UDC 631.95: 615.849

G. Chobotko,
doctor of Biological Sciences
V. Landin,
doctor of agricultural sciences
L. Raichuk,
candidate of agricultural sciences
I. Shvydenko, M. Umanskyi
Institute of Agroecology and Nature Management NAAS

Assessment of formation of the dose of internal irradiation of population at the remote stage of overcoming of aftereffects of Chernobyl disaster

Goal. To elucidate the peculiarities and nature of the formation of the dose of internal exposure of the population at the remote stage of overcoming the consequences of the Chernobyl accident. Methods. The research was carried out in settlements of Kyiv, Zhytomyr and Chernihiv regions with the help of a human radiation meter. An array of data is considered as a statistical collection of random variables, the type of distribution and a number of statistical indicators are determined. Results It has been found that now some aggregates show signs of not only lognormal but also exponential and normal laws. This indicates the stabilization of conditions affecting the formation of magnitude, and the absence of prevailing reasons (their balancing) of the formation of the population. Conclusions The current feature of dose formation is the dependence of the dose of internal exposure mainly on the local particularities of the diet, and therefore, both on the socio-economic characteristics of the region / locality and the individual family.

Key words: dose of internal irradiation, radionuclide, 137Cs, random variable, statistical distribution, hypothesis, consistency criteria.

Formulation of the problem. Human habitat in radioactive contaminated areas inevitably leads to a certain degree of risk of obtaining additional internal radiation due to the entry of radionuclides into its body with local food products, which leads to changes in health status [3]. Patterns of radiation dose formation among inhabitants of a certain locality coincide with pollution in the natural environment and / or with the distribution of the specific activity of radionuclides in food. Therefore, the research of scientists is focused on monitoring the contamination of agricultural lands near settlements, radioactivity of products food and so on. Without knowledge of the reason for the formation of the dose of radiation, its values can not be properly assessed or predicted radiation dose, the more planning anti-radiation measures. In the study of dosage formation in groups of the same type of social behavior of rural residents, the concept of AM was taken as the basis. Scriabin [5, 6]. Its essence is that a person or a group of people with certain personal and socio-economic characteristics interacts with the surrounding habitat, contributing to the formation of the dose that is its property. This approach explains some patterns of dosage formation, but involves a laborious collection of indirect data on some people or their groups with similar behavior and leaves some questions open. For example, it is not possible to explain the presence of high doses of internal exposure in some people living in families, other members of whom have a much lower dose of radiation.

Consumption of radioactive contaminated food (mushrooms, berries, game, milk) is the main dose-forming factor, determined by a number of indirect factors related to the socio-economic characteristics of the settlement [7, 8]. Consequently, we can assume that every locality must be characterized by its own dose. Since a populated area generates a dose, then the dose is a property of a specific locality.

The purpose of the work - is to find out the peculiarities and nature of the formation of the dose of internal exposure of the population at the remote stage of overcoming the consequences of the Chernobyl accident.

Materials and methods of research. During 2011-2014, the Department of Radioecology in the Agrosphere of the Institute of Agroecology and Natural Resources of NAAS has surveyed residents of 174 settlements in 17 districts of Kyiv, Zhytomyr and Chernihiv regions belonging to the II, III and IV zones of radioactive contamination - only about 15,800 measurements. Measurement was carried out using a human radiation meter (HDL). In order to find out the features and character of the formation the individual dose of internal exposure of the inhabitants of the region, the whole array of data is considered as a statistical collection of random variables [1, 2, 4]. For this purpose, by means of a table of random numbers, the settlements of three administrative districts - Naroditsky and Ovrutsky Zhytomyr region were selected. and Bila Tserkva Kyiv region, belonging to the II and III zones of radioactive contamination. In order to detect changes in the formation of an individual dose of internal exposure to the most critical category of the population of the region (forestry workers), 2 forestry farms were selected (Poliske Polisky, Polissya Region, Kyiv Oblast, and SE Ovrutsky Forestry, Ovruch, Zhytomyr Region.).

The hypothesis of the form of the distribution law was tested according to the Pearson consistency criterion.

Research results. In order to identify the peculiarities and nature of the formation of the individual dose of internal radiation, we determined the type of distribution and a number of statistical indicators: average, standard error, median, fashion, mean square deviation, sample variance, asymmetry coefficient, variation coefficient (table). Each of these characteristics and their comparison makes it possible to estimate the totality of data and determine the probable law of their distribution (the proximity of mean arithmetic and mean square deviations, high values of the coefficient of asymmetry and the coefficient of variation - for exponential; proximity of mean arithmetic mean, mod and median, low value of coefficient of asymmetry and variation - for normal; the closeness of the absolute value of the median logarithm and the mean arithmetic values of the logarithms of the variants - the logarithmically normal distribution, etc.). According to these data, histograms and distributions were constructed to determine the type of distribution.

Based on the data provided, the following preliminary conclusions and assumptions can be made. The relatively high values of the asymmetry coefficient (Selce, Narodychi village, Vistupovichy village, Bazar village, Berezhely village) indicate that the type of distribution of the dose of internal exposure of the population differs significantly from the normal one - in the normal distribution this figure equals 1 and the deviation of the distribution from the normal is in the range of ± 3 (Rososhkovskoye village, village Kalinovka, Pavlovka village, Yosy-shek village). Therefore, for these settlements, one can express and test the hypothesis of the type of distribution.

On the basis of the obtained statistical characteristics of the distribution of the hypothesis for p. Selce, village of Narodichi, with. Vistupovichi, p. Bazaar, p. Berezhetus allows to expect an exponential type of distribution without additional intermediate calculations. Thus, its formal feature is the relatively high absolute values of the asymmetry coefficient (3.19; 4.58; 1.36; 2.98; 6.22 respectively) and the coefficient of variation (114%; 113%; 82%; 70%; 136% respectively) and close by values mean arithmetic and mean square deviation. For the purpose of confirmation or negation of the hypothesis of the distribution law have constructed distribution histograms and have carried out the approximation. Approximation of experimental data on these settlements confirmed the hypothesis of p. Selce, village of Narodichi, with. Vistupovichy and others Berezhest (Fig. 1, a). For s. the Bazaar of the hypothesis has not been confirmed.

For changes in discreteness (reduction of the interval up to 0,05 mSv / year) (Fig. 1, b), the given sets of data indicate a logarithmic normal distribution (except for Berezhetus, where the Gaussian distribution was observed).

Consequently, according to Pearson's criterion, the hypothesis of the exponential distribution law was adopted for the villages Selets, Vistusovichy and Berezhely. This indicates the ability of such populations to sustain in specific conditions. With regard to the mentioned settlements, the socio-economic conditions, especially the diet of the population, the level of food contamination with radionuclides, which is reduced mainly due to the physical decay of radionuclides, are unchanged or unchanged. There are grounds to expect that the exponential law of distribution of the individual dose of internal exposure of the population affected by the Chernobyl accident in the distant regions will be characteristic for many settlements of Northern Polissya of Ukraine, taking into account the relative immutability of socio-demographic and economic characteristics of the region.

For the native village and village. The bazaar adopted a hypothesis with respect to the logarithmically normal the law of distribution. This kind of distribution is formed on the multiplicative principle [4]. That is, among the factors that influence the formation of this population, are preferable (wild mushrooms, berries, milk). Approximation of experimental data in the districts of Rossochivsk, Kalinovka, Pavlovka and Yosyivka with the subsequent verification by the Pearson consistency criterion made it possible to take into account the hypothesis of the Gaussian distribution (as previously indicated by the low values of the asymmetry coefficient). These statistical aggregates are formed as a result of the influence of a large number of independent (or non-dependent) random variables, none of which are predominant.

Thus, in the remote period after the Chernobyl accident, the differentiation of settlements has been established by the nature of the formation of the dose of internal radiation. This can be explained by socio-demographic and ecological-economic features. Obvious are the influence of middle-aged inhabitants of the settlement, their level of education, contact with the forest, the share of workers of certain categories, socio-economic status, etc. All this eventually forms a personal eating behavior. It should be noted that until now, in the vast majority of affected by the Chernobyl accident in the regions, a slightly different nature of the distribution of doses of internal radiation was observed - logarithmically normal [9].

Our analysis of the distribution of doses of internal exposure of forestry workers of the State Enterprise "Poliske Forestry" (Polissya district of Kyiv region) and SE "Ovrutsky forestry" (Ovruch Zhytomyr region) in 2006 and 2014 (Fig. 2) indicates a significant decrease in both individual doses of internal exposure in the vast majority of the surveyed, as well as a decrease in the number of people with high levels of radiation in the state enterprise "Poleskoe Forestry".

Employees of the State Enterprise "Ovruch Forestry" reduce the additional doses of internal radiation less noticeable. Reducing the value of the variation factor in 2014 indicates the effect of a smaller number of factors on the formation of individual units of the data set, since the less variety of conditions that affect the indicator, the smaller its variation. Reduction of the variation coefficient for dose values irradiation - a consequence of a closer grouping of the population around the median, indicating a greater irradiation dose leveling. This can be explained by the fact that today the main factor of dose formation is a diet, in this case - a significant proportion of products of forest origin (wild mushrooms, berries, game). Distribution of doses of internal exposure of forest workers better approximated logarithmically normal distribution.

The analysis of settlements gives a very clear idea of the mechanisms of forming the dose of internal exposure of local residents. According to its results, it is possible to adequately estimate or predict the distribution of the dose both in the village as a whole and in separate groups of its inhabitants. It can be a solid basis for detecting the most irradiated, so-called critical groups of rural society. However, a number of issues remain unanswered. More revealing the causes of radiation dose formation will allow the analysis of individual families (identifying the most significant socio-demographic and economic characteristics of the family that affect the formation of the dose of internal radiation of its members: the number of members and the number of children, middle age, education and professional orientation of seven ' the level of income, etc.), since a certain value of the dose of internal exposure is a property not only of a certain settlement, but also of a separate family.

Conclusions

Radioecological monitoring of inhabitants of settlements makes it possible to state that in the long-term period after the Chernobyl accident, the nature of the formation of the dose of internal radiation has changed somewhat. If in previous studies for the overwhelming majority of settlements a logarithmically normal distribution law was characteristic, now some sets reveal signs of exponential and normal laws. Such a distribution shows the stabilization of the conditions affecting the formation of the mass in the case of the first type of distribution (diet, level of radioactive contamination, socio-economic status, etc.) and the absence of prevailing reasons (their balancing) of the formation of the population in case of the second type of distribution. The detected feature of dose formation is the dependence of the amount of internal radiation dose not so much on the level of surface contamination of the territory as on the local peculiarities of the diet, and therefore on the socioeconomic characteristics of the region / locality and the individual family. These conditions encourage the need for further in-depth studies.

Bibliography

1. *Волошин М.І.* Елементи соціально-економічної моделі виробника органічної продукції/ М.І. Волошин, О.І. Корніцька//Агроекологічний журнал. — 2009. —

№ 1. — С. 16 – 18.

2. *Волошин М.І.* Параметри модельних агроформувань в умовах оренди землі/М.І. Волошин, О.М. Моклячук, Т.М. Красільнікова//Агроекологічний журнал. — 2012. — № 31. — С. 28 – 31.

3. *Деякі* аспекти дозиметричної характеристики та особливості внутрішньоклітинного метаболізму дітей — мешканців радіоактивно забруднених територій/Є.І. Степанова, Г.М. Чоботько, І.Є. Колпаков та ін.//Агроекологічний журнал. — 2013. — № 1. — С. 22 – 27.

4. *Райчук Л.А.* Елементи методики оцінювання формування дози внутрішнього опромінення населення на віддаленому етапі подолання наслідківаварії на Чорнобильській АЕС/Л.А. Райчук//Наук. вісн. НЛТУ України: зб. наук.-техн. праць. — 2014. — Вип. 24.07. — С. 150 – 156.

5. *Скрябин А.М.* Дозиметрический контроль: техника и методы/А.М. Скрябин//Материалы междунар. симпоз. «Актуальные проблемы дозиметрии». — Мн., 1997. — С. 159 – 160.

6. *Скрябин А.М.* Чернобыль сегодня: социальные аспекты радиационной защиты/А.М. Скрябин: сб. тез. III съезда по радиационным исследованиям. — М., 14 – 17 окт. 1997 г. — С. 300.

7. *Соціально-екологічні* чинники споживчої поведінки населення на радіоактивно забруднених територіях Полісся/Д.П. Качур, П.В. Замостян, Г.П. Паньковська та ін.//Агроекологічний журнал. — 2010. — № 2. — С. 106 – 109.

8. *Формування* дози внутрішнього опромінення населення Українського Полісся внаслідок споживання харчових продуктів лісового походження/ Г.М. Чоботько, Л.А. Райчук, Ю.М. Пісковий, І.І. Ясковець// Агроекологічний журнал. — 2011. — № 1 — С. 37 – 42.

9. *Чоботько Г.М.* Особливості моніторингу сезонного розподілу дозових навантажень населення, що мешкає в III та IV зонах радіоекологічного контролю Українського Полісся/Г.М. Чоботько, Ю.М. Пісковий, Є.Є. Перетятко//Агроекологічний журнал. — 2010. — № 2. — С. 21 – 25.