Radiological atlas of Zhambyl oblast in Kazakhstan

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Complex of radiation studies was carried out on territory of Zhambyl oblast in 2011-2013. All impact radiation factors were studied including radon appearances in room air and water supply sources. Outcomes of the studies and previous investigation allow make up a Radiological Atlas of Zhambyl oblast with showing basic radiological problems and developing measurements for its decisions.

Key words: *radioecologikal atlas, uranium, radon, radioactive waste, radiocontamination, rehabilitation measures.*

Itroduction

Zhambul oblast is a desert and semidesert plain located in the basin of the lower course of the rivers Shu and Talasa, between the ridges Karatau in the southwest, the Kyrgyz Alatau in the south and Shu-Ili Mountains (Aitau) in the east. The largest area among the mountain systems in the oblast is occupied by the Shu-Ili Mountains, within which are situated the bulk of the radiation facilities of the oblast. The main among these facilities are the Central Shu-Ili uranium ore of Balkhash uranium ore province, occupies the main part of the Shu-Ili Mountains. The territory of Central Shu-Ili district is a complex structure, which consists of structure-formation and different ages magmatic complexes, which are interconnected in an aggregate relationship [1].

Betpakdala-Shu-Ili-Kendyktasskaya uranium province consisting of several uranium deposits that are intensively developed by two mine groups from the 50s to mid 80s of last century occupies the North-Eastern part of Zhambyl oblast. Shutdown of uranium mines occurred in the crisis years were left without adequate reclamation. Genetically with uranium and thorium associated other ore zones and deposits. These include gold (Aksuek), copper (Shatyrkul, Zhaisan), and coal (Kulan).

In the south of Zhambyl oblast is passed the regional geochemical vein system of Tau-Dzhabagly-Kyrgyz range. In the Malyi Tau are known phosphate field, which includes more than 40 occurrences of phosphorites with a high content of uranium. In Dzhabagly are diffused vanadium carbonaceous-siliceous shales enriched in uranium. In the Malyi Tau are marked outcrops of the small arrays of late ordovician granites and granitoids, and in Dzhabagly – middle carboniferous granites and granitoids. Kyrgyz range is saturated by the complexes of Proterozoic and Ordovician granite and granodiorite, which spatially and genetically associated with numerous deposits of copper, polymetal with associated uranium mineralization.

Radiogeochemical zones on the areas of the outcrops of rock roaches are manifested in the escape of temporary and permanent water ducts and later in stand-by tanks. They are genetically related with increased values of radioactivity in sediments of alluvial fans of rivers and streams from the mountains Malyi Karatau and Dzhabagly, Talas and Kyrgyz ridges in the south of Zhambyl oblast, Shu-Ili Mountains, and Kendyktas and Kastek – in the northeast of Zhambyl oblast.

These streams are characterized by the increased of the radiogeochemical background in the areas of water flowing into the rivers Shu, Talas and Ters (Assa) basins and form at different sorption barriers uranium concentrations, what reaching levels of ore occurrence, and small deposits (Assinsky, Kumozek).

The tectonic structure of the area is also extremely difficult [2]. The basis of its deep structure forms a system of large geo-blocks with various geochemical orientation. Deep faults in the crust determine the main tectonic plan of the district. Besides them are manifested numerous tectonic faults of various orders, which may be the channels of delivery of radon from the depths to the surface (Figure 1).

Radiological knowledge of the territory of the area of works before 2011-2013 was extremely uneven. The southern and eastern part of the region were the most studied. It was associated with the conducting in the period up to the 90s works on prospecting and exploration of uranium on the territory of Balkhash uranium ore province, covering almost the entire area of the Chu-Ili Mountains, as well as special works (radiogidrolitochemichal surveying – 2004 [3], radiation monitoring of area of rural settlements – 2009 [4]) on the territory of residence of the main part of the population (Figures 2 and 3).

Research goal

On the territory of the oblast is situated the main part of Balkhash uranium ore province, including 12 uranium deposits, more than 20 ore occurrences, which to a greater extent determined the radiation situation in in the oblast. In addition, in the region were identified dozens of areas of radioactive contamination of various origins, also contributing to the formation of high levels of radiation risk. Data for radiation situation in Zhambyl oblast accumulated in the pass years allowed in the period of 2011-2013 to conduct a complex and detailed works whose purpose was the developing of the Radiological Atlas of the oblast with a reflection of the modern radiation situation, identifying of the major radioecological problems and development of measures for their solution.

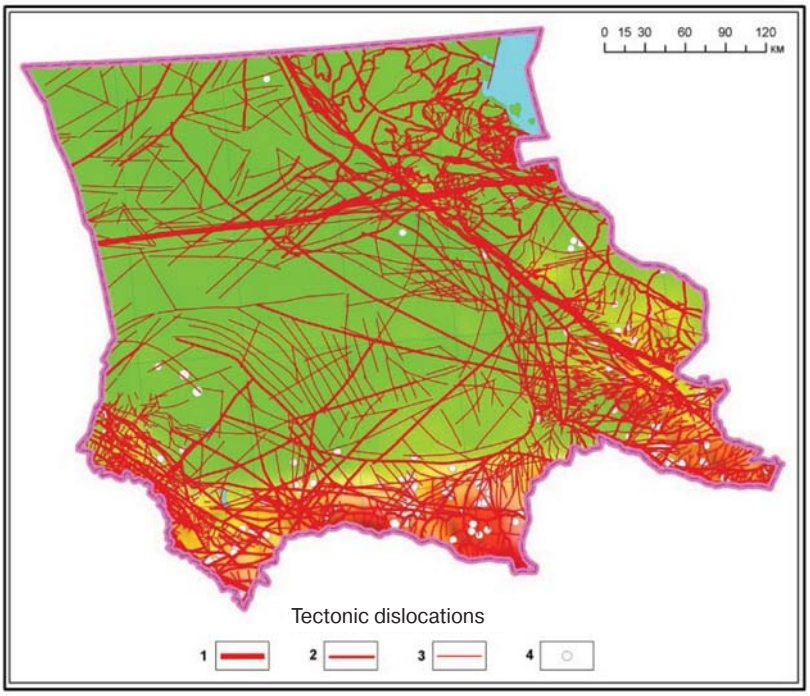

Fig. 1. Scheme of tectonic structure on the territory of Zhambyl region according to the decoding satellite images. Legend: Tectonic dislocations: 1 – 1-th order, 2 – 2nd order, 3 – 3-th order, 4 –seysmosoevents

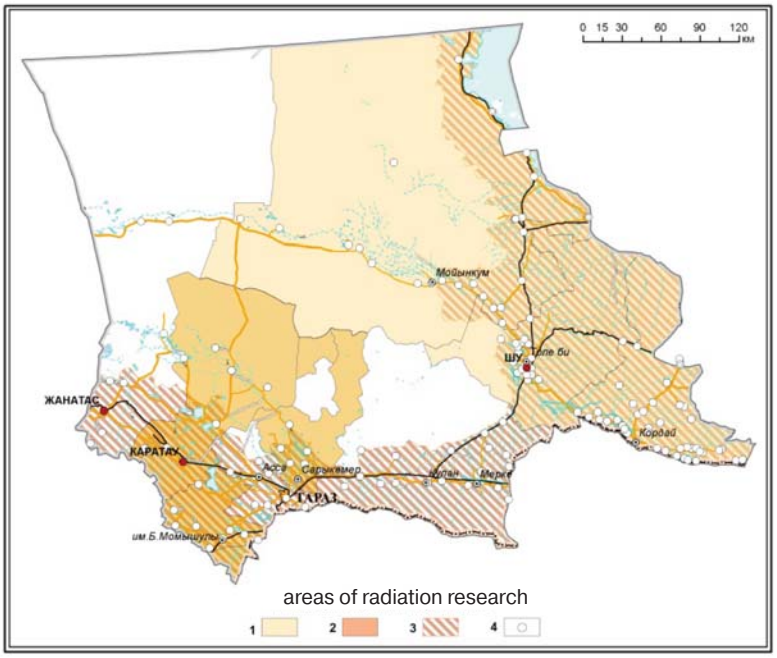

Fig. 2. Scheme of the areas of radiation research in Zhambyl oblast Legend: areas, researching by 1-TOO «EKOSERVIS-C», 2009. (ecological and demographic survey), 2-TOO «EKOSERVIS-C», 2009. (radiation monitoring), 3-AO Volkovgeology 2008. 4-studied localities

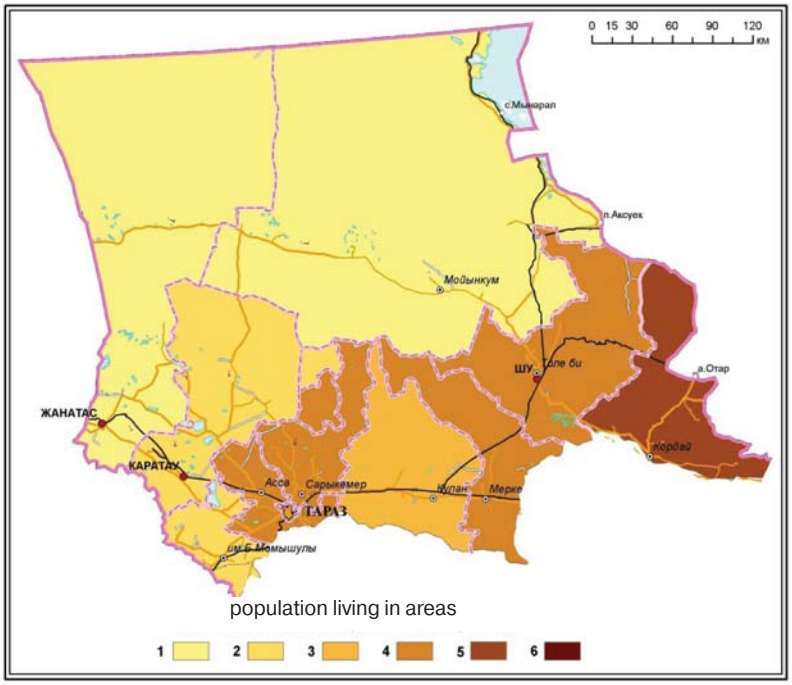

Fig.3. Scheme of the distribution of population of Zhambyl oblast by population in areas Legend: population living in areas (people):
1 – 30000-40000, 2 – 40000-50000, 3 – 50000-60000, 4 – 60000-90000, 5 – 90000-100000, 6 – 120000-320000

Materials and methods

Received data on the results of radiometric examination of past years allowed determining and implementing in 2011-2013 years for the developing of the Radiological Atlas of the oblast the set of studies. Main of this studies were radiological surveying of the settlements, estimation of radon concentration in soil, water, agricultural products, evaluation of indoor radon concentration and radon concentration in drinking water sources, estimation of public doses. At estimating of exposure was taken into account affecting of all these factors, and influence of the pass uranium facilities and radiation exposure to patients and personnel during X-ray examinations. In view of conducting earlier radiogidrolitochemical surveys of the territory and radiation monitoring of the settlements the studies included the system allowed estimating of radon hazardous and provide zoning of the territory of the oblast according to the radiation situation with compilation of radiation-hygienic passports of the districts and settlements, and eventually, to develop the Radiological Atlas of the Zhambyl oblast [5].

Results and discussion

Taking into account studies of previous years in Zhambyl oblast was made radiation survey of 316 villages and 4 towns. Analysis of natural and geological features allowed selecting of 4 landscapes-radiogeochemical blocks with various structural-tectonic and radiation-geochemical characteristics and with different levels of public exposure, were identified 10 areas with high radiation intensity, which occupy about 15% of the territory.

In the result of the radon hazardous assessment was found that the 26.2% of surveyed villages were exceeding the regulation limit (200 Bq/m^3) of radon concentration. The analysis of the radioactivity of the water showed that in 45.1% of surveyed water sources used for drinking water supply identified excess (up to tenfold or more) of alpha activity. The activity of radon in drinking waters throughout the territory of Zhambyl oblast does not exceed the standard of 60 Bq/L. Nevertheless, on the map of the distribution of volume activity of radon are well-defined areas of increased activity of radon in the water. To these areas largely limited to dedicated areas of abnormal activity of radon in indoor air.

The results of these studies allowed to compilate radiation-hygienic passports for all 10 districts of the oblast, for the towns (Taraz, Shu, Karatau and Zhanatas) and for dedicated radon hazardous zones. In passports are submitted data about background and anomalous radiation characteristics of environment in the districts and towns – the indoor and outdoor air, drinking water, soil, food, dose rate of gamma radiation inside and outside the building, and the radioactivity of building materials, the conditions of the using of X-ray machines and ampoule of radioactive sources, the presence of natural or technological objects and abnormal elevation of radioactivity on the surface area of the villages, radiation sources, and the structure of the exposure of the population with medical procedures, the results of the estimates of doses from external and internal exposure. At the conclusion of each passport is given a generalized evaluation of the sources of the anomalous radiation exposure and were given activities to reduce doses of radiation exposure and health risks, based on the features of the distribution of radioactivity in the environment area. Each passport is accompanied by a map with the location of the abnormal radiological manifestations and proposed measures to eliminate them. Radiation characteristics of the areas formed the basis for developing of the Radiological Atlas of oblast.

Compiled Radiological Atlas of oblast includes about 130 maps and charts (30 maps with different characteristics of the region, 86 maps with the results of the radiological survey of villages and 10 maps – application to the radiation-hygienic passports of areas). In the Atlas on the base on the analysis of the constructed maps and analytical material were formulated radiation problems of the Zhambyl oblast and proposed measures to improve radiation situation and reduce risks to public health from ionizing radiation sources. Estimations show that research during the developing of Radiological Atlas of oblast and the implementation of the presented measures to reduce exposure and collective dose, and therefore the preservation of public health is economically advantageous, as the economic effect of implementation of these measures in the region could reach $1 million or more per year.

The results of studies of the radiation situation in Zhambyl oblast with the assessment of levels of radioactivity of environment allowed us to estimate dose per person from ionizing radiation. The value of radiation dose differs markedly by region. In two areas, the quantity of doses close to the European average (2.4 mSv/year), in the five areas, it exceeds the average value in one and a half times, and in three districts dose exceeds centralkazakh level (4.2 mSv/year).

The main factors in determining of the radiation dose to the population is the natural radioactivity of the region, the alpha and beta activity of drinking water sources and the activity of radon-222 in indoor air.

Radiation characteristics of the surface area of the Zhambyl oblast enough homogeneous – 16-24 mSv/h, but sometimes activity levels reaches 0,27-0,30 Sv/h or more in areas where exposed granite rocks or other entities with high radioactivity. In the water sources used for drinking water supply, often detected excess alpha activity (up to ten-fold or more). These two factors make a definite contribution to the radiation dose. However, the main contribution to the public dose, as noted in other areas [6], creates a radon activity. If as a result of assessing radon found that 26.2% from the surveyed villages were with excess of regulation value (200 Bq/m^3) of radon activity, with a taken as regulation value 100 Bq/m^3 the number of settlements increase to 52.8%. Elevated median values of radon in indoor air spatially close together and combined into groups with similar geological setting location of settlements. The combined groups include settlements with a high median value of radon EEVA (over 50 Bq/m^3) or dwelling with excess of regulation value of radon EEVA 200 Bq/m^3. Identified excess form 10 anomalous zones. On the territory of the dedicated zones was conducted detailed work with determination as momentary change of radon concentrations, and integral, which were exposed by a period of 3 months in 2442 detector. When comparing of the results of measurements of radon EEVA made by radiometer Ramon-01, and measurements of radon concentration performed by a system RadoSys (Hungary), found that the median values of radon momentary concentration are confirmed by the integral value (with differences less than 30%).

Based on analysis of the developed maps and analytical data based on the results of studies of past years [7] were conducted zoning of Zhambyl oblast by radiation situation demonstrated in the map of the total radiation dose (Figure 4), indicating that in oblast necessary to conduct detailed studies of local radiation hazardous areas and measures to reduce risks to human health from exposure to ionizing radiation from natural and anthropogenic sources [8].

In developing of the Radiological Atlas was completed evaluation of the radiation condition of almost all towns and all radiation facilities (uranium deposits and occurrences, storage and disposal of radioactive waste, and others.), which made it possible to identify the problems and measures to improve the radiological situation and reduce the radiation risk to public health. These activities include:

• Completion of the disposal of all radioactive wastes generated in the exploration and mining of uranium and the development of other minerals associated with uranium mineralization, as well as the necessary measures to ensure radiation safety (periodic monitoring of the status of radiation safety of ore facilities, completion of covering of refuse dumps of radioactive rocks by inert soil at a number of sites and the restoration of eroded parts of surficial to prevent unauthorized use of stone material with a population of ore dumps, closing several shafts and adit entrances, construction warning signs of radiation danger and restore of barriers (over most of the uranium facilities).

• Completion of rehabilitation of identified areas of radioactive contamination.

• Replacement of obsolete x-ray equipment.

• Re-inspection of the detected exceeding of the maximum alpha activity in drinking water sources (primarily in settlements with excess of 1.0 Bq/l) and, in case of confirmation of the excess of the norm, the adoption of measures to ensure drinking water quality.

• Conduct a wider radiation survey of drinking water sources used by people (in addition to the basic in every village studied in research) and informing the public about the need to use for drinking water sources only proven.

• Conduct education of the population about the necessity of radon mitigation activities (sealing of residential and office spaces from the proceeds of radon from beneath the floor, the organization of the natural ventilation of the underground space, and, if necessary, forced ventilation equipment, etc.) and providing comprehensive assistance in the implementation of these activities.

• Extensive monitoring of revealed abnormal instantaneous activity of radon in indoor air, by measurements of radon track method to obtain integral values that will clarify map of the doses from radon according to the average values and will serve to identify new areas in which it will be necessary to conduct radon mitigation activities depending on the level of radon hazard.

• Development of recommendations and requirements for newly constructed homes, providing indoor radon activity below 100 Bq/m3, and development and implementation of the system familiarization with these recommendations and requirements of the builders of new homes in rural areas.

Conclusions

1. Compilation of Radiological Atlas serves to identify all the factors of radiation in the region, and the Atlas is the operational effectiveness of the instrument for the development of measures to reduce radiation doses and public exposure.

2. In connection with the completion in 2008 of rehabilitation works on objects of exploration and mining of uranium ore, the impact of these facilities on the environment and the health of the population are now significantly reduced and can be evaluated as a factor in the low level of risk to public health Zhambyl oblast.

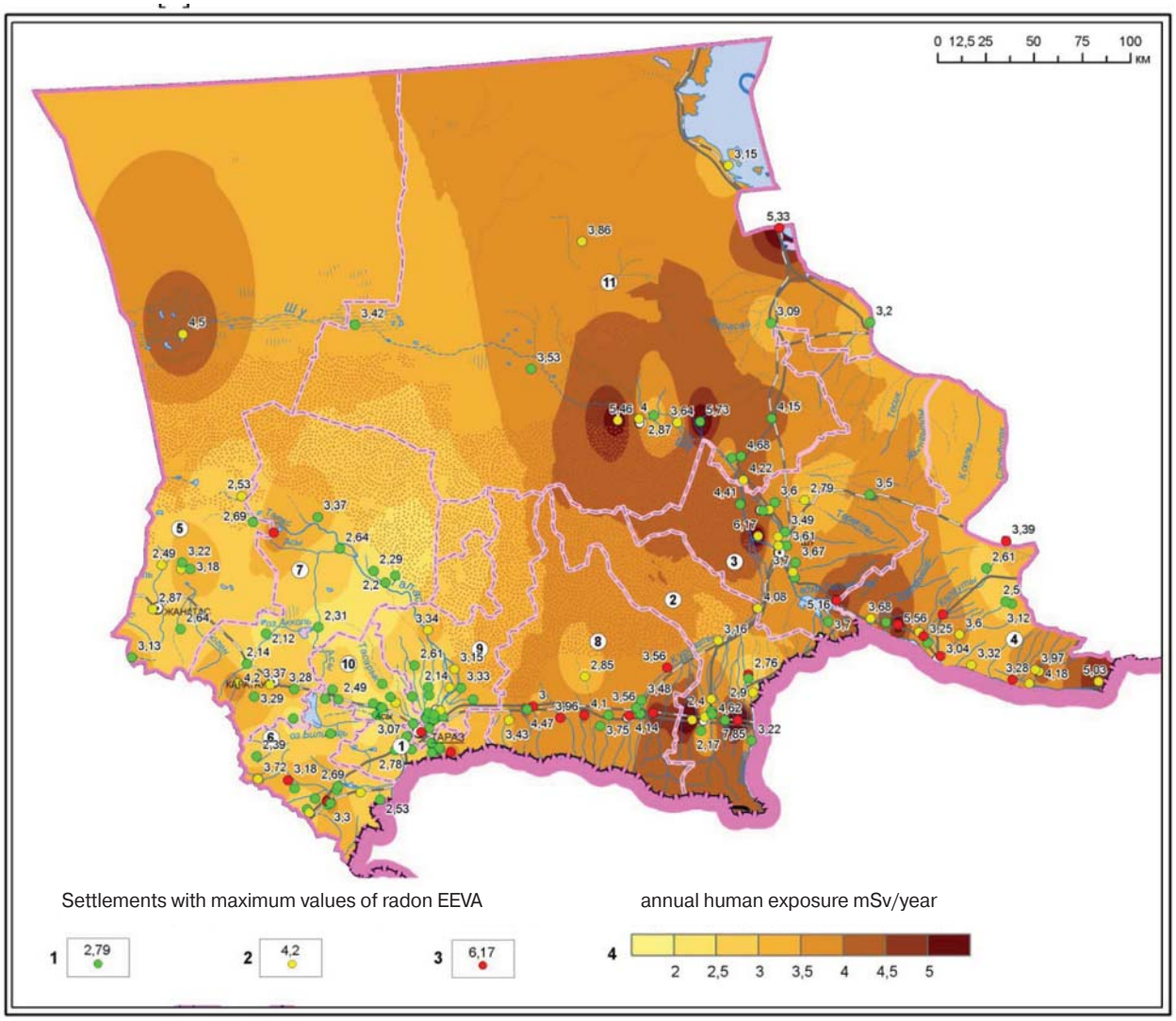

Figure 4. Map of the total radiation dose Zhambyloblast
Legend: Settlements with maximum values of radon EEVA: 1 – to 100 Bq/m^3, 2 – from 100 to 200 Bq/m^3, 3 – 200 Bq/m^3 and above (upper value of the annual total dose, mSv/year), 4 – the annual human exposure mSv/year

3. Key risks to public health are exceeded of the regulatory level of radon concentration in indoor air in a number of areas, and the identification of increased radioactivity (mainly alpha activity) in water sources used for drinking purposes, indicating of necessity of detailed studies of identified by these criteria radiation hazardous areas and take action to reduce risks to human health from exposure to ionizing radiation from natural and anthropogenic sources.

4. The maximum effect of reducing radiation risk can be achieved by introducing radon protection of premises, cleaning of contaminated drinking water sources (or their replacement), and reducing unwarranted use of the defective x-ray equipment.

5. Conduct research and implementation of the proposed measures to reduce risks to human health from exposure is financially attractive to economic efficiency on the field up to $ 1 million per year due to preservation of health of the population living in radon areas.

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