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AGRO-ECOLOGICAL POTENTIAL OF SOIL COVER OF VINNYTSIA REGION

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Scientific monograph





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The monographic study examines the main components of the agroecological potential of the soils of the Vinnytsia region.The scientific work is aimed at forming the concept of modernization of soil conservation and environmental safety, namely, rational nature management at the expense of limited resource provision due to climate change. The research methodology is based on experimental studies of scientific topics on the topic: "Development of bio-organic technologies for growing agricultural crops for the production of biofuels and ensuring the energy independence of the agricultural sector". The expected results of the research are aimed at achieving complex ecological, economic, energy and social effects. The authors have considerable experience in research related to rational nature management, the development of land reclamation measures taking into account the concepts of rational nature management, which ensure the optimization of land use, as well as the biologicalization of agriculture. The scientific research of the authors has been commercialized, in particular, contracts have been concluded for the performance of research within the framework of farm contract and state topics.

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CURRENT STATE OF THE DEVELOPMENT OF DEGRADATION PROCESSES IN THE SOIL COVER OF VINNYTSIA REGION

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Abstract. Soil resources are the basis of the development of the agrarian sector of the country's economy and ensuring a favorable environment for humans, therefore the protection and rational use of soils is an important component of national security. In terms of the quality of soil resources, Ukraine occupies one of the leading places in the world, and the concept of "Ukrainian chernozem" is our image feature. *The purpose.* Study of the degradation processes of the soil cover of the Vinnytsia region. *Methodology*. In the course of researching the topic of our work, we used the materials of the annual statistical reports of the main statistics department in the Vinnytsia region, as well as materials provided by the Vinnytsia branch of the Institute of Soil Protection of Ukraine, the State Environmental Inspection in the Vinnytsia region. *Result*. Unfortunately, due to the inefficient management of soil resources in Ukraine over the last quarter of a century, most of the soil is in a pre-crisis state, and in some places in a crisis state with a tendency to deteriorate. A third of Ukraine's arable land is eroded, about 40% is over-compacted and 20% has unregulated acidity, almost 70% of arable land has a deficit of available moisture for plants, and the balance of nutrients remains deficient. In recent years, in connection with global climate changes, the consequences of crisis phenomena in the state of soils have become even more tangible and threatening, and the introduction of the land market necessitates their urgent overcoming. *Practical implications.* The unsatisfactory state of affairs in this area requires comprehensive consideration and the implementation of appropriate regulatory measures.

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On the other hand, the scientifically based use of Ukraine's unique soil resources will contribute to Ukraine's successful promotion to the world food market, as well as the diversification of economic development. *Value/originality.* This indicates the relevance and necessity of solving the problem of sustainable management of the country's soil resources. Out of 60.3 million hectares of its territory, 42 million hectares are agricultural lands, 33.2 million hectares are under arable land. Over the last 30 years, the area of eroded arable land increased by 1.9 million hectares, that is, 64 thousand hectares were lost every year, and now the area of eroded land is 11.3 million hectares, or almost a fifth of the entire territory of Ukraine. Application of monocultures in large regions, violation of crop rotation, almost complete rejection of organic fertilizers, reduction of the share of leguminous crops lead to dehumification of soils, reduction of yields.

1. Introduction

The main problem of soil resources in Ukraine, as well as in other countries with an underdeveloped system of soil protection, which poses a threat to national security, is soil degradation. The most characteristic degradation processes in soils are the following: losses of humus with an intensity of 0.42–0.51 t/ha per year and nutrients, especially phosphorus and potassium; erosion losses of the upper fertile layer; over-compaction, destruction of the structure, lumpiness and crust formation; acidification of soils, especially in Polissia and the Carpathian region; secondary salinization and salinization of irrigated soils; activation of peatlands; pollution by radionuclides (11.1% of arable land), pesticides (9.3%) and heavy metals (8%) [12].

In recent years, many new ideas and approaches aimed at protecting soil resources have been born in the world. The Global Soil Partnership (GSP), whose mission is to improve the global management of the planet's limited soil resources to ensure healthy and productive soil for world food security, as well as to support other key ecosystem activities on which our society depends, including regulating water regimes and provision of clean water, climate regulation, preservation of biodiversity and cultural heritage [26; 56].

The main priorities for the European region are: "sealing" or sealing of soil, salinization and pollution. Soil "sealing" and land extraction. In the densely populated countries of Western Europe, soil sealing is one of the most dangerous phenomena. The European Commission has already carried

out significant work to raise awareness of this problem and proposals to eliminate the negative trend.

Salinity and acidity. Salinity is a widespread threat in Central Asia, and it is a challenge in parts of Spain, Hungary, Turkey and Russia. With considering the importance of the problem in Eurasia, this the topic will be considered in the framework of this plan for the implementation of the EGP and the sub-regional soil partnership for Eurasia [60; 65].

Soil pollution. Soil pollution is a widespread problem in Europe and manifests itself most strongly locally. The most common pollutants there are heavy metals and mineral oils. Situation is already improving in most regions and has been specifically reviewed by the European Environment Agency (EEA) EIONETNRC network.

Proposals for discussion for future participants of the UEP:

a) the most common pollutants are agrochemicals that degrade soil biodiversity and are closely related to ecosystem activities;

b) diffuse pollutants.

These additional threats to the maintenance of a wide range of soil functions, which are necessary to meet many of the Sustainable Development Goals, are also worthy of consideration by the EGP. At the EU level, as stated in the 2012 report of the Commission on the Implementation of the Soil Thematic Strategy and Current Activities, soil degradation is increasing in the EU.

Let's consider the indicated problems in a little more detail. The EHP report is of some interest in terms of information, because it contains the latest materials on the state of European soils.

In addition, the authors of the report suggest focusing the efforts of the future members of the UEP on identifying and overcoming various problems of soil degradation in their countries.

Soil sealing (permanent covering of the soil with impermeable material) and related land acquisition lead to loss of important soil functions (for example, water filtration and storage, and food production). Between 1990 and 2000, at least 275 hectares of soil were lost per day in the EU, amounting to 1,000 square kilometers per year. Between 2000 and 2006, average soil loss in the EU increased by 3%, including 14% in Ireland and Cyprus, and 15% in Spain. Between 1990 and 2006, 19 EU member states lost potential agricultural production equivalent to a total of 6.1 million tonnes of wheat, with large regional variations.

A recent new water-induced soil erosion model built by the JRC (EU Joint Research Center in Ispra, Italy) estimated the affected surface area in the EU27 at 1.3 million km². Almost 20% of them have soil losses exceeding 10 t/ha/year. Erosion is not only a serious problem for soil functions (estimated to cost €53m per year in the UK alone); it also affects fresh water quality because it leaches nutrients and pesticides into water bodies. For example, agricultural losses of phosphorus exceed 0.1 kg/ha/year in most of Europe, and reach a level of more than 1.0 kg/ha/year in problem areas (hot spots). The fight against the prevention and prevention of erosion will be a key contribution to the achievement of the EU goals. Soil erosion is particularly intense in wildfire areas, which are estimated at 500,000 ha/year according to the European Forest Fire Information System (EFFIS) and leads to the loss of soil carbon.

The risk of erosion is highest in Spain (up to 44% of the territory), Slovakia (up to 40%), Portugal (up to 33%), Bulgaria, Andalusia, Corsica, central Italy and Greece. The smallest is in northern Europe. It is difficult to give a quantitative assessment of local soil pollution in full, because most of the EU member states do not have comprehensive studies and comparable information. In 2006, the European Environment Agency estimated that there was a total of 3 million hectares of contamination (European Information and Observation Network EIONET and National Soil Reference Centers NRC), potentially 250,000 contaminated sites in the EU. Remediation is underway, although there are large variations between EU member states reflecting the presence or absence of national legislation. It was estimated that in 2004, costs for soil restoration in the EU27 amounted to €5.2 billion, of which 21.6% in Germany, 20.5% in the Netherlands, and 5.9% in France and Great Britain [25; 44].

Soil biodiversity provides solutions to numerous issues, including the transformation of nutrients into forms that can be used by plants and other organisms, water purification by removing pollutants and pathogenic microorganisms from it, maintaining the composition of the atmosphere in a favorable state, participation in the carbon cycle, and also as a major source of genetic and chemical resources (for example, antibiotics). The indicator-based map prepared by the JRC shows a preliminary assessment of the regions where it is located soil biodiversity is under threat. It includes areas with high population density and/or intensive agricultural activity (for

example, cultivation of grain and industrial crops, livestock, greenhouses, orchards, vineyards and horticulture).

2. Analysis of recent research and publications

A significant part of the country's land fund is subject to degradation, and in the case of its uncontrolled development, it can replenish the share of land in need of conservation. Loss of humus. For 140 years, since the first measurements of the humus content in the soils of Ukraine, carried out by V.V. Dokuchaev, humus losses in the soils of the forest-steppe reached an average of 22%, in the soils of the steppe – 19.5%, and in the soils of Polissia – about 19%. The greatest losses of humus occurred in the 1970s, when the share of row crops – sugar beets and sunflowers – increased dramatically in the structure of crops. It was possible to partially stop humus losses thanks to the annual application in the country of an average of 8.4 t/ha of manure and about 170 kg of d.r.y. of mineral fertilizers per 1 ha of arable land. In subsequent years, the decrease in fertilizer application led to a gradual decrease in humus content from 3.36% in 1986–1990 to 3.14% in 2006–2010.

In 2011–2015, agricultural enterprises applied from 2.5 to 4, 8 t/ha of straw and 11.6–16.6 t/ha of siderates annually, which contributed to stopping the decrease in humus content. Loss of nutrients. Until 1990, in Ukraine, on average, about 150 kg of d.r./ha was applied with a N:P:K ratio of 1:0.7:0.7 on an area of about 90% of arable land. Until 1996–1998, the restructuring of social and economic relations was accompanied by a sharp decrease in the level of agricultural chemicalization to 20–30 kg d.y./ha, but since the beginning of the century and until now, there has been a gradual increase in the use of mineral fertilizers to the level of 80–110 kg d.y. ./ha on an area of 80% arable land with a N:P:K ratio of 1:0.2:0.2. According to the State Committee of Statistics of Ukraine, in 2017, agricultural enterprises contributed 48.9 kg of NPK per 1 ha of agricultural land. The balance of NPK in the agriculture of Ukraine in 2017 was negative for all nutrients and totaled 36.0 kg/ha.

Soil erosion. Compared to European countries, whose arable land makes up 30–32% of the total area, plowed land in Ukraine reaches 53.8%. Such an imbalance in the structure of agricultural land was formed half a century ago during the campaign in the former USSR to increase the area

of arable land at the expense of erosion-dangerous, eroded, low-fertility slopes, as well as valuable and irreplaceable in the aspect of environmental protection. As a result of the extremely high level of plowing of agricultural land, there was a very high risk of water and wind erosion. The total area of eroded land has now increased to 13.4 million hectares, and arable land to 10.6 million hectares (32% of all arable land). Up to 500 million tons of topsoil is washed away from arable land every year, with which 24 million tons of humus are lost, and losses of agricultural products from soil erosion, according to expert estimates, exceed 9–12 million tons of grain units per year. The eroded lands include 4.5 million hectares with moderately and severely eroded soils, including 68,000 hectares that have completely lost the humus horizon. More than 50% of Ukraine's arable land is deflationally dangerous, 12.4 million hectares of which are located in the steppe zone. Physical degradation of soils. Phenomena of physical soil degradation are observed on more than half of the arable lands. Physically degraded soils are vulnerable to erosion, absorb and retain atmospheric moisture worse, limit the development of plant root systems. Soil compaction is the most dangerous consequence of intensive mechanical cultivation in all natural zones of Ukraine, which is accompanied by adverse ecological consequences and significant economic losses. The high vulnerability of soils to overcompaction is noted in chernozem soils with low equilibrium density and moisture, which is equal to or higher than the moisture of physical maturity. Almost 22 million hectares of arable land are at real risk of over-compaction. Secondary salinization and salinization of soils. According to the State Geocadastre, there are 2.8 million hectares of saline soils in Ukraine, 2 million hectares of which are used as arable land, and about 0.7 million hectares are irrigated.

Over the past twenty years, measures for reclamation of saline soils in Ukraine have been carried out unsatisfactorily. The volumes of gypsum and other gypsum-containing rocks decreased from 1341 thousand tons in 1990 to 16 thousand tons in 2015, and the area – from 305 thousand hectares to 7.1 thousand hectares, respectively. Under such a system of agriculture, there is a widespread deterioration of the quality of the solontic soils, the loss of their fertility and the productivity of agrocenoses on these lands. Other degradation processes and damages from degradation. The qualitative state of land resources is significantly affected by hydrometeorological

and dangerous exogenous geological processes and phenomena (slides, landslides, landslides, karst, soil subsidence, abrasion, destruction of reservoir banks, etc.), which are spread over more than 50% of the territory. Flooding processes are developing on 17% of the territory. According to various estimates, the area of degraded and infertile soils in arable land is from 6.5 to 10 million hectares, or more than 20% of the area. Direct annual losses only from crop failure due to the main types of soil degradation reach a total of about UAH 33.6 billion in Ukraine. As a result of the spread of degradation, the soil potential for grain production in Ukraine, which is 80–100 million tons, is realized by only 70%.

3. Literature review

Analysis of the latest research and publications shows that the problem of sustainable soil management is currently being actively studied by foreign scientists. So, for example, the Voluntary Guidelines for Sustainable Soil Management (VGSSM) and global actions to ensure soil health are in the field of view of scientists [1]; evaluation and regulation of the implementation of sustainable soil management practices [2]; managing the solution of soil protection problems [3], including through relevant legislation and policy [4]; long-term effectiveness of sustainable land management practices to control runoff, soil erosion, and nutrient loss in agroecosystems [5]; opportunities and barriers for sustainable management of soil resources [6]; tools of sustainable soil management: soil ecosystem services, energy and economic analysis [7]; assessment of soil quality for sustainable land use and management [8]; analysis of the possibilities of using consulting services to support sustainable soil management [9]. At the same time, domestic scientists are investigating the genetic and production aspects of the development of Ukrainian agronomic soil science [10]; the role of soils in the development of society [11]; formation of sustainable systems of land use and soil protection in modern conditions [12]; scientific principles of sustainable management of soil resources of Ukraine [13]; the influence of soil fertility and land quality on the formation of sustainable competitiveness of agricultural enterprises [14]; efficiency of agricultural land use [15]; spatial features of soil cover as the basis of sustainable soil management [16]. The ecological and economic foundations of a holistic concept of sustainable soil management in Ukrainian agriculture are outlined

in the monograph of one of the co-authors [17]. In previous studies, it was established that the existing soil resource management system in Ukraine is not sufficiently balanced and does not ensure the preservation of soil fertility, therefore the problem of preserving soil resources and overcoming soil degradation in Ukraine requires new approaches and a comprehensive solution in the legislative, organizational, institutional, informational, technological and financial aspects [12–23]. Therefore, it is necessary to solve the issue of scientific substantiation of the national strategy of sustainable management of soil resources in order to achieve a neutral level of degradation and guarantee national security.

4. Intensity of contamination of agricultural soils with toxicants

In Vinnytsia, the natural and climatic conditions are favorable for the development of agriculture and animal husbandry. The unique investment potential of the Vinnytsia region is the land fund. The region has the largest share of Ukrainian chernozems, a significant part of them, 21%, is chernozem type lands. This is a unique concentration of high-quality land resources. According to statistical data, more than 2 million hectares of agricultural land, which is 3.3% of the area of Ukraine, are reserved for land users.

It is known that soil quality is a combination of its physical, chemical and biological properties, which have undergone significant changes due to an ineffective system of economic land use, soil reproduction and progressive degradation of agricultural landscapes.

Ukrainian lands, in particular, the soils of the Vinnytsia region, are degrading as a result of negative processes that accompany the use of agricultural lands, namely: loss of humus and nutrients; drying (desertification) and overwetting (waterlogging), salinization and acidification, pollution by discharges, emissions, waste, chemical means of plant protection, erosion damage. Summarizing these changes, it can be noted that the condition of the soils causes a decrease in their functions in agro-ecosystems. Characteristics of soil quality are based on characteristics of soil processes, as well as indicators acquired as a result of economic activity or anthropogenic changes.

It is known that the increase in soil acidity contributes to a noticeable decrease in the yield of agricultural crops and reduces the quality of

produced products, which requires an additional increase in the use of mineral fertilizers and, as a result, an increase in soil pollution with heavy metals, nitrates and other harmful substances. The dynamics of soil acidity in the Vinnytsia region according to the data of the Vinnytsia branch of the Institute of Soil Protection of Ukraine is shown in Figure 1.

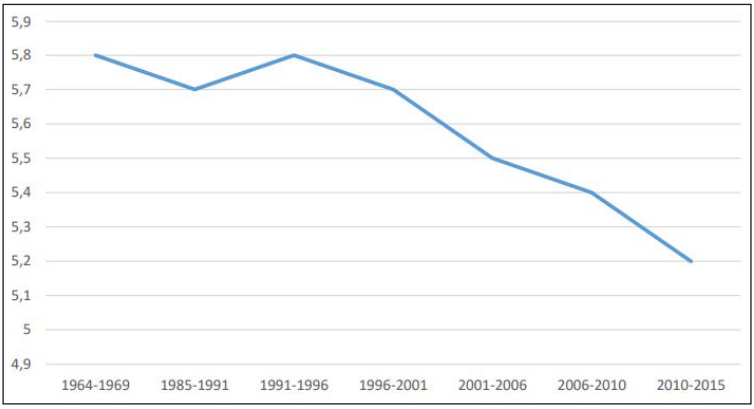

Figure 1. Dynamics of soil acidity in the Vinnytsia region (Institute of Soil Protection of Ukraine)

So, at present, the methods of improving the soil have been determined. The main ones are formed in the following directions:

– increasing the sustainability of agricultural landscapes;
– increasing the level of natural biogeochemical cycles;
– restoration of soil fertility;
– ensuring environmental cleanliness of all types of agricultural products.

5. Current state of the development of degradation processes in the soil cover of Vinnytsia region

It is reported [13] that soil degradation is the deterioration of useful properties and soil fertility due to the influence of natural or anthropogenic factors. Land degradation – natural or anthropogenic simplification of the landscape, deterioration of the condition, composition, useful properties and functions of the land and other natural components organically connected to the land. Soil pollution – accumulation of substances in soils

that negatively affect their fertility and other useful properties. The main cause of soil degradation is human activity (anthropogenic intervention). Humanity, with a population of more than 5 billion people and an annual increase of 80-85 million, having mastered various technologies to ensure the desired benefits and life comfort, is changing the nature of the planet on a global scale. Unaware of the dangers, individual nations and humanity as a whole involve the Earth in a grandiose experiment, the course and consequences of which people can neither predict nor control. Degradation, soil erosion, reduction of the humus cover of the planet, contamination with poisonous chemical and biological compounds and radionuclides are the obvious consequences of anthropogenic influence on the earth. Industrial society involuntarily accelerates processes of a planetary scale, which it is not ready to manage either morally, intellectually, or materially clearly defined.

Out of 60.3 million hectares of its territory, 42 million hectares are agricultural lands, 33.2 million hectares are under arable land. Over the last 30 years, the area of eroded arable land increased by 1.9 million hectares, that is, 64 thousand hectares were lost every year, and now the area of eroded land is 11.3 million hectares, or almost a fifth of the entire territory of Ukraine. Application of monocultures in large regions, violation of crop rotation, almost complete rejection of organic fertilizers, reduction of the share of leguminous crops lead to soil dehumification, reduction of yield.

Natural fodder lands and pastures, too so-called public, practically never received either organic or mineral fertilizers. Ukrainian farmers, who currently use 2.6% of agricultural land and produce 0.9% of crop and 0.4% of livestock products, use almost no fertilizers.

Norms for indicators of land degradation are established for each category of land in order to prevent deterioration of their condition and are used to control the use and protection of land. Standards for indicators of land degradation include indicators of the maximum permissible deterioration of the state and properties of land resources due to anthropogenic influence and negative natural phenomena, as well as standards for the intensity of agricultural land use. The use in agricultural production of agricultural machinery, the specific pressure of the running parts of which exceeds the standards, is prohibited. Indicators of the intensity of agricultural land use are established taking into account the

Table 1

Distribution and types of soil degradation in Ukraine

Types of soil degradation	Spread (% of the total area) according to the degree			
	weak	medium	strong	all
Loss of humus and nutrients	12	30	1	43
Condensation	10	28	1	39
Swimming and crust formation	12	25	1	38
Water erosion	3	13	1	17
Acidification	5	9	0	14
Waterlogging	6	6	2	14
Pollution with radionuclides	5	6	0,1	11,1
Wind erosion, loss of the top layer of the soil	1	9	1	11
Pollution by pesticides and other organic substances	2	7	0,3	9,3
Pollution by heavy metals	0,5	7	0,5	8
Salting, alkalizing, salting	1	3	0,1	4,1
Water erosion, formation of ravines	0	1	2	3
Side effect of water erosion (due to siltation of reservoirs, etc.)	1	1	1	3
Lowering of the upper level of the daytime surface	0,05	0,15	0,15	0,35
Deformation of the Earth's surface by wind	0,04	0,23	0,08	0,35
Aridization of soils	0,04	0,18	0	0,21

data of agrochemical land certification. When establishing indicators of the intensity of agricultural land use, agricultural crops whose cultivation is limited or prohibited are determined, as well as technologies and separate agrotechnical operations for their cultivation. Indicators of the intensity of agricultural land use are used in the process of drawing up design and technological documentation for the cultivation of agricultural crops. In Ukraine, there is a need to significantly reduce the percentage of plowed areas, turn arable land into cultivated pastures, return the land to its natural state, apply economical methods of farming and animal husbandry, and rationalize all expenses for the production of bread and food.

Vinnytsia, as an intensively active agro-industrial region, has not remained aloof from the outlined directions of soil cover degradation. As will be shown in the following subsections, the issue of dehumification and decalcification of soils, contamination by radionuclides, heavy mists and pesticide residues, general signs of agrophysical degradation (overcompaction, decrease in the content of agronomically valuable structures, the content of water-soluble of such units, etc.

6. Development of erosion processes

In Vinnytsia region, 79% of agricultural land and 75.5% of arable land are degraded to varying degrees (including 9.4% – highly degraded). The main cause of soil degradation is accelerated water and wind erosion, as a result of the location of arable land on slopes of more than 20, as well as the use of environmentally dangerous equipment and technologies, etc. According to SE "Vinnytsia Institute of Land Management", there are 641.9 thousand hectares of erosion-hazardous land in the region. Such scientists as O.V. Mudrak, O.V. Dedov, M.M. Hanchuk, H. Denisyk. On the basis of the generalization of their scientific research and the results of reports on the state of the region's environment, this subsection was written [1; 23; 29; 39; 68].

The soil cover of the region is one of the most eroded (41.2%) among the regions of Ukraine, including 35.6% of arable land. The general characteristics of the erosion of the territory and its analysis from the standpoint of geomorphology and anthropogenic landscape changes and covered in recent publications [16; 52].

Therefore, some of the indicators will be duplicated in the context of a more detailed assessment of soil erosion in the region. 851.1 thousand ha were damaged by water erosion, which is 37.2% of the total area of agricultural land, including arable land located on a slope of more than 2-70 – 575.7 thousand ha (31%) and 40 thousand hectares of fodder land, and more than 70 – 20.5 thousand hectares (see table 2). As part of the soil cover, light gray and gray podzolic soils are the most eroded (36-39.8% of eroded soils from the total survey area according to various estimates) [3; 19; 26; 38; 48],

Light gray and gray forest soils have the lowest anti-erosion ability among the soils of the region – their erodibility is 37.2% with an erosion

Table 2

Distribution of soils in Vinnytsia according to gradations of slope steepness and degree of erosion

Steepness of slopes, degrees	The area of the village land		Uneroded		Weakly eroded		Moderately eroded		Strongly eroded		% of all eroded lands within gradations
	thousand hectares	%	thousand hectares	%	thousand hectares	%	thousand hectares	%	thousand hectares	%	
0–2	1225,4	66,6	1188,1	97,0	37,3	3,0	-	-	-	-	3,0
2–5	444,8	24,2	274,5	16,7	333,8	75,1	33,8	7,6	2,7	0,6	83,3
5–10	154,9	8,4	3,9	2,5	43,9	28,3	79,9	51,6	27,2	17,6	97,5
10	14,2	0,8	-	-	-	-	4,7	33,0	9,5	67,0	100
Total, hectare	1839,3		1266,5		415,0		118,4		39,4		
%	100,0		68,9		22,6		6,4		2,1		

instability coefficient of 0.47 – 0.57 for unwashed soils, up to 0.66 – 0.74 in lightly washed soils and almost 1 .0 in the middle and strong declensions. The area of their distribution in the region is 632.7 thousand hectares.

Unlike deep, shallow, low-humus chernozem soils, they have a very high percentage of erosion – 49% (more than that of charred soils), but they have a small distribution area – 1.6%. This intensive development of erosion is explained by their location, namely, the steepness of the slopes and the southern exposure, where the temperature regime of snowmelt promotes erosion. These soils are common in the south of the region in the land uses of Chechelnytskyi, Kryzhopolskyi and Pishchanskyi districts.

Black soils and turf soils on dense and loose carbonate and non-carbonate rocks, which were formed in the conditions of steep and steep slopes in the large catchment areas of the Yampil, Mogilev-Podilsky, and Shargorod districts, have a very low anti-erosion ability. The erodibility of these soils is 97.3%. But the area of their distribution is insignificant (0.1%) and therefore they have little effect on the general erosion of the territory of the region.

In addition, the danger of erosion development is closely related to the following factors:

1) water permeability, which, along with the intensity of precipitation, determines the possibility and intensity of runoff formation;

2) anti-erosion resistance of soils – their ability to resist washing and erosion, water flows and

3) the general level of soil fertility, which largely determines the level of the ability of agricultural crops to protect the soil.

Water permeability is the most important property of the soil, which best characterizes the soil in physical terms and determines its water regime. The water balance of the soil, including the surface runoff, and, therefore, the erosion resistance of the soil largely depends on the water permeability.

Therefore, the water permeability of soils is understood as the phenomenon that occurs in the soil during the entry of water onto its surface, that is, it is the ability soil to pass water through itself. The phenomenon of water permeability consists of two phases:

1) soil saturation with water (absorption or infiltration) and

2) penetration of water through the soil layer that is maximally saturated with water (seepage or filtration). Therefore, in the process of conducting the experiment, we determine two values that characterize water permeability: the rate of absorption and the rate of filtration. The speed of absorption is determined by the amount of water that has passed per unit of time for the maximum saturation of the studied soil layer (up to the maximum field moisture capacity). The rate of filtration is the rate of passage of water through the soil layer that is maximally saturated with water. Naturally, there is no solid boundary between the first and second phases.

The first phase can be divided into two stages. The first stage is pure absorption, when water enters the soil, which does not reach the field moisture capacity, and moves in it under the action of the suction forces of the surface of soil particles and capillary menisci. The action of gravity is not significant. In the second stage, discharge prevails. At this stage, the absorbent capacity of the soil is reduced to a minimum, and the film, capillary and gravitational movement of water prevails.

The transition to the second stage occurs faster in those soils and soils with greater non-capillary porosity. Through non-capillary pores, water moves under the influence of gravity, the effect of molecular forces in non-capillary pores is negligible. Thus, water retention in the soil is determined by its capillary permeability, and filtration depends on non-capillary spaces

in the soil. And, finally, in the filtration phase, water moves through the studied soil horizon under the influence of gravity.

When characterizing the water permeability of the soil, in addition to the speed of absorption and the speed of filtration, the total amount of absorption for a certain period of time is also given – the water layer (in millimeters). Absorption and filtration rates are usually given in millimeters per minute. O.N. Kaczynskii proposed the gradation of soils by water permeability. If the soil passes more than 1000 mm of water in 1 hour at a pressure of 5 cm and a temperature of 10 C, the water permeability is considered poor, from 1000 to 500 mm – excessively high, from 500 to 100 – the best, from 100 to 70 mm – good, from 70 to 30 mm – satisfactory, less than 30 mm – unsatisfactory.

Thus, the speed and quality of soil water permeability determines the potential risk of soil erosion.

7. Practical value and conclusions

The results of the analysis of the dynamics and current condition of soils and their fertility are objective evidence of the growth of their degradation rates: reduction of humus and nutrients reserves, over-compaction, erosion, acidification, salinization, salinization, etc. – about 17 types in total. The main causes of degradation are a shortage of organic and mineral fertilizers, a decrease in the amount of chemical reclamation, insufficient protection of soils by agroforestry measures, but most importantly, insufficient interest of land users in preserving and restoring soil fertility. Currently, the area of degraded and infertile soils is more than 8 million hectares, and the direct annual loss of income only from crop failure due to the main types of soil degradation reaches a total of about 33.6 billion UAH in Ukraine. Despite the strengthening of soil degradation processes, funding for anti-erosion and soil protection measures is decreasing. During 2009–2014, the amount of state budget funds for the implementation of land protection works decreased by almost 20 times compared to previous years. During 2015–2020, the state budget did not allocate funds for soil conservation and reproduction works, ensuring their rational use, which made it impossible to implement the necessary measures. The Law of Ukraine "On Land Protection" provides for the development of the National Program for Land Protection. However, until now, such a program has

not been approved in Ukraine. Article 184 of the Land Code of Ukraine, Article 36 of the Law of Ukraine "On Land Management" and Article 54 of the Law of Ukraine "On Land Protection" determine the need for a periodic (every 20 years) continuous survey of the soil cover of Ukraine. Unfortunately, such surveys have not been conducted for 40 years, although the soil cover has undergone significant changes. Among the strategic priorities for solving problems, the following are the main ones: adoption and practical implementation of the National (nationwide) soil protection program; carrying out a repeated solid survey of soils; strengthening of state control over the preservation of soils and their fertility, organization of soil monitoring taking into account European experience, ensuring the functioning of the soil information center; improvement of the legislative provision of soil protection; introduction of organic and mineral fertilizers, chemical meliorants in full to ensure a deficit-free balance of humus and nutrients in the soil, optimization of the reaction of the soil solution; improvement of economic stimulation of the implementation of soil protection measures by subjects of economic activity.

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