modernization of irrigation systems, taking into account their environmental and reclamation condition.
- conversion of irrigated agriculture on the adaptive-landscape environmentally safe (compensatory) agriculture systems;
- rational structure of sowing areas and crop rotation oriented on market economy with the obligatory inclusion in crop rotation the perennial legume grasses;
- restoration of works with chemical reclamation of irrigated land and irrigation water, on the fundamentally new provisions;
- usage of internally soil reserves of calcium salts (soil self-reclamation) through the reclamation plantage plowing on the area about 500 thousands of hectares;
- a complex of engineering, agromeliorative and preventive measures nominated the composition of which for each region should take into account the occurrence causes and the development features of flooding processes;
- soil replenishment with organic matter by plant residues, organic fertilizers, crop rotation with perennial legume grasses;
- effective application of fertilizers.

Conclusions. On the basis of observations, generalization and systematization the criteria of evaluation of the development of degradation processes are worked out. The levels of their ecological danger are determined. The most common forms of the irrigational degradation of the soil are characterized, they are developed after using for the irrigation waters of the not proper quality and/or because of the low level of agriculture and insufficient resource investments. Integral estimation of the irrigated soils according to the degree of irrigational degradation is developed. The preventive and straight anti-degradation methods of using the ameliorated soils are proposed, which provide a profit and the preservation of resources, protection of soils, the balance of natural processes. Thus obtained results will serve as a State-owned tool which would subsequently facilitate the use and protection of soil resources all over the country for securing the sustainable development of agriculture in Ukraine.

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НАУКОВО-МЕТОДОЛОГІЧНЕ ОБҐРУНТУВАННЯ МОДЕЛЕЙ ПРОДУКТИВНОСТІ ЗРОШЕННЯ ДЛЯ УМОВ ПІВДНЯ УКРАЇНИ

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Постановка проблеми. Вирішення продовольчої проблеми є однією з глобальних задач сільськогосподарської науки та виробництва. Продовольство виступає основним регулятором чисельності населення на Земній кулі, яке збільшилося за останні 40 років удвічі та продовжить стрімко зростати у найближчі десятиліття. Для успішного вирішення вказаної проблеми при таких темпах зростання чисельності населення та з метою протидії глобальним змінам клімату в напрямку потепління та порушення циклічності надходження атмосферних опадів необхідно, щоб площі зрошуваних земель збільшувалася щорічно на 0,5-0,7% [1-3].

За минулі 15-20 років площа зрошуваних зе-