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ENVIRONMENTAL MONITORING OF THE AGROSPHERE: THEORY, METHODOLOGY, PRACTICE

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У запропонованій статті розглянута теорія, методологія і практика проведення комплексного екологічного моніторингу агросфери України. Вона зумовлена екологічно необґрунтованим землекористуванням, недостатнім техніко-технологічним забезпеченням, здійсненням недієвих інвестиційно-інноваційних економічних і технологічних рішень, порушенням збалансованості агроландшафтів за рахунок їх значної розораності, ущільненням ґрунту, погіршенням співвідношення площі ріллі й еколого-стабілізаційних угідь та природно-заповідного фонду, неефективністю реалізації екологічної і смарагдової мереж, руйнуванням ґрунтового покриву (зменшенням буферності ґрунту), зниженням рівня агробіорізноманіття, зростанням площ деградованих земель. Це відзначає те, що в Україні існують усі ознаки екологічної кризи агросфери, розв'язати які покликана агроекологія, на основі екологічного моніторингу з використанням сучасних інформаційних і космічних технологій, оцінювання рівня забруднення всіх складових агроландшафтів патогенними організмами, органічними ксенобіотиками і важкими металами, вивчення міграції і трансформації токсикантів у системі «ґрунт—рослина—тварина—продукція—людина». Це дасть змогу розробити методи і технології відновлення забруднених ґрунтів і повернення їх у сільськогосподарське виробництво, розробити модель оптимального співвідношення між вирощуванням рослин і тварин за певного стану компонентів довкілля, забезпечити високу якість сільськогосподарської продукції, зберегти біорізноманіття агроландшафтів. Тому авторами запропоновано науково обґрунтовану методику вдосконалення екологічного моніторингу агросфери України для різних типів агроландшафтів, їхню оптимізацію, ефективне використання та збереження біорізноманіття. Наведено етапи і специфіку проведення комплексного екологічного моніторингу агросфери для різних типів агроландшафтів, їхніх функціонально-структурних елементів, запропоновано основні напрями і практичні підходи. Доведено необхідність здійснення цієї комплексної системи екологічного моніторингу агросфери для різних типів агроландшафтів на території держави та створення регіональних інформаційно-консультаційних центрів з агроекологічних питань. Для ефективного проведення комплексного екологічного моніторингу агросфери України для різних типів агроландшафтів рекомендовано створити банк еталонних ґрунтів (з метою порівняльного аналізу). Запропоновано створити відповідні бази даних екологічної інформації для консультативно-впроваджувальних центрів з агроекологічних питань, що дасть можливість ефективно реалізувати програми сталого розвитку агросфери України.

Ключові слова: *агробіорізноманіття, агроландшафти, агроекосистеми, екологічна паспортизація, сталий розвиток, оптимізація землекористування.*

INTRODUCTION

The development of the twenty-first century society shows that it has a number of environmental problems such as climate change, pollution of air, surface and groundwater and soil, increasing the share of arable land in agriculture, erosion, deforestation, desertification, reduction of biotic diversity of flora, fauna and microorganisms, soil degradation, depletion of natural resources caused by large-scale industrialization and urbanization and environmental consequences of the military actions of the Russian Federation. Current trends of qualitative changes in Ukrainian society, European integration and the development of international directions of cooperation in the field of guaranteeing the quality of life and health lead to the priority of sustainable development of Ukraine's agricultural sector, which accounts for about 70% of the country's territory. After all, a significant negative anthropogenic impact on the components of the environment, irrational use of agricultural resources and military actions in Ukraine have led to the degradation of agricultural landscapes, loss of agrobiodiversity, and failure in ensuring the formation, effective use and implementation of the national ecological and Emerald Networks and sustainable development of the agricultural sector. The latter, together with all types of agricultural landscapes occupies from 50 to 80% of the territory in different regions of the of the country. An important problem for ensuring the sustainable development of Ukrainian agricultural sector is also the problem of mine clearance of the territories, which, according to UN experts, occupy 20% of the country's area [1; 2].

The purpose of the research is to propose a scientifically based methodology for improving environmental monitoring of the agrosphere of Ukraine for various types of agrolandscapes, their optimization, effective use and preservation of biodiversity.

ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

The analysis of recent studies shows that environmentally unreasonable land use, insufficient technical and technological support, implementation of ineffective investment and innovative economic decisions, violation of the balance of agricultural landscapes due to their significant plowing and erosion, soil contamination with pesticide residues and heavy metals, industrial emissions, soil compaction, reduction of soil fertility, and depletion due to the predominance of nutrient removal over nutrient input, increased acidity of the land, its salinization, disruption of crop rotations, deterioration of the ratio of arable land to ecological stabilization lands and natural reserves has led to significant destruction of soil cover (reduced soil buffering), an increase in the area of degraded land, disappearance of small rivers, and deterioration of the quality of drinking water for the local population, aggravation of the environmental crisis in the regions affected by the Chornobyl accident. This has caused a decline in land productivity, agricultural production efficiency, quality and environmental of agricultural production, quality and environmental safety of food products, and reduced biodiversity and a balance of agroecosystems. Above-mentioned negative effects were also strengthened by weed infestation of fields, non-compliance with crop rotations and contour reclamation farming systems, reduction of the number of farm animals, reduction of the use of fertilizers, chemical ameliorants, contamination with radionuclides and salt residues pesticides and heavy metals, various types of construction, development of mineral resources, increase in the area of illegal landfills, non-compliance with environmental standards, etc. Currently, about 20% of the country's agricultural land are in poor environmental condition. Recent studies show that the rate of decline in land fertility is increasing every 10 years (1980–2020), they amount to a loss of 0.1%, which can be revived only within 100 years, provided that the land is used rationally and efficiently of land. Environmental scientists (agroecologists) in Ukraine, studying the consequences of anthropogenic impact on biota in soils have shown that human activity in a short period of time has led to such a terrible phenomenon that we now call «environmental AIDS», that is, the destruction of nature's immune system, the disappearance of its basic functions such as self-healing, self-purification and self-development [3; 4; 6; 7].

Soils are an important component of nature's immune system, and they are the basis for the production of food and feed, fuel and fiber. Without soil resources, it is impossible to develop ecosystems and increase human well-being. Soils play a key role in the supply of clean water, they are a factor in resilience during floods and droughts. Conservation of soil resources plays an important role in climate change adaptation measures and is also a necessary for ensuring food, water and energy security of the humanity. On December 5, at the initiative of the United Nations, we celebrate World Soil Day, which was established on December 20, 2013, by the resolution of the 68th session of the UN General Assembly. Of course, Ukraine's greatest natural wealth is black soil, which accounts for almost 25% of the world's and 50% of Europe's reserves. Ukraine has a powerful potential of land resources, which, according to experts predict that it can meet the food needs of 600 million people. However, the efficiency of their use is characterized by a rather low level [6; 7].

According to many Ukrainian scholars (O. Sozinov, H. Bilyavsky, M. Zubets, O. Tarariko, V. Patyka, A. Travliiev, A. Boyko, M. Holubets, O. Furdychko, B. Priester, V. Radchenko, O. Bondar, Yu. Tarariko, P. Pysarenko, O. Drebot, I. Hudkov, M. Klymenko, D. Lyko, O. Demianiuk, N. Ridei, G. Chobotko, A. Parfeniuk, A. Pryschepa, Ye. Tkach and others), Ukraine has all the signs of an ecological crisis in the agricultural sector, which agroecology is called upon to solve on the basis of environmental monitoring using modern information and space technologies, assessing the level of pollution of all components of agricultural landscapes by pathogenic organisms (viruses, bacteria, macromycetes), organic xenobiotics and heavy metals, studying the migration and transformation of toxicants in the system «soil–plant–animal–product–human». This will make it possible to develop methods and technologies for the remediation of contaminated soils and their return to agricultural production, to develop a model of the optimal ratio between growing plants and animals under a certain state of environmental components, to ensure high quality agricultural products, and to preserve the biodiversity of agricultural landscapes [1–5; 7–14].

MATERIALS AND METHODS OF RESEARCH

The objects of the proposed integrated environmental monitoring of the agro-sphere of Ukraine for different types of agricultural landscapes (field, garden, meadow-pasture, vineyard, mixed) should be:

- agro-landscapes, united by common agroclimatic conditions, and the cycle of substances and energy;
- agricultural landscapes of zones, sub-zones, regions, and oblasts;
- agricultural landscapes of unified physical and geographical regions;
- facies, tracts and areas of agricultural landscapes;
- dominant soil types, subtypes, and other soil taxa — genera, species, varieties, and cultivation options that are distinguished within a soil province and reflect the diversity of soils, their fertility, environmental sustainability, and the degree of damage from degradation processes to the maximum extent possible;
- species composition of various biota and agrobiodiversity;
- sources and types of agricultural landscape pollution;
- all types and levels of anthropogenic pressure on the agricultural landscape;
- socio-environmental factors, including the level of environmental education and culture of the rural population and agricultural managers, the health and well-being of agricultural workers, etc. [12–14].

Among the types of environmental monitoring of the agricultural sector (benchmark, production, current, crisis, special, scientific), it is appropriate to conduct prognostic monitoring, which should differ in content, scale, efficiency, methodology, and levels.

Soil monitoring should become the basis for comprehensive environmental monitoring of agricultural landscapes (agricultural, forest, water, reclaimed, recreational, protected and other categories of land). In the system of agricultural lands monitoring, the objects of monitoring should be the soils of agricultural lands (arable land, hayfields, pastures, perennial plantations, fallow land, lands of temporary conservation), their nutrient, water, thermal and gas regimes, biochemical (enzymatic) activity, preservation of full-fledged pedobiota (macro-, meso- and microfauna of the soil), optimization of physical condition, prevention of their disintegration, compaction, etc. [1; 5].

The survey of agricultural land for environmental monitoring should include such stages as preparatory, field, laboratory and desk ones.

The preparatory stage is the selection of an object (farm, land plot), preparing and processing of relevant cartographic material. It includes clarification of the territory and objectives of environmental studies, generalization of existing materials on agrochemical monitoring and functional (economic) land use, review of the results of previous studies and structural characteristics of agrolandscapes — soil and vegetation, geological and geomorphological. The result of this stage is a preliminary detailed (1:25,000–1:10,000 scale) scheme of the agro-landscape structure of the study area, which indicates the profiles and points of field observations both on the territory of arable land agro-landscapes and adjacent territories such as hayfields, pastures, meadows, forest belts, forest glades, etc.

The field stage is soil sampling. It begins with clarifying the boundaries of agricultural landscapes and placing observation points, guided by the fact that within one elementary agricultural landscape, 3–5 pits (in the first year of observation) or digs (in the 2–3rd year for subsequent years of research) are laid. The boundaries of agrolandscapes and anthropogenic phenomena (erosion, waterlogging, flooding, felling, clogging of water bodies and land, fires, etc.) are specified by routes during the opening of soil transects. At the observation points, a complete description of the site surface is made, a soil transect is laid to the depth of the soil-forming rock, and samples are taken for further laboratory research, documenting everything in a field journal of the prescribed form. Informational field surveys should include documentation of such characteristics of the observation points as: *a*) location, nearest settlements and watercourses, prevailing elevations, transportation routes, etc.; *b*) nature and specifics of land use; *c*) relief element, landscape, elementary agricultural landscape; *d*) hydrological characteristics of the nearest watercourse, spring, well with a description of the physical properties of water and valley characteristics; *e*) type and species composition of vegetation, morphological signs of phytopathologies, anthropogenic impact on vegetation; *f*) description of genetic horizons of the soil section, including the soil-forming rock; *g*) anthropogenic processes and phenomena occurring on the surface of the agricultural landscape and adjacent territories (roads, dumps, sumps, buildings, garbage dumps, etc.). At the observation points, samples of natural waters, vegetation (collective phytocoenosis, individual morphological parts of crops), soils (furrow samples of the topsoil, humus and soil-forming horizons, agrochemical monitoring interval of 0–20 cm) are taken, indicating their number in the field journal and on the standard sample label.

The laboratory stage involves the preparation and analysis of soil samples. This stage of research includes analytical determinations of nutrient (or toxic) chemical elements relevant to the farm in vegetation ash, soils and rocks (mobile and gross forms of occurrence), and water bodies, which are the main parameters of biogeochemical chains. Along with this, the accompanying characteristics of agricultural landscapes and natural areas are determined to identify factors of biogeochemical differentiation of agricultural landscapes such as plant ash content, agrochemical parameters of soil horizons, macrocomponents of water bodies.

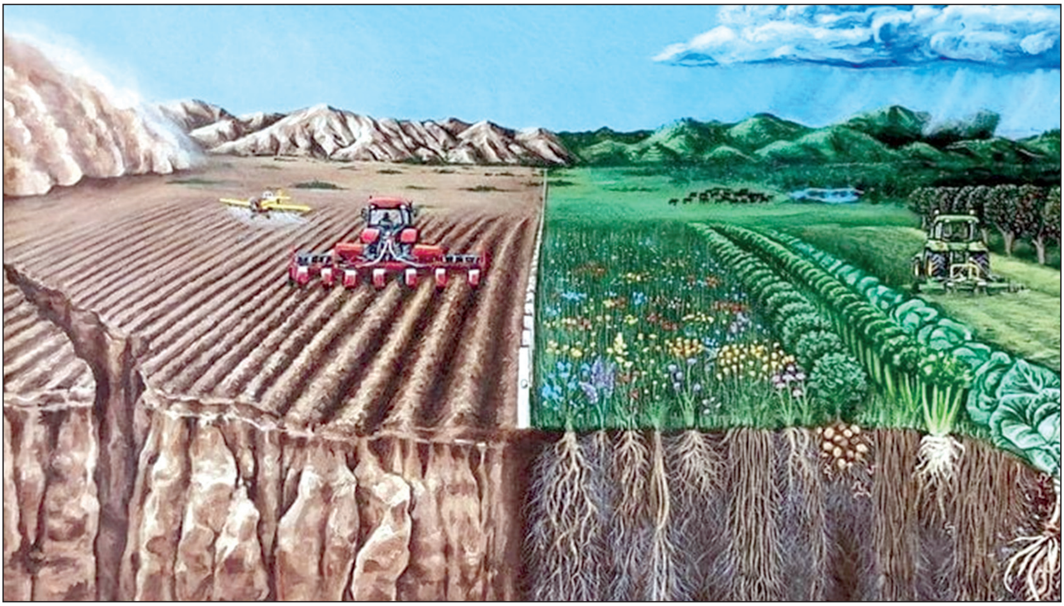
The desk-based stage involves processing the analysis results, creating an electronic database, drawing up cartograms, diagrams, tables, and preparing an agrochemical passport. This stage consists of informative synthesis of the materials from the field and laboratory stages using statistical analysis, graphical modeling, identification of natural features and anthropogenic deformations of agricultural landscapes, and determination of the prospects for balanced nature management on the studied lands. The first component of the desk-based stage is the construction of a refined map (cartographic scheme) of the spatial distribution of agrolandscapes. For this purpose, the taxonomic classification of the factors of functioning of all links of the chain «rocks — soils — water — natural vegetation and crops» in the agrolandscapes of the study area is completed, maps of the features and distribution of agrolandscapes are drawn up, conventional notations for the map are formed and field observation points are placed on it. The second component of the desk-based stage is the compilation of a database with the designation of the agrolandscape, its components, sample numbers, laboratory analysis methods, content of the studied chemical elements and related quantitative parameters (agrochemical, hydrochemical, and other). The third component of the desk-based stage is the statistical analysis of the data (using methods of variation and correlation analysis) and the calculation of a set of biogeochemical, hydroecological and ecological-geochemical coefficients based on them. The final product is an agrochemical passport. Land plots of all forms of ownership located within the territory of Ukraine are subject to agrochemical certification. Agrochemical certification of arable land (100 hectares or more is mandatory) in the country is carried out every 5 years, and hayfields, pastures and perennial plantations (orchards, berry gardens, hop gardens, vineyards) — every 10 years [6; 12–14].

Research methods: descriptive, systematic, retrospective, statistical, analytical, chamber, bioindication, cartographic, field (detailed route, reconnaissance), morphometric, comparative, and predictive.

RESULTS AND DISCUSSION

To conduct comprehensive environmental monitoring of the agrosphere, we note that the agrosphere is a part of the biogeosphere dominated by cultivated plants, domestic animals, cultivated soils, and related organisms (weeds, insects, fungi, microorganisms, viruses, wildlife, etc.). The agrosphere also includes meadows, pastures, and rural settlements. The agrosphere includes all types of agrolandscapes, agrobiocenoses and agroecosystems. It was created and exists thanks to human intelligence and activity, so the agrosphere is not only a biological but also a social category, the main source of food and raw materials for the food and light industry; the habitat of a significant part of the population. It is characterized by impoverished biotic diversity (4–5 species of cultivated plants and 2–3 species of domestic animals dominate). It requires constant significant expenditures of anthropogenic energy. In Ukraine the agricultural sector occupies almost 60% of the territory. Researching the patterns of the agrosphere, identifying ways to reduce its contradictions with the biosphere and transition to the principles of sustainable development, approximation to the conditions of the noosphere is of great importance for the present and future of our country. Agroecology studies the peculiarities of the formation, existence and development of the agrosphere. Therefore, today we have two ways of development of the agrosphere in Ukraine: agroecological, which makes it possible for all living things to exist in the environment and agrochemical, which has a devastating impact on environmental components and human health (*Fig.*) [7; 15].

The need to implement the agro-ecological pathway and comprehensive environmental monitoring of the Ukrainian agrosphere for different types of agricultural landscapes is caused not only by reforms in the field of land relations, the land market, and the organization of agricultural production, which requires the establishment of soil bonuses and their monetary valuation, but also by operational control over the balanced use and protection of soils, their classification (development of a catalog), and the identification of environ-



Ways to develop agriculture in Ukraine

mentally safe raw material zones for growing biological products. After all, according to representatives of various fields of science (agroecologists, economists, sociologists, doctors, educators), about 20% of the country's population (including 15% of children) currently needs high-quality «environmentally friendly» food [5; 12–14].

Today, the EU is following the agroecological path, where the European Economic Commission has adopted a new strategy for the development of the agricultural system, which plans to reduce significantly the use of chemical pesticides. The goal of the strategy is to make this system more sustainable and safer for human health. The strategy aims to reduce pesticide use by 50% in the next decade (by 2030). It also envisages a 50% reduction in the sale of antimicrobials for farm animals and a 20% reduction in the use of fertilizers. The area of organic farming will be increased by 25% by 2030, compared to the current 8%. Chemical pesticides will be banned from vulnerable areas, including EU urban green zones [15].

For the development of organic farming in Ukraine, it is advisable to identify territories and farms that are suitable for growing high-quality, biologically complete crops. The primary step in addressing this issue is to conduct comprehensive environmental monitoring of the Ukrainian agricultural sector which includes a scientific and information system of observation, comprehensive environmental assessment of agricultural landscapes and agroecosystems, taking into account abiotic, biotic and socio-economic factors, control and forecasting of changes in soil fertility and their ecological condition in order to manage productivity and preserve agrobiodiversity. An important provision in the implementation of environmental monitoring of the agrosphere is the combination of interrelated areas such as scientific, methodological and directly production. Their functional direction should be subordinated to specialized structural units of research and educational institutions, centers, laboratories located in a certain soil and climatic zone, having the appropriate material and technical base (equipment, reagents, developed methods) and highly qualified industry specialists [13; 14].

In order to ensure the balanced development of the agricultural sector and take into account the specifics of nature management, systematic environmental monitoring of agricultural landscapes should consist of a whole range of separately identified components in the following areas and parameters:

❒ ***Monitoring of landowners and land users*** is a structure of land which includes level of plowing (*Table*), percentage of forest cover, protected areas (general and strict), ecological stability of soils, economic and physiological conditions of soils, soil damage by erosion processes (gully and plane erosion, deflation), man-made flooding, landslides, forest species suffocation, abrasion, karst, salinity, subsidence, waterlogging, waterlogging, acidification.

The plowing of territory and agricultural land in different countries

Country	Plowed area, %	Plowed agricultural land, %
Ukraine	53.9	78.0
Poland	36.5	75.1
Germany	34.1	71.0
Canada	4.7	68.6
France	33.5	63.1
Netherlands	30.9	55.0
Austria	16.5	47.5
USA	17.5	38.9
United Kingdom	25.1	35.3
China	12.0	21.5

❒ ***Phytobiotic*** monitoring is a certain species composition of the phytobiota, projected coverage of different types of vegetation, its biomass, taxonomic and typological, biomorphological, biological, ecological, geographical, genetic, coenotic, demographic, sozological structure of the phytobiota. A subspecies of phytobiotic monitoring should be phytosanitary, phytoindication and quarantine. *Phytosanitary* is the determination of the number or status of pests that are directly or indirectly introduced into the territory by various means.

Phytoindication is a certain system of observations of anatomical and morphological indicators of changes and assessment of damage to plants in agricultural landscapes by abiotic and anthropogenic factors. For example, the identification of plants-indicators of anthropogenic impact on arable land (plants-indicators of initial and severe acidification, stagnant moisture in the cultivated soil layer, waterlogging, excess nitrogen in it, appropriate supply of nitrogen and humus, alkalization of carbonate soil, etc.), on pastures, phytoindication of toxic substances in the air. Pedobiota can be quite good bioindicators, most of all earthworms and colembola. Phytoindicator monitoring should cover large areas of agricultural landscapes (landscape facies, tracts and areas), belong to the relevant physical and geographical elements of zoning (landscape edges, regions, districts), be cost-effective, be carried out at a minimum cost and predict environmental changes (using various types of modeling and forecasting) that can be expected at certain intervals. For this purpose, it is advisable to select not only the object, but also certain signs (indicators) that should be clearly recorded during phytoindication of agroecosystems by using a species that is highly sensitive and responds accordingly to anthropogenic environmental changes.

Quarantine is aimed at preventing the introduction and spread of harmful organisms or the need to control the areas of their distribution (localization) or elimination. It is carried out to ensure quarantine in compliance with sanitary measures in the production, storage, transportation and sale of products and the introduction (reintroduction) of organisms. An important direction is phytopathogenic protection.

❒ ***Microbiological*** monitoring is the determination of the functional structure of soil microbial cenoses; strategic forecasting of the appropriate direction of microbiological processes for the plant rhizosphere, which lead to degradation, restoration or degree of stability of the soil complex when applying various agroecological measures; identification and selection of microbiological features for the construction of models of balanced agroecosystems and their formation.

❒ ***Phytovirological*** monitoring is the functional structure of phytovirus cenosis;

forecasting the relevant processes of transformation of phytovirus states of soil; formation of phytovirus cenosis of sustainable agroecosystems.

❒ ***Population and genetic*** is an assessment of recessive biosafety of changes in genetic diversity of breeds and varieties; assessment of the impact of GMOs (genetically modified organisms) on the formation of sustainable agroecosystems.

❒ ***Agrochemical*** monitoring includes determination of recessive and actual levels of soil fertility by indicators of *physical* condition: density, air permeability and moisture permeability; *chemical* humus content in the soil, as well as the content of basic nutrients (amount of rapidly hydrolyzed nitrogen, mg/kg, nitrification capacity, mg NO_3/kg soil, level of mobile phosphorus, exchangeable potassium) and trace elements (sulfur, manganese, molybdenum, zinc, copper, boron, cobalt); *physical and chemical* acidity (actual, hydrolytic, exchange), amount of absorbed bases, salinity (type and degree of salinity), salinity; *biotic state:* soil edaphon, the presence of macro- (earthworms, large insects, insect larvae, millipedes, plant roots), meso- (ticks, nematodes, millipedes, small insect larvae) and microbiota (bacteria, fungi, soil algae, protozoa), ecological groups of soil animals by way of movement and habitat (geoexenes, geobionts, geophiles); *biochemical* state (quality and safety of agricultural products). It is important to study and determine the annual and prospective need for chemical ameliorants (especially liming and gypsumizing soils), conduct soil reclamation (agrochemical) zoning, determine the need for organic and mineral fertilizers, trace elements for all levels of management, and establish the level of effective soil fertility and conduct bonetting.

❒ ***Hydroecological*** monitoring means observation, study and forecast of pollution and self-purification processes, determination of the ecological state and reaction of aquatic ecosystems that are part of the agricultural landscape to various anthropogenic factors related to agricultural activities; forecasting and establishing the dynamics of changes in aquatic ecosystems based on modeling, depending on various sources and types of pollution (eutrophication, toxification, thermification, acidification, radionuclide pollution), structure and directions of agricultural land use.

❒ ***Forestry and environmental*** monitoring includes observation, assessment and forecasting of pollution processes and determination of the ecological state and response of forest landscapes to the impact of various natural and anthropogenic factors that determine the state and productivity of forest ecosystems, and implementation of measures to improve their productivity. This type of monitoring makes it possible to plan in advance the density, composition of future crops in the agricultural landscape, planting locations, and optimal age structure when creating anthropogenic sustainable forest plantations, taking into account habitat conditions, categories of forestry areas and agroclimatic zones, using introductions, to determine the degree and type of damage to shrub and tree species by environmental factors, disease and pest infestation, to conduct phytoindication and timely and moderate sanitary felling, to calculate the costs of forming forest crops, to conduct boning and cadastre.

❒ ***Toxicological*** monitoring is the level of contamination of soils, surface and groundwater, and various types of vegetation with chemicals of toxicity classes I–IV, identification of sources and types of contamination, assessment of the hazard of contamination according to relevant environmental and toxicological criteria, environmental and toxicological zoning and mapping of agricultural landscapes. An example of ecological and toxicological monitoring of organic xenobiotics is the following scheme of its organization, which consists of the following stages: 1) drawing up an observation program, which includes scientific justification for the choice of observation site (sampling point), observation objects (soil, plant, crop and livestock products); 2) identification of sources and types of organic xenobiotic pollution, objects, nature and scale; 3) consideration of the ways of entry and transformation of toxic substances in individual links of agrophytocenosis; 4) sampling of the objects under study; 5) chemical and analytical control over the content of residual amounts of pesticides in the selected samples; 6) identification of areas with crisis pollution by persistent organic pollutants; 7) assessment of background pollution and agricultural land by persistent organic pollutants; 8) assessment of the impact of agricultural technologies on the pollution of water sources and agricultural products by modern pesticides; 9) based on chemical analysis and biotests, ecological and toxicological assessment of pesticide pollution levels and determination of the impact of these levels on the quality of agricultural products, as well as determination of the suitability of agricultural land for growing certain crops; 10) assessment of phytotoxicity of pesticide-contaminated soils; 11) targeted regulation and management of environmental quality.

❒ ***Biotic*** monitoring means determination of the status of agrobiodiversity species: endemic, relict, vulnerable, rare, endangered, plants and animals whose habitats are or may be within the boundaries of agricultural activities; this also includes monitoring of: *a*) forest ecosystems and areas undergoing targeted spontaneous afforestation (especially valuable representative steppe areas); *b*) natural fodder lands, pastures, hayfields, steppe areas, including those belonging to floodplain, floodplain-terrace, slope and floodplain (watershed) areas; *c*) wetlands and peat bogs, reclaimed lands; *d*) honey, medicinal, fruit and berry, industrial, fodder crops; e) segetal and adventitious weeds, including quarantine weeds; *f*) soil microflora; *g*) agricultural pests: spread of quarantine organisms (golden potato cyst nematode, American white butterfly, chestnut moth, bark beetle, etc.); pathogenic microorganisms, bacteria, viruses; insect pests (harmful turtle bug, beetle, locust, beet weevil, beet aphid, Colorado potato beetle, winter scoop, ticks, pests of gardens, vineyards, berry fields) blood-sucking insects (pathogens, helminths); vertebrates (mouse-like rodents, birds, ungulates — wild pigs, deer, roe deer, elk, bison, etc.).

❒ ***Sanitary and hygienic*** monitoring is determination of soil contamination density with radionuclides (Ci/km^2) and their migration; content of gross forms of heavy metals of the I hazard class (mobile forms of mercury, astatum, cadmium, selenium, lead, zinc); II hazard class (boron, cobalt, molybdenum, nickel, copper, stibium, chromium); Hazard class III (barium, tungsten, vanadium, manganese, strontium); content of pesticide residues; bituminized substances in case of oil contamination and their migration; number and percentage of pathogenic microorganisms in 1 g of soil, bacteria, viruses;

❒ ***Socioenvironmental*** monitoring includes determining the state and dynamics of: environmental education, upbringing and culture of the rural population; environmental safety; sanitary and environmental, socioeconomic and medical-demographic conditions of the population in specific agricultural areas, establishing the specifics of migration processes; labor resources in agriculture; activities of public environmental organizations; informing the population about environmental safety, environmental policy and environmental management and their compliance with the prin [13; 14; 16; 17].

In order to establish an overview initial assessment of the ecological state of agricultural landscapes, it is necessary to conduct preliminary monitoring, during which background information on the ecological state of various types of agroecosystems is formed, the main sources that lead to deviations from their optimal ecological state are identified, and areas of influence are determined. Ongoing monitoring is carried out within the established network to a minimum extent, where only the most informative and important elements of agricultural landscapes or agroecosystems are subject to control. In the event of a sharp deterioration in the environmental condition, extraordinary monitoring is carried out.

In order to carry out comprehensive environmental monitoring of the agricultural sector effectively, it is advisable to create a bank of reference soils (for comparative analysis). This can only be done at special environmentally friendly testing sites (test plots). For objective and complete environmental monitoring of agrolandscapes, it is appropriate to develop energy and resource-saving models that will allow generalization and comparison, building agroecological maps, developing forecasts, organizing environmental audits, accounting, inspection (control), management, improving environmental standardization and regulation, and conducting appropriate environmental policy within territorial communities on the basis of remote sensing and geographic information systems (GIS). It is important to establish advisory and implementation centers such as «extension services» (in the United States) and «advisory services» (in Poland) on the basis of various regional offices (departments) and agencies. Therefore, it is necessary to unite the systems of regional (local — enterprises, institutions and organizations, settlements, territorial communities; district; regional) services (agriculture, ecology and natural resources, forestry and hunting, basin water resources management, regional branches of the State Institution «Institute of Soil Protection of Ukraine», the State Environmental Inspectorate, the State Food and Consumer Service), their electronic computing equipment into a single information and consulting environmental center, which should carry out The efficiency of this center will depend on the effectiveness of cooperation between the following agencies and services: agrotechnical, investment and innovation, organizational and legal, agrochemical (regional soil protection centers), land reclamation, quarantine (plant protection), entomological, hydrometeorological and climatological, water management (basin water resource management), forestry (departments of the state forestry, forestry, agroforestry), geological exploration, statistical, scientific and methodological, sanitary and environmental (departments of the state food and consumer service), departments of agro-industrial development, ecology and natural resources, and state environmental inspections. As all these services currently work separately, farms are mainly responsible for the harvest, its good quality, environmental safety, biological integrity, optimization of the structure of agricultural landscapes and agroecosystems, increasing their resistance to degradation and preservation of agrobiodiversity [13; 14].

CONCLUSIONS

Only an effective system of integrated environmental monitoring of the agrosphere of Ukraine will allow us: 1) to determine the real environmental status of agrosphere resources (land, water, biotic); 2) to optimize the structure (agrolandscapes, agricultural lands, agroecosystems) by creating an optimal ratio between agrolandscape elements (arable and ecologically stabilizing lands — forest, wetlands, hayfields, pastures and nature reserve fund) for each agrolandscape facies, tract, locality, district, region, intra-regional agrolandscapes and unified physical and geographical regions; 3) to withdraw from intensive cultivation heavily degraded, polluted and unproductive agricultural lands, includingч. soils located on slopes with a steepness of 3° and more, low-productive soils, previously plowed water protection and coastal protection lands of the hydrographic network, land located directly around livestock complexes, poultry farms and settlements, radiation-contaminated lands contaminated with heavy metal salts and pesticides, and include them in the structural elements of the ecological network (as buffer and restoration areas) of the agrosphere with the prospect of renaturalization; 4) to conduct an environmental assessment of systems (farming, soil cultivation, fertilization, plant protection); 5) to assess and establish the norms of anthropogenic load on natural resources of the agrosphere (industrial enterprises, agrotechnologies, agrochemicals); 6) to establish the patterns of migration of pollutants in agroecosystems; 7) to propose ecological principles of agricultural waste management; 8) to determine the ecological state of rural settlements; 9) to establish the level of environmental safety in the agro-industrial complex; 10) to adapt agricultural production to the predicted climate change; 11) to propose a scientific basis for ecological forecasting of the development of the agrosphere based on the development and implementation of short-term and long-term local, regional and national programs for the revival of agricultural landscape components, identifying «environmentally friendly» raw material zones, organic farming and obtaining environmentally safe products and raw materials based on agro-ecological zoning, cluster analysis and expert assessments; 12) prevent the irreversible loss of part of the gene, demo, price and ecological funds, increase the area of the nature reserve fund at the expense of low-productive, partially degraded and technogenically contaminated (including radioactive) agricultural lands; 13) to organize and widely implement the development of environmental education and upbringing, using a system of continuous environmental inspection, expertise (strategic environmental assessment and environmental impact assessment) of hazardous facilities that affect the ecological state of agricultural landscapes; 14) to carry out environmental certification of agricultural facilities, audit and management in the field of agro-natural resources. For this purpose, it is necessary to create appropriate environmental information banks for advisory and implementation centers on agro-environmental issues, which will enables the effective implementation of programs for the balanced development of the Ukrainian agrosphere.

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