

Ministry of education and science of Republic of Kazakhstan RSE «al-Farabi Kazakh National University» «National Nanotechnology Laboratory of Open Type»



Modeling of the distribution of radionuclide concentrations in organs and tissues of the human body

M.T.Bigeldiyeva, V.V.Dyachkov, A.V.Yushkov, Yu.A.Zaripova

National Nanotechnology Laboratory of Open Type, Almaty, Republic of Kazakhstan

Monitoring the accumulated dose in the population from natural terrestrial radionuclides and timely assessment of the maximum dose to prevent potential risks of radiogenic oncological diseases is an important and one of the priority tasks. The main source of the accumulated dose by the population is the natural terrestrial radionuclides that enter the body through human life, and this problem is international in nature [1].

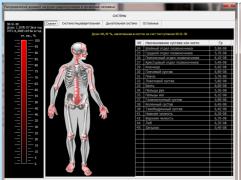


Fig. 1. Computer program interface for calculating the relative concentration of natural radionuclides in the skeletal system of the human body

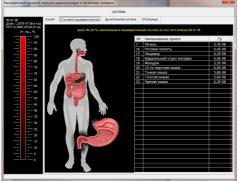


Fig. 2. Computer program interface for calculating the relative concentration of natural radionuclides in the organs of the digestive system of the human body

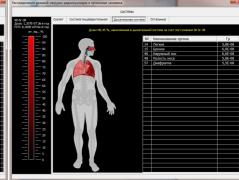


Fig. 3. Computer program interface for calculating the relative concentration of natural radionuclides in the respiratory system of the human body

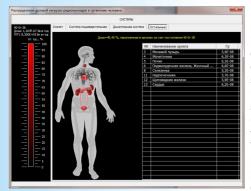


Fig. 4. Computer program interface for calculating the relative concentration of natural radionuclides in the organs of other systems of the human body

The concentration of chemical elements in the organs and tissues of the human body pretty much depends not only on the use of certain products, but also on geographical residence with a different geological landscape [2]. Different concentrations of chemical elements accumulated in various organs or tissues entail the accumulation and corresponding distribution of natural radionuclides. In this work, the authors developed a software-mathematical complex [3], which allows you to simulate the distribution of natural nuclides and radionuclides in the organs and tissues of the human body. Unlike existing software systems that simulate the interaction of radiation with biological objects, such as Geant4-DNA, etc. [4], the developed program simulates the spread of radionuclides throughout the body, taking into account the conversion factors from one organ to another. Thus, a mathematical calculation based on experimental accumulation coefficients and methods for calculating the doses of ICRP makes it possible to calculate the internal radiation doses of the corresponding organs and tissues. Such modeling allows us to calculate the risks of cancer due to internal exposure to incoming natural terrestrial radionuclides. The distribution of the studied radionuclides is visualized, which allows you to visually study the potential areas of internal sources of radioactive radiation.

The software calculates the dose in the human body from the incoming radionuclide, taking into account its accumulation coefficient in organs and tissues: $c \cdot \overline{F} \cdot 1.6 \cdot 10^{-13} \cdot 4.4k$

 $D = \frac{\varepsilon \cdot \overline{E} \cdot 1.6 \cdot 10^{-13} \cdot A \cdot (k_{T})_{i} \cdot (k_{R})_{i}}{m}$

where ε is the average efficiency of absorption of gamma quanta in the human body and is equal to 10%; *E*-the average energy emitted by a radionuclide in one decay act is 1.3 MeV; *A* is the activity of the radionuclide in Bq; *kT* is the coefficient of accumulation of elements in human organs and tissues for a given radionuclide [5]; *kS* is the dose coefficient of exposure Sv / Bq [6-9]; *mj* is the mass of a human organ or tissue, in this version of the software it is the mass of the entire human body and is equal to 70 kg; i is the selected radionuclide.

The field in the central part of the window contains a profile of the human body, which, depending on the selected body system, shows the corresponding organs. For a visual demonstration, the organs are colored with the intensity of the accumulated calculated dose. Such visualization of "highlighted" organs of the human body makes it possible to assess the degree of risk of malignant radiogenic tumors.

- 1. The risk of lung cancer due to exposure to indoor daughter products of radon decay: Publication 50 of the ICRP. M .: Energoatomizdat, 1992 .-- 112 p.
- 2. L.P.Rikhvanov, N.V.Baranovskaya, T.N.Ignatova et al. Chemical elemental composition of human organs and tissues and its environmental significance // Geochemistry. 2011. No. 7, Iss. 49.- S. 779-784.
- 3. V.V.Dyachkov, M.T.Bigeldiyeva, A.V.Yushkov, Yu.A.Zaripova. Calculation of the dose of radionuclides in the human body // Kazpatent. Application for software copyright No. 8416 dated 27.20.2020
- 4. S. Guatelli, S. Incerti. Monte Carlo simulations for medical physics: From fundamental physics to cancer treatment // Physica Medica. Volume 33, January 2017, Pages 179-181
- 5. Rikhvanov L. P., Baranovskaya N. V., Ignatova T. N. et al. Chemical elemental composition of human organs and tissues and its ecological significance // Geochemistry. 2011. No. 7, Issue. 49 .-- S. 779-784.
- 6. Standards of radiation safety NRB-99 // Republic of Kazakhstan. 1999.
- 7. Hygienic standards "Sanitary and epidemiological requirements for radiation safety" // Approved by order of the Minister of National Economy of the Republic of Kazakhstan dated February 27, 2015 No. 155.
- 8. Sanitary rules "Sanitary and epidemiological requirements for radiation safety" // Order of the Minister of Health of the Republic of Kazakhstan dated June 26, 2019 No. KR DSM-97.
- 9. Sanitary Rules "Sanitary and Epidemiological Requirements for Radiation Hazardous Facilities" // Order of Acting Minister of National Economy of the Republic

