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ADMINISTRATION OF MEASURES FOR THE RESTORATION OF SOILS TRANSFORMED AS A RESULT OF MILITARY OPERATIONS

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Abstract. *The Earth is a wealth of society. Its role in addressing the food problem cannot be overstated. It is known that the population's demand for staple food products doubles on average every thirty years. The solution to this incredibly complex task primarily depends on the efficiency of land utilization. Observations are conducted using ground-based methods, primarily field-based techniques, and remote sensing tools. The establishment of correlation relationships between ground-based and remote sensing methods is carried out on dedicated test sites. The purpose of the article is to provide proposals for implementing measures for the restoration of lands transformed as a result of military actions. The methodology should include modern mathematical support, including principles of database creation, automated data processing and retrieval systems, and methods for real-time and long-term forecasting. For an accurate assessment of such transformations and the implementation of targeted regulation of soil processes, there is a need to organize systematic monitoring services to observe them. The absence of such monitoring can lead to irreversible degradation of the soil cover, which would later require enormous costs and time for restoration. It is clear that from both economic and socio-environmental perspectives, it is more practical and advantageous to prevent adverse changes rather than trying to remedy them later. By processing such information, it is possible to identify optimal natural conditions for various activities, predict both positive and negative factors for agricultural operations, and take measures to reduce the impact of negative factors on human life and activities. It is known that for a long time, observations were only conducted on changes in the state of the natural environment caused by natural factors. Large balanced ecological systems, geosystems, change extremely slowly under the influence of natural processes. These gradual evolutionary changes occur only over time measured by historical epochs. The deteriorating ecological situation in Ukraine, including the agroecological state of the soil cover, emphasizes the need for the State Agrochemical Service to transition from soil agrochemical surveys to comprehensive soil-agrochemical monitoring of agricultural lands. Such monitoring belongs to the ecological monitoring type and consists of three main components: soil surveys (including laboratory analysis), assessment of their agro-ecological condition, prediction of changes in relevant indicators, and soil fertility management, which refers to the specific properties of soils that distinguish them qualitatively from their parent geological formations.*

Keywords: *scientific and technological progress, soil formation process, degradation of the soil cover, anthropogenic factors, ecological systems, seasonal variations in vegetation biomass, technogenic transformation of soils.*

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Introduction. Natural changes in the environment, both short-term and long-term, are extensively observed and studied by existing geophysical services in many countries, including hydro-meteorological, seismic, ionospheric, gravimetric, magnetometric, and other services.

In order to distinguish anthropogenic changes from other natural changes, there has been a need to organize specialized research on the alterations of the biosphere under the influence of human activities [3].

The system of repeated investigations of one or more environmental components in space and time, with a defined purpose and according to a prepared program, has been proposed to be called "monitoring."

The term "monitoring" emerged prior to the United Nations Stockholm Conference on the Human Environment (Stockholm, June 5-16, 1972). The initial proposals for such a system were developed by experts from the Scientific Committee on Problems of the Environment (SCOPE) in 1979.

Indeed, the term "monitoring" is not just a new definition for the already existing geophysical services but refers to a system that is synthesized to detect anthropogenic effects on the environment, utilizing information and certain elements from the existing geophysical services.

When considering the main objectives formulated for the Global Environmental Monitoring System (GEMS) in terms of detecting environmental changes due to anthropogenic influences, it is important to note that there may not be any contradictions in the monitoring goal in the provided definition. However, efforts to detect and prevent natural disasters of meteorological or hydrological nature are carried out by existing meteorological and hydrological services, while the prevention of diseases is the responsibility of relevant health services and so on. These services certainly need to be developed, but it may not be appropriate to merge them into a single monitoring system [4].

It is worth noting that the system for monitoring anthropogenic changes in the natural environment is not fundamentally a new system that requires the organization of a network of new observation stations, lines, telecommunications, data processing centers, etc. It is an integral component of the comprehensive environmental monitoring and control system, which has already been developed in several countries.

Indeed, the system for monitoring pollution can and should be integrated into an existing environmental monitoring and control service, utilizing its experience, station network (with the addition of necessary new elements), telecommunications lines, and data processing centers, while developing specific components for pollution monitoring. This approach allows for the efficient use of resources and expertise already available within the established environmental monitoring framework.

As already noted, to ensure the functioning of a monitoring and control system for the environment that can detect changes caused by human activities, detailed information about natural fluctuations and changes in the environment is necessary. Conducting monitoring requires obtaining (or having) such information [5].

Monitoring encompasses the following main directions of activity:

1. Observing the factors that influence the environment and its condition.

2. Assessing the actual state of the natural environment.
3. Forecasting the state of the surrounding natural environment and evaluating its condition.

Therefore, monitoring is a system of observations, assessment, and forecasting of the environmental state that does not involve managing the quality of the environment or forecasting its state to prevent deterioration. It is evident that the organization of a monitoring system is a necessary condition for proper environmental quality management.

National monitoring refers to a monitoring system within a specific country. Such a system differs from global monitoring not only in terms of scale but also in the primary objective of obtaining information and assessing the state of the environment in national interests. For example, an increase in air pollution levels in specific cities or industrial areas may not have significant implications for assessing the state of the biosphere on a global scale. However, it is an important issue for implementing measures within that particular region and at the national level.

Certainly, a global monitoring system should be based on national monitoring subsystems and include elements of these subsystems. There is no need to fully incorporate these subsystems into the global system, as they are responsible for national issues and considerations.

Sometimes the terms "transboundary" or "international" monitoring are used. It is most appropriate to use these terms for a monitoring system that is utilized in the interests of multiple countries. They can be used to address issues related to the transboundary transfer of pollution between nations and similar matters.

Therefore, monitoring is a multifunctional information system. Its main tasks include: observing the state of the biosphere, assessing and forecasting its condition, determining the intensity of anthropogenic impact on the environment, identifying factors and sources of such impact, assessing the intensity of their influence.

Monitoring serves as a valuable tool for understanding and managing environmental changes, as well as for developing strategies to mitigate the impact of human activities on the biosphere.

Let's consider a universal scheme of an environmental monitoring information system that is applicable to the overall system as well as to any specific geophysical service within the system (such as a hydro-meteorological service or a pollution monitoring system). Since pollution monitoring is a relatively new element in the environmental monitoring system, let's focus on it in more detail.

The most universal approach to defining the structure of a monitoring system for anthropogenic changes in the natural environment is to divide it into blocks (Fig.1).

The figure illustrates individual blocks of the system, as well as direct and feedback connections between these blocks.

The "observation" and "state forecasting" blocks are closely related, as environmental forecasting is only possible with representative information about the actual state (direct connection). On one hand, the construction of a forecast involves knowledge of the patterns of natural environment changes, the availability of a scheme, and numerical calculation capabilities. On the other hand, the direction of the forecast largely determines the structure and composition of the observed system (feedback connection).

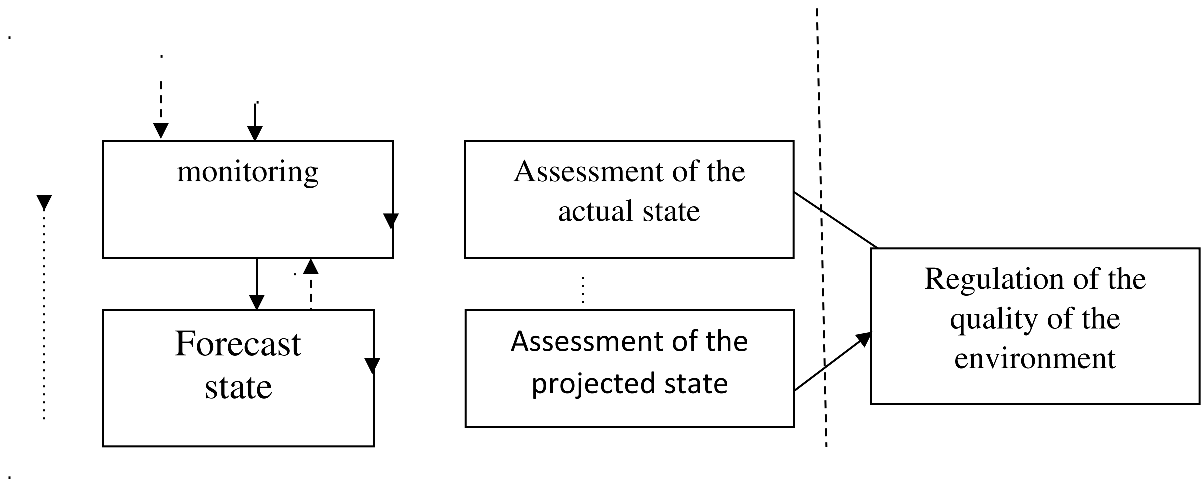

Figure 1. Monitoring Block Diagram

Data characterizing the state of the natural environment obtained from observations or forecasts should be evaluated depending on their application in different fields of human activity (using specially selected criteria). The evaluation aims to determine the damage caused by impacts on the environment, as well as to identify optimal conditions for human activities and refine existing ecological reserves. The purpose of such assessments is to determine permissible anthropogenic loads on the environment.

Observations of the environmental state should include monitoring of anthropogenic sources and factors (including pollution sources, harmful radiation, etc.), as well as the state of biosphere elements (including the response of organisms to impacts and changes in their structural and functional indicators). This involves gathering data on the pristine (or background) state of biosphere elements.

Soil monitoring is a system of observations, quantitative assessment, and control of soil and land use with the aim of organizing management for their productivity. It is, as mentioned before, a component of environmental monitoring and is part of the monitoring system for related environments and the biosphere as a whole. It is important to note that soil pollution, as the object of observation, has several significant specific characteristics.

Firstly, soil is the least mobile natural environment compared to, for example, the atmosphere or surface waters. The migration of pollutants in the soil occurs relatively slowly. As a result, high levels of soil contamination with certain substances are localized in the areas where they are released into the external environment. Additionally, gradual changes in the chemical composition of soils can occur, disrupting the integrity of the geochemical environment and living organisms.

The most intensive pathway for the transport of pollutants reaching the soil can occur through the atmosphere, in cases where contaminants from the soil enter the atmosphere through evaporation or with dust. Another relatively rapid pathway for the spread of pollutants is their leaching through surface waters. However, not all of these transport mechanisms play a significant role in soil pollution. Under the influence of physicochemical factors and primarily through the activity of microorganisms, the decomposition of organic pollutants takes place. In some cases (such as soil contamination with benzo(a)pyrene, pesticides, and other substances), it is even possible to establish an equilibrium between their input into the soil and their degradation within the soil.

The concept and technical-economic justification for soil monitoring in Ukraine have been developed at the O.N. Sokolovsky Kharkiv Institute of Soil Science and Agrochemistry (UNDIGA) under the guidance of Academician V.V. Medvedev [32]. Its necessity is determined by four main factors:

The exceptional importance of maintaining soils in a state that preserves their capacity to regulate biogeochemical cycles, which serve as the foundation for human and biosphere life-support systems.

The significance of monitoring and preventing the negative development of soil formation processes that occur extensively across agricultural territories due to unsustainable human activities, resulting in dehumification, erosion, overuse, contamination, acidification, waterlogging, salinization, excessive peat extraction, and other detrimental phenomena.

The necessity for substantial improvements in soil fertility, productivity, and the quality of agricultural products, aiming to maximize the benefits from land reclamation and chemical treatments, overcome stagnation in crop yields, and enhance the overall quality of agricultural production.

The inability to establish an adequate assessment of the current state of the soil cover based on the available information, due to outdated soil survey data, limitations in scope, narrow target audience orientation, lack of data coordination, and the diversity of methodologies used by hydrogeological and reclamation expeditions, hydro-meliorative, sanitary-epidemiological services, and others. Consequently, there is a need for rational investment to address soil degradation phenomena.

Aims. The purpose of the article is to provide proposals for implementing measures for the restoration of lands transformed as a result of military actions.

The objects of monitoring include major soil types, subtypes, genera, species, and varieties, which are selected within a soil province and reflect the mosaic nature of the soil cover, as well as all types and levels of anthropogenic pressures. Permanent monitoring points include natural objects such as forests and reserves, high-level reference objects of agricultural land use (state farm experimental stations, stationary trial plots, farms implementing contour-meliorative farming systems), and ordinary farms. Considering that reliable assessment of soils, especially the prediction of their fertility, requires information on climate, parent rock materials, water (surface or, in extreme cases, the first horizon of groundwater), quantity and quality of crop production, these components are also included in the objects of monitoring. This approach allows for the integration of soils with other environmental elements, and with a similar development of monitoring for fauna, flora, and humans, it provides a comprehensive understanding of the state of the biosphere.

The reliable diagnosis of soil conditions requires the following information:

changes in the structure of the soil cover, transformations of land use, assessment of the rate of change in key soil properties (organic matter content, pH, cation exchange capacity, physical, water, air, and nutrient regimes, biological activity of soils, pollution levels); evaluation of erosion intensity, indicators of meliorative state (quality of irrigation water, level and mineralization of groundwater, salinization of soils as a whole and the root zone, secondary salinization, rates of reclamation of drained peatlands, transformation of organic substances, secondary ironization), and finally, the assessment of effective soil fertility.

The list of field and laboratory analytical works depends on the minimum required number of indicators that comprehensively characterize the aforementioned processes. The frequency of studies depends on the dynamics of indicators under natural and anthropogenic conditions. The total number of monitored indicators is 115. One complete monitoring cycle lasts for 5 years. Special types of operational reporting should be provided for indicators that characterize crisis environmental situations such as erosion, pollution, and product quality.

Methodology. Observations are conducted using ground-based methods, primarily field-based techniques, and remote sensing tools. The establishment of correlation relationships between ground-based and remote sensing methods is carried out on dedicated test sites. The methodology should include modern mathematical support, including principles of database creation, automated data processing and retrieval systems, and methods for real-time and long-term forecasting.

Results. The main sources of radiation pollution are nuclear power plants, nuclear fuel production facilities, nuclear weapon storage facilities, nuclear waste processing plants, and waste disposal sites.

Radiation monitoring is an information and technical system for the observation, assessment, and forecasting of the radiation state in the biosphere.

The main and potential sources of radiation pollution in peacetime are nuclear power plants, nuclear fuel production facilities, nuclear weapon storage facilities, nuclear waste processing plants, waste disposal sites, and others.

Currently, there are 14 operating nuclear reactors in Ukraine. A significant portion of Russia's nuclear power plants are within the potential transboundary impact zone in the event of an emergency situation. In medicine, industry, and scientific institutions, tens of thousands of radioactive sources are used. A significant amount (approximately 800 PBq) of radionuclides is located within the Shelter Object of the Chernobyl Exclusion Zone [6].

Despite significant efforts to enhance the safety of nuclear reactors and other nuclear facilities, they all remain sources of nuclear hazards and potential sources of radiation contamination in the environment.

The main pollutants in radiation contamination (such as in the aftermath of a nuclear accident) are radioactive emissions (in the first hours following the accident) and internal exposure from radionuclides entering the human body through food and water.

The main objectives in developing methods for comprehensive radiation monitoring are as follows:

1. Development of air sampling methods, measurement of specific α-, β-, and γ-activities, and procedures for dose assessment.
2. Development of γ-spectrometry methods and corresponding dose assessment procedures.
3. Strategy and techniques for sample collection, measurement of specific activity, and dynamic modeling for assessing collective dose.

Currently, there is a wide range of equipment available for sampling and measuring the activity of air samples. However, there is still no methodology that fully satisfies the requirements for post-accident radiation monitoring. In particular, there is no technique that allows for separate measurements of different chemical forms of radioiodine. Significant improvements are needed in the methodology for chemical separation and measurement of pure α- and β-emitters in emergency conditions.

There is a wide range of equipment for γ-spectrometry; however, this equipment is designed for measuring natural and long-lived radionuclides. In the case of short-term assessments, the power of exposure dose rate can be very high, reaching up to 1 mSv/h. In such fields, standard germanium detectors do not work due to high pulse loads, and spectrometers based on sodium detectors do not have sufficient energy capabilities required for spectrometry of fresh radioactive fallout.

For the majority of the population in Ukraine living in contaminated areas, the main source of effective collective dose is food consumption. For example, 70-90% of Cs-137 intake is associated with the consumption of milk.

Long-term radiation doses to the population from Cs-137 and Sr-90 in food products depend on the different chemical behavior of radionuclides in the soil. After deposition on the soil, cesium is fixed in the mineral fraction of the soil and becomes less available to plants. It is believed that the process of fixation in the mineral fraction of the soil is completed within the first few years, although a significant portion of Cs-137 remains in chemical forms that are readily available to plants [7].

Radiation monitoring methods should include both the assessment of the contamination source and the evaluation of environmental contamination in the close zone (up to 5 km) and the distant zone (up to 100 km). Specific timeframes, data formats, procedures for data transmission and utilization for dose prediction, and decision-making recommendations should be developed.

The "GAMMA" radiation monitoring system has been developed since 1994 within the TACIS program. The implementation of the first stage of this project involves the creation of a network of three radiation monitoring stations in the vicinity of the Rivne, Zaporizhia, and Inchalin (Belarus) nuclear power plants.

The main objectives of the GAMMA system are:

- Detection of significant exceedances of radiation levels in the monitored areas.
- Notification of responsible personnel about such exceedances and providing them with the necessary information to take protective measures.

The GAMMA-1 system in Ukraine includes a national center (Information and Crisis Center, ICC) located in the Ministry of Ecology and two local centers in Rivne and Zaporizhia. Additionally, the system comprises:

- 27 power dose rate γ-radiation monitoring stations installed in the vicinity of the

Rivne nuclear power plant.
- 11 power dose rate γ-radiation monitoring stations installed in the vicinity of the Zaporizhia nuclear power plant.
- 1 automatic station for monitoring α-β-activity of aerosols, located 5 km away from the Rivne nuclear power plant.
- 1 automatic station for monitoring γ-activity of water at the Rivne nuclear power plant.
- 2 automatic meteorological monitoring stations (at the Rivne and Zaporizhia nuclear power plants).

Information from the respective sensors regarding radiation doses is transmitted to the local centers via radio channels and then relayed to the national center through dedicated telephone lines. The Ministry of Emergency Situations of Ukraine and regional subdivisions of the ministry in Rivne and Zaporizhia also have real-time access to the GAMMA-1 system (online mode).

From 1992 to 1997, a pilot project of the remote monitoring system for nuclear power plants was implemented at Unit 5 of the Zaporizhia nuclear power plant. The goal of the remote monitoring system was to obtain and transmit independent information about the state of the nuclear power plant to the ICC in real-time. This project was carried out within the cooperation program with the Federal Ministry of Environment of Germany.

In 1997, the German side provided computer and switching equipment for the reception, processing, and visualization of parameters at the ICC. The installation of a dedicated telephone line between the ICC and the Zaporizhia nuclear power plant was carried out, enabling the automatic real-time transmission of data to the ICC.

The Ministry of Ecology and Natural Resources plans to expand the remote monitoring system to all nuclear power plants in Ukraine (with the proper support from Germany and the European Union). In parallel with the GAMMA system, the European Union has developed and implemented the RODOS system (Real-Time On-line Decision Support System) as part of the TACIS program. RODOS is a European real-time decision support system for external emergency response in the event of nuclear accidents. The RODOS project involves scientists from over 40 institutions in Central and Eastern European countries, Ukraine, Russia, and Belarus.

The main objectives of the RODOS system are to provide tools for processing and managing large volumes of meteorological and radiation information, to assess and forecast the radiation situation in the event of an accident, and to model the use of countermeasures and response options during emergencies.

Discussion. The methodology defines the sequence of obtaining primary baseline information necessary for assessing the radiation situation in areas affected by radioactive contamination [8].

The land use survey consists of two stages: the first stage involves conducting γ-survey, which allows for precise determination of optimal sampling locations, and the second stage involves soil sample collection at these optimal locations. The **γ-survey** is conducted using calibrated and validated SRP-68-01 instruments at a distance of 1 meter from the ground surface. Prior to the survey, comprehensive data collection and analysis of all available information on the area are conducted, based on which the subsequent strategy for refining the radiation situation is determined.

If reliable information is available regarding the contamination density determined by express methods and the results of γ-spectrometry, then conducting only a control sample collection, consisting of 3-4 samples, may be sufficient. After processing and comparing the results with previously obtained data, this can serve as a basis for either proceeding with further refinement work or discontinuing it. In cases where the available information raises doubts, a comprehensive refinement of the radiation situation is conducted. It is also necessary to consider the absolute values of contamination density in agricultural fields. Areas where contamination density exceeds 5 Ci/km2 should be surveyed in more detail. The ratio of work volumes between contamination densities below 5 Ci/km2 and above 5 Ci/km2 should be 1:2. The level of detail in the survey in each agricultural field is determined by specialists from the Department of Environmental Protection and Natural Resources, using regional and provincial maps of radioactive contamination.

The cartographic basis for conducting γ-survey consists of land use plans executed at scales of 1:10,000 and 1:25,000. These plans should indicate the boundaries of fields, meadows, pastures, and forests, transportation routes, hydrographic network, contours of settlements, field and crop rotation designations, soils, and other supplementary information that characterizes each specific land use area. It is also necessary to have information about soil cultivation practices for each field after 1986. The cartographic basis used for soil-agrochemical surveys in agricultural fields is highly suitable for conducting γ-survey. However, unlike the previous method, the peculiarity of γ-survey lies in considering the entire field as the elementary plot, with route lines marked every 200 meters. The start and end points of the route should be placed no closer than 50 meters from the field boundary. While moving along the route, the surveyor performs indicative measurements using the SRP-68-01 instrument. The measurement results are recorded as follows: in case of minor changes in instrument readings (up to 30%), the background gamma values are marked on the plan along the route line every 200 meters. If, during continuous observation, the difference between instrument readings exceeds 30%, this result is recorded on the measurement plan, and additional surveying is conducted within a radius of 20-30 meters around it to determine the size of the anomalous spot and to map it on the cartographic basis.

After completing the first stage of the survey, the second stage, which involves soil sample collection for assessing surface radioactive contamination, begins. In conditions of homogeneous background gamma radiation, where the difference between individual measurement readings does not exceed 30%, one sample is collected within the field. A composite sample is formed by combining individual soil samples taken from 2 or 3 fields in the crop rotation if the contamination is uniform across the area. The sampling locations within a specific field are preferably distributed evenly, taking into account micro-landscape features.

If there are one or several anomalous spots covering more than 10% of the total field area, it is necessary to collect samples in these locations. In the areas where sampling is deemed permissible, the dose rate is measured at a height of 1 meter and

0.03-0.04 meters above the ground surface using instruments such as DRG-01T, DBG-06T, and IR-02. The location is considered suitable for sample collection if the dose rates at the specified heights differ by a factor of 1.3.

The selected location should be flat, homogeneous, and open. Individual soil samples are collected using a known area auger to a depth of 20 cm. The composite sample consists of no fewer than 5 individual samples with a total volume of 1500-3000 cm3.

Each individual sample is weighed, excluding the label, and its mass is recorded in the catalog (record). The contamination density calculation is performed using the following formula:

$$P = 2.7 * 10^{11} * \frac{A*M}{m*s*n} \quad (1)$$

where: A - activity of the sample on the day of measurement, in Becquerels (Bq), M - mass of the composite sample, in kilograms (kg), m - mass of the individual soil sample, in kilograms (kg), s - area of the sampling device, in square meters (sq. m), n - number of individual soil samples.

To determine the contamination density of the territory with plutonium, measurements are conducted on intact areas using a standard ring with a diameter of 140 mm and a height of 50 mm. After collection, each ring is packaged in the same manner as the soil samples obtained using the auger.

To determine the contamination density, a comprehensive radiological survey of all farms located within the territory of radioactive contamination was completed using the methodology in 1988. However, as proven by the Ukrainian Institute of Agricultural Radiology, the most straightforward, significantly more productive, and reasonably accurate method for comprehensive radiological survey of agricultural lands and its refinement is the method of converting gamma survey data into soil contamination density with radiocesium through a proportionality coefficient. This coefficient is determined by the following formula:

$$K = \frac{An}{R\gamma} \quad (2)$$

where K - experimentally determined proportionality coefficient between gamma background and soil contamination density; An - average contamination density determined by spectrometric analysis of 10-15 soil samples, Ki/km^2; Rγ - gamma background measured by the SRP-68-01 device at the center of the sampling area at a height of 1 meter above the ground, mR/h.

To experimentally determine the proportionality coefficient K for specific types of agricultural lands (fields, meadows, pastures) in typical locations based on the nature of the soil cover and contamination, test plots measuring 10x10 meters are selected. Within these plots, 10-15 soil samples are collected using a soil auger to a depth of 20 cm, and the gamma background radiation level is measured at the center of each plot using the SRP-68-01 device. The collected soil samples are dried, mixed, and the concentration of the radionuclide is determined through spectrometric analysis. To convert the obtained results to kg of soil, the specific mass of the soil is also determined. The soil contamination density is calculated using the formula:

$$A_n = 2 * 108 * C_{sr} * d \qquad (3)$$

where: An - soil contamination density by the radionuclide, Ki/km^2; Csr - average radionuclide concentration in dry soil, Ki/kg; d - specific mass of soil, g/cm^2.

The soil contamination density can also be calculated using another formula:

$$A = \frac{C_{sr} * m * 31.85 * 10^8}{r} \qquad (4)$$

where: Csr - average radionuclide concentration in dry soil, Ki/kg; m - average mass of the soil sample in the auger volume, kg; r - radius of the auger, cm.

By substituting the calculated average contamination density value into the formula (2), the proportionality coefficient between the gamma background radiation and the contamination density is determined. The average value of the proportionality coefficient (based on the number of experimental test plots) is used for calculating the soil contamination density in the specific region.

Once the experimentally justified and weighted proportionality coefficient is obtained, you can proceed with conducting a comprehensive radiological survey or refining the contamination density of the soils based on the previous survey data (e.g., from the 1988 survey) or by conducting another round of γ-survey.

The measurements of γ-background using the SRD-68-01 device are substituted into the formula:

$$A_n = K * P \qquad (5)$$

After simple calculations, the contamination density indicators of the soil with radiocesium are obtained. Based on these indicators, cartograms, field contamination information, and radiological passports are compiled for each agricultural enterprise.

Based on the contamination density cartograms, all fields should be divided into three groups: up to 5 Ki\км^2, 5-10 Ki\км^2, and 10-15 Ki\км^2. If possible, within each group of fields, it is advisable to carry out land reclamation considering the soil contamination density and the specific accumulation of radiocesium by agricultural crops.

The results of the radiological survey are also used for the preliminary assessment (prediction) of the potential for obtaining agricultural crops, meat, and milk with levels of radionuclides that exceed the permissible limits.

Conclusion. In conclusion, the deteriorating ecological situation in Ukraine, including the agroecological state of the soil cover, emphasizes the need for the State Agrochemical Service to transition from soil agrochemical surveys to comprehensive soil-agrochemical monitoring of agricultural lands. Such monitoring belongs to the ecological monitoring type and consists of three main components: soil surveys (including laboratory analysis), assessment of their agro-ecological condition, prediction of changes in relevant indicators, and soil fertility management, which refers to the specific properties of soils that distinguish them qualitatively from their parent geological formations.

Unlike soil agrochemical surveys, which have been conducted periodically every 5 years since 1965 by regional design and search stations for chemicalization in almost all farms, comprehensive soil-agrochemical monitoring raises this crucial area of agrochemical service to a higher scientific and methodological level, primarily through prediction and quality assessment of soils using a combination of agrochemical, agrophysical, and toxicological indicators.

Considering this, it is advisable to study and apply the experience of foreign countries in organizing agricultural landscapes in soil monitoring (USA), mitigating the negative consequences of chemicalization (Japan, the Netherlands, Sweden), radioecological research (Japan, Sweden), marketing nature conservation technologies (Germany, Japan), computational techniques for monitoring (USA, Bulgaria), organizing quality water supply and product quality control (France, Austria), providing climate information to consumers (France, the UK), and conducting environmental education work (Germany, Switzerland).

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