

## **Annotation**

Dissertations for the degree of Doctor  
of Philosophy (PhD)  
6D060800 – Ecology

**Murzalimova Assel Kabdygalievna**

Monitoring of radioecological effects of ionizing radiation using  
geoinformation systems (using the example of Sarapan and Zhanan wintering  
grounds)

**The relevance of the topic-** For many years, ground, air and underground tests of nuclear devices have been conducted on the territory of the Semipalatinsk Test Site (STS). The test area was contaminated with nuclear materials, nuclear fission products, as well as radionuclides of induced activity.

After the closure of the landfill in 1991, settlements appeared on it, and herds of horses and sheep began to graze on the territory of the landfill. Protecting the environment, especially the population, from the effects of residual radioactivity is the main task in solving the problems of the landfill. It is necessary to carry out additional work on the assessment of the consequences of radionuclide contamination of STS with the subsequent development of recommendations on the use of land from the point of view of radiation safety. This creates the need for scientific development and practical implementation of methods and approaches that provide an assessment of the degree of impact of radioactive contamination of soil and vegetation cover on the living population.

The most appropriate approach to solve these problems is to conduct radioecological monitoring of the territory of the STS. The main task of radioecological monitoring is to create a unified information space that can be formed based on the use of modern geoinformation technologies. The large amount of information inherent in environmental research, often due to the complexity of perception and complex nature, cannot help solve the problem without reference to a geographical map.

The integrative nature of geographic information systems (GIS) makes it possible to create on their basis a powerful tool for collecting, storing, systematizing, analyzing and presenting information. The use of GIS for the analysis of radioecological processes in radioactively contaminated territories at the sites of nuclear tests makes it possible to efficiently process a large amount of information necessary to solve problems related to the rehabilitation of contaminated territories. The development of personal computers, local and global data transmission networks, GIS and other information technologies used creates a potential opportunity for the introduction of information and analytical environmental monitoring systems designed to support decision-making in the field of radioecological situation analysis and environmental management.

The need to make specific management decisions to improve the radiation situation of the landfill and the protection of public health determined the relevance of the dissertation work.

**The purpose of the work:** to conduct radioecological monitoring of the wintering grounds of Sarapan and Zhanan, located on the territory of the former Semipalatinsk test site, using geoinformation systems necessary for the effective use of land and management decisions.

To achieve this goal, the following tasks were set:

1. Development and implementation of the structure of the information and analytical unit of the radioecological monitoring system of the Sarapan and Zhanan wintering grounds located on the territory of the former Semipalatinsk test site;
2. Determination of the spatial distribution of radionuclides in the soil of wintering grounds located near the "Atomic Lake";
3. Investigation of the parameters of the vertical distribution of radionuclides in the soils of wintering grounds in the area of "Atomic Lake";
4. Study of indicators of accumulation of radionuclides in the "soil-plant" system, conducting an elemental analysis of vegetation growing near the "Atomic Lake".

The object of the study. The objects of the study are the soil and vegetation cover of wintering grounds located near the "Atomic Lake" on the territory of the former agricultural complex.

**Research methods.** The thesis uses system analysis, mathematical modeling, theory of information systems and processes, theory of decision-making, simulation and real experiments. The specific activity of radionuclides was determined by  $\alpha$ ,  $\gamma$  - spectrometer, elemental analysis – by mass spectrometry. Standard statistical packages Microsoft Access 2019, Excel 2019, Statistica 11 and Golden Surfer 11, ArcGIS were used for data processing.

**The main provisions submitted for protection::**

-Development and implementation of the structure of the information and analytical unit of the radioecological monitoring system of the Sarapan and Zhanan wintering grounds located on the territory of the former STS.

- The studied soils are characterized by increased specific radioactivity of  $^{137}\text{Cs}$ ,  $^{90}\text{Sr}$ ,  $^{241}\text{Am}$ ,  $^{239+240}\text{Pu}$ . In soil samples near the "Atomic lake", the values of the activity of radionuclides vary widely. The spatial distribution of radionuclides in the soils of the Atomic lake area is uneven.

-The parameters of the vertical distribution of radionuclides in the soils of wintering grounds on the territory of the "Atomic lake" were investigated. For the studied radionuclides, there is a concentration of activity in the surface layer of 0-5 cm of the main soil and a decrease in activity at a depth of 15-20 cm.

-A number of radionuclides were obtained by their ability to accumulate by plants from the soils of the studied territory:  $^{90}\text{Sr} > ^{137}\text{Cs} > ^{239+240}\text{Pu} > ^{241}\text{Am}$ . Data on the accumulation of radionuclides by plants in the area near the "Atomic lake" indicate their low availability for plants.

### **Description of the main results of the study:**

1. The effective structure of the information and analytical unit of the radioecological monitoring system of the Sarapan and Zhanan, located on the territory of the former STS. The application of the proposed scheme of radioecological monitoring in the study area was carried out using affordable and effective software systems Microsoft Access, Excel, Statistica and Golden Surfer, ArcGIS.

Microsoft Access, Excel were used to combine information about the coordinates of the selected samples and the laboratory analyses performed. Golden Surfer 11 and ArcGIS software. Scattering diagrams of radioactive contamination, depending on the goals set. The interpolation of the research results was carried out by Kriging and Natural Neighbor methods.

Standard statistical packages Statistica 11 were used to calculate and process statistical data on the transition coefficients in the soil-plant system and vertical migration of radionuclides in the soil. According to the results of field studies of the wintering grounds of Sarapan and Zhanan, located on the territory of the agricultural complex, an ecological database has been created.

2. With the depth of sampling in light and dark chestnut soils, a decrease in the values of cation absorption capacity, quantitative indicators of mobile cations and the percentage of humus was observed. Granulometric analysis showed that the soils of the studied territory were characterized by the predominance of coarse-grained and fine-grained fractions, which make up about 41% of the soil mass. It was found that the pollution of wintering grounds around the "Atomic Lake" is uneven ( $^{137}\text{Cs}$  from 6.4 to 4500 Bq/kg,  $^{90}\text{Sr}$  from 8 to 4300 Bq/kg,  $^{241}\text{Am}$  from 1 to 350 Bq/kg,  $^{239+240}\text{Pu}$  from 7 to 1800 Bq/kg). The features of the spatial distribution of radionuclides on the territory of wintering grounds near the "Atomic Lake" are revealed.

3. For the studied radionuclides, a sharp decrease in the specific radioactivity of  $^{137}\text{Cs}$ ,  $^{90}\text{Sr}$ ,  $^{241}\text{Am}$ ,  $^{239+240}\text{Pu}$  was observed at a depth of 15-20 cm, with the main part of the activity concentrated in the surface layer of the soil at 0-5 cm.

4. In plants selected near the "Atomic lake", the coefficients of accumulation of radionuclides vary within narrow limits (0.01-0.08). A small value of the accumulation coefficients showed weak activity of radionuclide movement in the soil and, accordingly, low accumulation in plants. A number of radionuclides were obtained by the ability to accumulate in plants from the soils of the studied area:  $^{90}\text{Sr} > ^{137}\text{Cs} > ^{239+240}\text{Pu} > ^{241}\text{Am}$ .

An elemental analysis of the vegetation growing near the "Atomic lake" was carried out. It is established that the concentration of elements in dry phytomass is unevenly distributed. The accumulation of elements such as Ni, Cs, V, Cr, Pb, U, Cd, Ga and As was observed from the studied plants. A geochemical series of accumulation coefficients has been established:  $\text{As}17 > \text{Ga}12 > \text{Cd}6 > \text{U}5 = \text{Pb}5 > \text{Cr}3 = \text{V}3 = \text{Cs}3 > \text{Ni}2$ . Correlation analysis showed a high level of interaction of elements in the vegetation cover. The obtained quantitative characteristics of radioactive contamination and the parameters of radionuclide

migration in the soil-plant system made it possible to assess the radiation situation and characterize the territory of the STS.

**Substantiation of the novelty and importance of the results obtained:**

An approach has been developed to create information and analytical systems for radioecological monitoring, which are the theoretical basis for the preparation of appropriate software, and can also be used in the development of such systems for the territory of the former agricultural complex and other man-made facilities.

The features of spatial distribution and parameters of vertical migration of radionuclides in soils near the "Atomic lake" are determined.

The parameters of the accumulation of radionuclides in the "soil-plant" system near the "Atomic lake" have been determined.

For the first time, an ecological database has been created based on the results of field studies of the Sarapan and Zhanan wintering grounds located on the territory of the former STS.

The results of radioecological monitoring of the Sarapan and Zhanan wintering grounds located on the territory of the former STS can be used in scientific research on environmental protection issues. **Обоснование новизны и важности полученных результатов:**

**Personal contribution of the author** consists in setting up and conducting experiments, developing the structure of the information and analytical block of the integrated radioecological monitoring system, creating a flowchart for the use of software products in the radioecological monitoring system and their application in the processing of results, summarizing the data obtained by writing articles.

**Approbation of the work.** The main results of the work and individual provisions were presented at the international conference "III International Congress of Young Scientists on Sustainable Development", Moscow, June 30, 2017; VII International Student Forum "Green Bridge from generation to generation", Almaty, April 9-10, 2018; International Scientific Conference of Students and Young Scientists "Farabi Alemi", Almaty, April 2-12, 2019

**Connection with research work and government programs.** The topic "Monitoring of radioecological effects of ionizing radiation using geoinformation systems (for example, the Sarapan and Zhanan wintering grounds)" presented for the defense of the thesis was carried out within the framework of solving one of the urgent environmental problems of the Abai region (the ecological state of the territories of the former agricultural complex).

**Publications.** The main scientific results of the dissertation work have been published in 8 printed works, including 1 article included in the Scopus database, 3 articles in publications recommended by the Committee for Control in the Field of Education and Science of the Republic of Kazakhstan, and materials of international scientific and practical conferences.

**Structure and scope of work.** The dissertation consists of an introduction, 5 chapters, a conclusion and 206 references, contains 132 pages, 44 figures and 13 tables.