

Application of zonality conceptual model of chronic effects of ionizing radiation for studying the behavior of Sr-90 in terrestrial ecosystems

R.R. Shoshina^a, G.V. Lavrentyeva^{a,b,*}, B.I. Synzynys^a

^aObninsk Institute for Nuclear Power Engineering, National Research Nuclear University MEPhI., 1 Studgorodok, Obninsk, Kaluga Region 249040, Russia

^bKaluga branch, Bauman Moscow State Technical University., 2 Bazhenov str., Kaluga, 248000, Russia

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Abstract

Behavior of Sr-90 radionuclide in the system of «soil-plants-mollusc shells» was investigated on the example of biotope of regional radioactive waste storage facility. The purpose of the study was to examine the possibility of applying the conceptual model of zonality of chronic effects of ionizing radiation in natural populations in the investigation of behavior of radioactive strontium in terrestrial ecosystems and to identify radioecological zones of biological effects of chronic exposure to ionizing radiation of the mollusc population based on of the bio-geochemical regularities of technogenic migration of Sr-90 within the «soil-plants-mollusc shells» system. The study was conducted on the experimental site which represented the biotope of the regional radioactive waste storage facility. Analysis of samples of soil, plant (*Urtica dioica*) and terrestrial molluscs was implemented by the method of radiochemical separation followed with measuring the activity of the radionuclide using scintillation spectrometer «BETA-01C». Annual exposures to external beta-radiation received by tissues of molluscs irradiated by Sr-90 and its daughter radionuclide Y-90 contained in the shells were calculated using Levinger and Marinelli formula.

It was discovered that dose rates of irradiation of molluscs *Bradybaena Fruticicola fruticum* are within 0.03–1.60 Gy/year. Structuring of experimental data was implemented based on the obtained data on the specific activity of Sr-90 in the system under study in accordance with model by G.G.Polikarpov. Three ecological zones were identified on the experimental site with regular variation of specific activity of Sr-90 in mollusc shells. In the zone of physiological masking concentration of radionuclide in mollusc shells can be by one order of magnitude and even more higher than in the plant. In the zone of ecological masking and the zone of pronounced environmental effects specific activities of the radionuclide are reduced as compared to its concentration in plants by 8 and 40 times, respectively (no decrease of specific activities of the radionuclide in the plant is registered). The implemented studies allow formulating the conclusion on the possibility of adaptation of indicators of Sr-90 migration in terrestrial ecosystems.

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Keywords: Sr-90; Terrestrial molluscs *Bradybaena Fruticicola fruticum*; ecological zone; dose rate; soil and plants.

Introduction

Investigation of radiation sensitivity of animals is of interest for evaluation of the process of adaptation of organisms to the conditions of increased radiation background. It is possi-

ble with this respect to take into account different indicators including genetic and morphological indicators, populations of species, behavioral activity, etc.

Conceptual model of zonality of chronic effects caused by ionizing radiation can be of interest among the wide spectrum of other models [1,10,14 and 18] developed for identification of response by biota components to the effects of different genesis. Using this model it is possible to implement evaluation forecasting of biota conditions with identification of radio-ecological zones of dose rates of ionizing radiation in nature. Registration of changes taking place in the most sensitive structures and functions of living organisms and their communities constitutes the basis of identification of ecological zones.

* Corresponding author at: Obninsk Institute for Nuclear Power Engineering, National Research Nuclear University MEPhI., 1 Studgorodok, Obninsk, Kaluga Region 249040, Russia.

E-mail addresses: regina.rinatovna.m@mail.ru (R.R. Shoshina), Lavrentyeva_G@list.ru (G.V. Lavrentyeva), ecology@iate.obninsk.ru (B.I. Synzynys).

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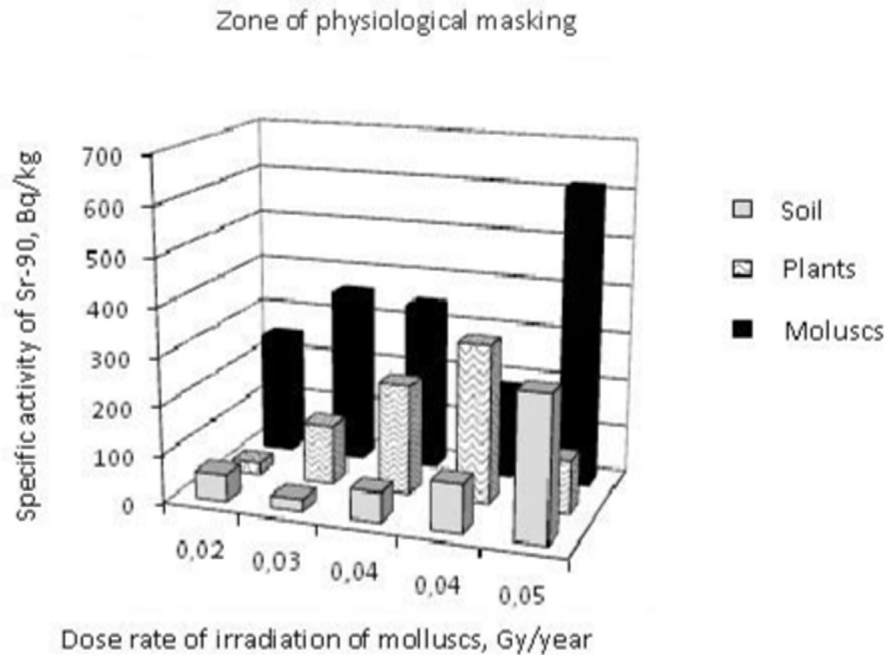


Fig. 1. Variation of specific activity of Sr-90 within the “soil-plants-mollusc shells” system within the physiological masking zone.

Attempt was made in the present study to identify radioecological zones of biological effects induced by chronic irradiation by ionizing radiation of populations of terrestrial molluscs *Bradybaena Fruticicola fruticum* on the basis of biological regularities of migration of technogenous Sr-90 within the system “soil-plants-mollusc shells”.

Materials and methods

Biotope of regional radioactive waste storage facility placed under the conditions of chronic irradiation as the result of the uncontrolled source of penetration of technogenous radionuclides developed following leakage from one of storage tanks at the facility serves as the experimental site [2,3,11,12]. Radio-ecological environment on the territory of the storage facility is determined by Sr-90 [12,21]. Selection of samples of soil, plant and terrestrial molluscs was implemented on local areas within the experimental site representing interest from the viewpoint of variation of values of dose rates of irradiation of molluscs [16].

Selection of samples of soil was implemented by the “envelope” method from the surface of soil cover underlying plant from the local areas equal to 1 m² on which molluscs dwell and from layers (0–5 cm and 20 cm depth).

Selection of samples of plants (stinging nettle *Urtica dioica*) was implemented taking into account specific features of habitation of molluscs on the local areas.

Molluscs were collected in the numbers amounting to not less than 8–10 species. Average age of terrestrial molluscs was determined for more correct calculation of dose rates of irradiation of animals [5]. Method of radiochemical separation with subsequent measurement of activity of the radionuclide using BETA-01S scintillation spectrometer according to

standard methodology of determination of Sr-90 concentration by beta-radiation emitted by its daughter radionuclide Y-90 was applied for determination of Sr-90 concentration in the selected samples [7].

Calculation of annual exposures of mollusk tissues from external beta-radiation emitted by Sr-90 and its daughter radionuclide Y-90 contained in the shells was performed using Levinger and Marinelli formulas for cold and warm periods of the year [19].

Results and discussion

Calculation of absorbed dose rates for molluscs taking into account specific activities of radiation emitted by Sr-90, Cs-137, K-40 and Ac-228 demonstrates that the main part of the absorbed dose for molluscs refers to external irradiation shaped by Sr-90 (taking into account the main contribution made by Y-90) for all the investigated local areas [12]. It is known that molluscs can act as indicators of Sr-90 content in the natural environment due to their capability to accumulate the radionuclide in their shells [17,20].

It has to be noted that approaches to the interpretation of data on the concentrations of radionuclides in components of ecosystems are wide enough including bio-geochemical indicators of migration of radionuclides, evolution of morphological indicators, behavioral activity, genetic indicators, etc. Functional dependences of variation of specific activity of Sr-90 within the “soil-plants-mollusc shells” system may be of interest here.

Functional dependences obtained as the result of the experiment were processed and distributed in accordance with conceptual model of zonality of chronic effects of ionizing radiation [8,9,14,15]. In agreement with the model under

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