ON THE ACTIVITY RATIO ^{90}Sr$/^{137}$Cs IN SOIL OF THE CHERNOBYL NUCLEAR POWER PLANT 30-km ZONE IN UKRAINE

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Two calculation methods of the total content of ^{90}Sr and fuel particles of the Chernobyl radionuclide fallout in soil of the 30-km zone of the Chernobyl NPP in Ukraine on the basis of direct and inverse density of soil contamination ratios of ^{137}Cs and ^{90}Sr are presented. It had been determined that the total content of fuel radionuclides in fallouts estimated by both methods differed about two times. Calculation disparity of content of fuel particles is the consequence of arithmetic average and harmonic average inequality. It was shown that the estimation of the total content of fuel particles in emergency fallout of about 1.5% was obtained due to harmonic means.

Keywords: radionuclide, density of soil contamination ratios, total content of radionuclides, fuel particle fallouts

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1. Introduction

In the past years the attention is again drawn to the problem that was probably solved a long time ago in the works by Kashparov and his research assistants [1, 2] and in other papers of this group – to the estimation of fuel release during the Chernobyl Nuclear Power Plant (ChNPP) accident.

Instead of the commonly accepted (3%) value of nuclear fuel release (outside the ChNPP site [3]), in [1, 2] on the basis of estimation of ^{90}Sr content $Q(^{90}$Sr$)$ in the 30-km zone by ^{137}Cs content $Q(^{137}$Cs$)$, the fuel release value of 1.5% is proposed to the Ukrainian 30-km zone of ChNPP. According to opinion of the authors of [4], the emission of plutonium isotopes should be reconsidered and its value reduced as well.

In the practical sense the possible reduction of plutonium isotopes fallout by about 2 times strongly influences the long-term forecast of soil contamination with α-emitting isotopes of transuranium elements.

The long-term forecast of soil contamination with α-emitting isotopes of transuranium elements depends on quantity of ^{241}Pu fallouts and increasing amount of α-emitter ^{241}Am as a result of ^{241}Pu radioactive decay. If fallouts of plutonium isotopes, as it follows from the works [1, 2], are twice less than the commonly accepted value, then the long-term forecast of α-emitting isotopes of transuranium elements should also be more

favourable. However, it is necessary to be sure of the correctness of assessments in works [1, 2]. The basic purpose of the present study is to check the correctness of the estimation of ^{90}Sr content $Q(^{90}$Sr$)$ from ^{137}Cs content $Q(^{137}$Cs$)$ in the soil of the 30-km zone of the ChNPP in Ukraine in [1, 2] and emergency release of the nuclear fuel and transuranium isotopes as well.

It is known that for several reasons the experimental determination of ^{137}Cs content $Q(^{137}$Cs$)$ in objects of terrestrial environment is the most reliable. Particularly, soil contamination with ^{137}Cs in the 30-km zone of the ChNPP in Ukraine is completely defined by emergency release of RBMK-1000 of the ChNPP. At the beginning of 1987 the total content of ^{137}Cs was $Q(^{137}$Cs$) \approx 5.5 \cdot 10^{15}$ Bq (see, for example, [5, 6]).

The detailed map-scheme of local density distribution of soil contamination $A(^{137}$Cs$)$ with ^{137}Cs of the 30-km zone of the ChNPP in Ukraine is charted after large-scale aero-gamma-spectrometer shooting of the territory in 1992–1994. In this connection there was a possibility to use these data for the estimation of ^{90}Sr total content $Q(^{90}$Sr$)$ and the total content of transuranium elements $Q(^{238}$Pu$)$, $Q(^{239+240}$Pu$)$.

Such experimental calculations for more accurate definition of the total content of ^{90}Sr $Q(^{90}$Sr$)$ in soil of the 30-km zone of the ChNPP in Ukraine have been made in [1]. For this purpose, the grid of aero-gamma-spectrometer map by ^{137}Cs was used. Results of this

work turned out to be unexpected. At the beginning of 1987 the total content of ^{90}Sr in soil of the 30-km zone of the ChNPP in Ukraine was estimated as $Q(^{90}\text{Sr}) = 1.25 \cdot 10^{15}$ Bq, which is less than the commonly accepted value $Q(^{90}\text{Sr}) \approx 3 \cdot 10^{15}$ Bq (see [4, 6] and references therein).

Moreover, on the basis of the evaluation of the total content of ^{90}Sr in radioactive fallout ($Q(^{90}\text{Sr}) \approx 1.25 \cdot 10^{15}$ Bq) in later work [2] it was concluded that the initial and commonly accepted estimation of nuclear fuel release during the accident in the ChNPP ($\sim$3.5%) had been overestimated approximately by a factor of two.

Naturally, this statement has not been accepted unanimously. In [4] the result of the initial work [1], at least, is not criticized. In the report of IAEA, devoted to the 20th anniversary of the accident in the Chernobyl NPP [7], fuel release of about 1.5% is admitted. In a similar anniversary report by Izrael [8], this value is not commented. In the National report of Ukraine, devoted to the 20th anniversary of the ChNPP accident [6], the possibility of nuclear fuel release of about 1.5% is not mentioned at all.

In this connection, in the present study one of the possible reasons of difference between the commonly accepted ($\sim$3$\cdot$10^{15} Bq)) total content of ^{90}Sr and that calculated in [1, 2] ($\sim$1.25$\cdot$10^{15} Bq) in soil of the 30-km zone of the ChNPP in Ukraine is considered.

2. Semiempirical method to estimate the total content of ^{90}Sr, $Q(^{90}\text{Sr})$, by the total content of ^{137}Cs, $Q(^{137}\text{Cs})$, in soil

Let us assume that for territory S there is an experimental map-scheme of distribution of average local density of soil contamination with ^{137}Cs $\langle A(^{137}\text{Cs})_i\rangle$, where $i = 1, 2, 3, \ldots, n$ is an index of map-scheme fragment with area S_i and $\sum S_i = S$. Then the total content $Q(^{137}\text{Cs})$ of ^{137}Cs for territory S is

$$Q(^{137}\text{Cs}) = \sum_{i=1}^{n} S_i \langle A(^{137}\text{Cs})_i\rangle. \qquad (1)$$

For estimation of the total content $Q(^{90}\text{Sr})$ of ^{90}Sr in soil by a known total content $Q(^{137}\text{Cs})$ of ^{137}Cs (Eq. 1) it follows that for each fragment of territory S_i it is necessary to determine experimentally or by computation the average ratios of soil contamination densities

$A(^{90}\text{Sr})$ to $A(^{137}\text{Cs})$, $\langle\alpha_i\rangle = \langle[A(^{90}\text{Sr})/A(^{137}\text{Cs})]_i\rangle$. Then a sought-after total content of ^{90}Sr in soil is

$$Q(^{90}\text{Sr})_\alpha = \sum_{i=1}^{n} S_i \langle A(^{137}\text{Cs})_i\rangle\langle\alpha_i\rangle. \qquad (2)$$

However, in [1], for this purpose, another scheme is used. For each fragment of territory S_i the average ratio of densities of soil contamination $A(^{137}\text{Cs})$ to $A(^{90}\text{Sr})$, $\langle\beta_i\rangle = \langle[A(^{137}\text{Cs})/A(^{90}\text{Sr})]_i\rangle$ was found. In this case a sought-after total content of ^{90}Sr in soil is

$$Q(^{90}\text{Sr})_\beta = \sum_{i=1}^{n} S_i \langle A(^{137}\text{Cs})_i\rangle/\langle\beta_i\rangle. \qquad (3)$$

At the first sight, both calculation schemes are equivalent and calculated total content of ^{90}Sr $Q(^{90}\text{Sr})_\alpha$ and $Q(^{90}\text{Sr})_\beta$ should be equal to each other according to Eqs. (2) and (3). Actually, it is not so. There is a basic distinction between two schemes of calculations, and the permanent inequality $Q(^{90}\text{Sr})_\beta < Q(^{90}\text{Sr})_\alpha$ holds true. Thus, more severe condition $Q(^{90}\text{Sr})_\beta \ll Q(^{90}\text{Sr})_\alpha$ is also possible. As it will be shown below, this statement is a consequence of the fact that the arithmetic average is always more or equal to the harmonic average.

Really, the coefficient $\langle\alpha_i\rangle$ is the arithmetic mean of a set of local ratios $\alpha_{ik} = \rho[A(^{90}\text{Sr})/A(^{137}\text{Cs})]_{ik}$,

$$\langle\alpha_i\rangle = \frac{\sum\limits_{k=1}^{m_i} \rho[A(^{90}\text{Sr})/A(^{137}\text{Cs})]_{ik}}{m_i}, \qquad (4)$$

where the fragment of territory S_i is also divided into m_i smaller fragments σ_{ik} and $S_i = \sum \sigma_{ik}$, $k = 1, 2, 3, \ldots, m_i$.

Besides, the coefficient $\langle\beta_i\rangle$ is the, arithmetic mean of a set of local ratios $\rho[A(^{137}\text{Cs})/A(^{90}\text{Sr})]_{ik} = \left\{\rho[A(^{90}\text{Sr})/A(^{137}\text{Cs})]_{ik}\right\}^{-1}$ for the same fragments of territory S_i:

$$\langle\beta_i\rangle = \frac{\sum\limits_{k=1}^{m_i} \rho[A(^{137}\text{Cs})/A(^{90}\text{Sr})]_{ik}}{m_i}. \qquad (5)$$

However, in Eq. (3) for $Q(^{90}\text{Sr})_\beta$ we deal not with the value $\langle\beta_i\rangle$, but with the inverse value $1/\langle\beta_i\rangle$. And the value $1/\langle\beta_i\rangle$ is nothing else but the harmonic average of a set of local ratios $\rho[A(^{90}\text{Sr})/A(^{137}\text{Cs})]_{ik}$.

By definition the arithmetic average of n quantities a_j is

$$\langle x\rangle = \frac{a_1 + a_2 + \ldots + a_n}{n}, \qquad (6)$$

and the harmonic average of the same quantities is

$$\langle h \rangle = n \left(\frac{1}{a_1} + \frac{1}{a_2} + ... + \frac{1}{a_n} \right)^{-1} . \qquad (7)$$

The arithmetic average of a set of positive quantities is larger than or equal to the harmonic average, $\langle x \rangle \geq \langle h \rangle$ (equality takes place for $a_1 = a_2 = \ldots = a_n$, see, for example, [9]).

It is easy to see that if quantities a_k are understood as ratios α_{ik}, then $\langle \alpha_i \rangle$ is the arithmetic mean of ratios α_{ik}, i.e.,

$$\langle x \rangle = \langle \alpha_i \rangle = \frac{\sum\limits_{k=1}^{m_i} \alpha_{ik}}{m_i} , \qquad (8)$$

while $\langle \beta_i \rangle$ is the arithmetic mean of inverse ratios $(\alpha_{ik})^{-1}$,

$$\langle \beta_i \rangle = \frac{\sum\limits_{k=1}^{m_i} (\alpha_{ik})^{-1}}{m_i} . \qquad (9)$$

The inverse value from Eq. (9) $1/\langle \beta_i \rangle$ is the harmonic mean $\langle h \rangle$ of α_{ik} ratios, i.e.,

$$\langle h \rangle = \frac{1}{\langle \beta_i \rangle} = m_i \left[\sum_{k=1}^{m_i} (\alpha_{ik})^{-1} \right]^{-1} . \qquad (10)$$

All these facts can actually explain qualitatively the underestimation of the total content of ^{90}Sr, $Q(^{90}\text{Sr}) \approx 1.25 \cdot 10^{15}$ Bq, obtained in [1] according to Eq. (3), in comparison with the commonly accepted value $\sim 3 \cdot 10^{15}$ Bq in soil of the 30-km zone of the ChNPP in Ukraine.

So, it is necessary to calculate the value $\langle x \rangle / \langle h \rangle = \langle \alpha_i \rangle \langle \beta_i \rangle$ to obtain quantitative estimations. It will be made below.

3. Quantitative estimations of the ratio $\langle x \rangle / \langle h \rangle$ for contaminated soil of southern territories of Gomel region

We have experimental data for the Polesskii State Radiation-Ecological Reserve (including the 30-km zone of Belarus) and adjoining territories (276 settlements) soil contaminated with γ-radiating fission fragments ^{95}Zr, ^{103}Ru, ^{106}Ru, ^{141}Ce, ^{144}Ce, ^{137}Cs and α-radiating plutonium isotope activity $A(^{239,240}\text{Pu})$ for ^{239}Pu+^{240}Pu [11, 12].

In general, it is the same base of experimental data that was used in [13, 14] for the estimation of the Chernobyl origin ^{239}Pu and ^{240}Pu masses fallen out on the territory of Belarus by the correlation method. Depending on the nuclide, the number of the investigated density of soil contamination ratios varied from 170 for plutonium isotopes to 270 for ruthenium isotopes.

Content $Q(^{90}\text{Sr})$ of ^{90}Sr in [1] was in accordance with the average experimental values of activity $\langle A(^{137}\text{Cs}) \rangle_i$ and with the average experimental and calculated values of activity $\langle A(^{90}\text{Sr}) \rangle_i$, on the territory fragment S_i. The average levels of soil contamination, for more radionuclides, were also used in the present study.

According to [10], the relative error during the measurement of the γ-activity of some radioisotopes in soil samples depended on the radioactivity value and varied from $\sim 50\%$ (a level of soil contamination 37–185 kBq/m^2) to $\sim 15\%$ (a level of soil contamination > 740 kBq/m^2). For each separate settlement the value of nuclide γ-activity was obtained by averaging activities of local measurements. The number of local measurements of activities for various settlements varied from 1–2 to 20–30.

The method of the measurement of α-activity of plutonium isotopes ^{239}Pu+ ^{240}Pu is considered in detail in [12]. Within the territory of 2×2 km^2, 7–8 samples were selected. They were combined, mixed carefully up and measured 4–5 times which allowed us to obtain the result with a measurement uncertainty of $\pm 30\%$ from an average and confidential probability of 90%.

^{95}Zr, ^{141}Ce, and ^{144}Ce nuclides, as typical fuel nuclides, were released from the Chernobyl reactor during the accident, mainly as fuel particles. Moreover, we can divide the total α-activity of plutonium isotopes ^{239}Pu+ ^{240}Pu into components, $A(^{239,240}\text{Pu}) = A(^{239}\text{Pu})+ A(^{240}\text{Pu})$. Therefore, the calculation of $\langle \alpha_i \rangle$, Eq. (8), and $\langle \beta_i \rangle$, Eq. (9), values for data [10–12] became simple. Preliminarily, however, we shall divide density of soil contamination $A(^{239,240}\text{Pu})$ into components.

It is easy to show that for the emergency reactor RBMK–1000 of ChNPP the activity ratio dependences on the burnup W are such that $A(^{106}\text{Ru}, W)/A(^{103}\text{Ru}, W) \approx W/50$ and $A(^{240}\text{Pu}, W)/A(^{239}\text{Pu}, W) \approx W/8$, i.e. approximately linearly dependent on the burnup W [13–15]. Eliminating the direct dependence on W, one gets

$$\frac{A(^{240}\text{Pu}, W)}{A(^{239}\text{Pu}, W)} = 6.21 \frac{A(^{106}\text{Ru}, W)}{A(^{103}\text{Ru}, W)} . \qquad (11)$$

In contrast to the burnup W it is possible to measure the activity ratio $A(^{106}\text{Ru}, W)/A(^{103}\text{Ru}, W)$ experimentally. Therefore, correlation between $A(^{240}\text{Pu}, W)$

Table 1. Comparison of arithmetic and harmonic means for density of soil contamination ratios (about 270 settlements).

No	ρ	$\langle x \rangle$	$\langle h \rangle$	$\langle x \rangle / \langle h \rangle$
1	$A(^{106}\mathrm{Ru})/A(^{103}\mathrm{Ru})$	0.221	0.216	1.02
	$A(^{103}\mathrm{Ru})/A(^{106}\mathrm{Ru})$	4.63		
2	$A(^{144}\mathrm{Ce})/A(^{141}\mathrm{Ce})$	0.592	0.571	1.04
	$A(^{141}\mathrm{Ce})/A(^{144}\mathrm{Ce})$	1.75		
3	$A(^{144}\mathrm{Ce})/A(^{103}\mathrm{Ru})$	0.530	0.420	1.26
	$A(^{103}\mathrm{Ru})/A(^{144}\mathrm{Ce})$	2.38		
4	$A(^{144}\mathrm{Ce})/A(^{106}\mathrm{Ru})$	2.44	1.93	1.26
	$A(^{106}\mathrm{Ru})/A(^{144}\mathrm{Ce})$	0.519		
5	$A(^{95}\mathrm{Zr})/A(^{137}\mathrm{Cs})$	5.78	2.30	2.51
	$A(^{137}\mathrm{Cs})/A(^{95}\mathrm{Zr})$	0.435		
6	$A(^{141}\mathrm{Ce})/A(^{137}\mathrm{Cs})$	5.40	2.29	2.36
	$A(^{137}\mathrm{Cs})/A(^{141}\mathrm{Ce})$	0.436		
7	$A(^{144}\mathrm{Ce})/A(^{137}\mathrm{Cs})$	3.48	1.45	2.40
	$A(^{137}\mathrm{Cs})/A(^{144}\mathrm{Ce})$	0.689		
8	$A(^{239}\mathrm{Pu})/A(^{137}\mathrm{Cs})$	$1.30{\cdot}10^{-3}$	$5.68{\cdot}10^{-4}$	2.29
	$A(^{137}\mathrm{Cs})/A(^{239}\mathrm{Pu})$	$1.76{\cdot}10^{3}$		
9	$A(^{240}\mathrm{Pu})/A(^{137}\mathrm{Cs})$	$1.79{\cdot}10^{-3}$	$7.58{\cdot}10^{-4}$	2.36
	$A(^{137}\mathrm{Cs})/A(^{240}\mathrm{Pu})$	$1.32{\cdot}10^{3}$		

and $A(^{239}\mathrm{Pu}, W)$ activities can be established experimentally as well:

$$A(^{240}\mathrm{Pu}, W) = A(^{239}\mathrm{Pu}, W)\, 6.21 \frac{A(^{106}\mathrm{Ru}, W)}{A(^{103}\mathrm{Ru}, W)}. \tag{12}$$

Based on Eqs. (11) and (12), it is possible to obtain expressions for partial activities $A(^{239}\mathrm{Pu}, W)$, $A(^{240}\mathrm{Pu}, W)$ using the experimental total activity $A(^{239,240}\mathrm{Pu}, W)$:

$$A(^{239}\mathrm{Pu}, W) =$$

$$\frac{A(^{239,240}\mathrm{Pu}, W)}{1 + 6.21 A(^{106}\mathrm{Ru}, W)/A(^{103}\mathrm{Ru}, W)}, \tag{13}$$

$$A(^{240}\mathrm{Pu}, W) = 6.21 \frac{A(^{106}\mathrm{Ru}, W)}{A(^{103}\mathrm{Ru}, W)}$$

$$\times \frac{A(^{239,240}\mathrm{Pu}, W)}{1 + 6.21 A(^{106}\mathrm{Ru}, W)/A(^{103}\mathrm{Ru}, W)}. \tag{14}$$

9 pairs of direct and inverse ratios of activities of ρ-type such as $A(^{106}\mathrm{Ru})/A(^{103}\mathrm{Ru})$ (direct), $A(^{103}\mathrm{Ru})/A(^{106}\mathrm{Ru})$ (inverse) have been investigated. Arithmetic means $\langle x \rangle$ and harmonic means $\langle h \rangle$ (for direct value), and also required values of $\langle x \rangle / \langle h \rangle$ were calculated. Results of calculations are presented in Table 1.

The sense of practical use of data from Table 1 will be shown by the example. For instance, we wish to define the total content $Q(^{144}\mathrm{Ce})$ of $^{144}\mathrm{Ce}$ by the total content $Q(^{137}\mathrm{Cs})$ of $^{137}\mathrm{Cs}$. Here $^{144}\mathrm{Ce}$ is an analogue of $^{90}\mathrm{Sr}$ in [1, 2]; these radionuclides by definition fell out only as part of a fuel matrix. In this case local experimental activity ratios $\rho_1 = A(^{144}\mathrm{Ce})/A(^{137}\mathrm{Cs})$ and $\rho_2 = A(^{137}\mathrm{Cs})/A(^{144}\mathrm{Ce})$ will be necessary.

Average of experimental values of the density of soil contamination was calculated for every 276 settlement which are on the territory of the Polesskii State Radiation–Ecological Reserve, and in adjoining territories of Braginsky, Narovljansky, and Hojniksky districts of Gomel region. The means of these ratios are the following: $\langle \rho_1 \rangle = \langle A(^{144}\mathrm{Ce})/A(^{137}\mathrm{Cs}) \rangle = 3.48$, $\langle \rho_2 \rangle = \langle A(^{137}\mathrm{Cs})/A(^{144}\mathrm{Ce}) \rangle = 0.69$.

It is easy to show that in the first case the total content of $^{144}\mathrm{Ce}$ is $Q(^{144}\mathrm{Ce}) = 3.48 Q(^{137}\mathrm{Cs})$, while in the second case $Q(^{144}\mathrm{Ce}) = 1.45 Q(^{137}\mathrm{Cs})$, i.e. it is 2.4 times lower. Naturally, this estimation has a qualitative character. Therefore, it makes sense to do the same operation for local sampling of experimental data and to evaluate the mean, dispersion and standard deviation of the ratio $\langle x \rangle / \langle h \rangle$.

For this purpose all experimental data were split into blocks including 10 settlements, i.e. in general there were 27 blocks and 27 local ratios $\langle x \rangle / \langle h \rangle$ for one radionuclide, accordingly. For the improvement of statis-
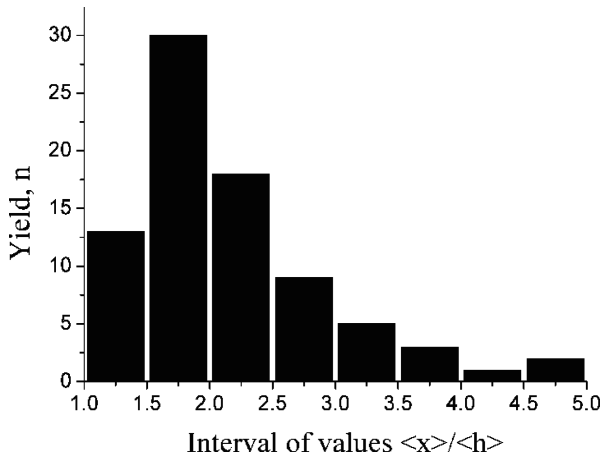
Fig. 1. Yields n of local values $\langle x \rangle / \langle h \rangle$ for ^{141}Ce, ^{144}Ce, ^{95}Zr to ^{137}Cs. The mean is $\langle \langle x \rangle / \langle h \rangle \rangle = 2.19$, standard deviation is ± 0.75.

tics three fuel radionuclides (^{95}Zr, ^{141}Ce, ^{144}Ce) were considered (No 5, No 6, No 7 ratios in Table 1). The sampling was made by grouping the settlements listed in the alphabetic order into groups of ten. Results of calculations of local ratios $\langle x \rangle / \langle h \rangle$ are presented in Fig. 1.

The method of calculation based on using the value $1/\langle \beta_i \rangle$ Eq. (3), as in [1, 2], gives the assessment of the total content of abovementioned nuclides approximately 2–2.5 times lower in comparison to those obtained using the value $\langle \alpha_i \rangle$ Eq. (2).

It is known that the arithmetic average is equal to the harmonic average in the case of equality of quantities $a_1 = a_2 = \ldots = a_n$. In the case when one nuclide is a nuclear fuel element and the second nuclide, ^{137}Cs, is mainly aerosol one, the strong dispersion of quantities $a_1, a_2, \ldots, a_n$ is possible. It also leads to a large difference between the arithmetic average and the harmonic average.

If we examine density of soil contamination ratios of two isotopes of the same element, then their release forms should be similar. Therefore, it is possible to assume that the arithmetic average in this case should not differ significantly from the harmonic average. In Table 1 density of soil contamination ratios between the nuclide pair ^{103}Ru, ^{106}Ru (No 1) and ^{141}Ce, ^{144}Ce (No 2) meets these conditions. Here the difference between the arithmetic average and the harmonic average is negligibly small.

Density of soil contamination ratios between fuel elements such as ^{144}Ce and ruthenium isotopes ^{103}Ru, ^{106}Ru, which can fall out both in fuel and aerosol forms, should have the intermediate character. Really, in this case the difference between the arithmetic average and the harmonic average is about 30%.

4. Conclusion

In works [1, 2], after more than 15 years from the accident in the ChNPP, one of the main characteristics of the accident – fuel release (and, accordingly, of transuranium isotopes) outside the reactor site – is brought into question.

Instead of the standard estimation of fuel release of about 3%, in works [1, 2] on the basis of a new, more careful experimental investigation and calculation of the total content $Q(^{90}\text{Sr})$ of ^{90}Sr in soil of the 30-km zone of the ChNPP in Ukraine, the release estimation of just about 1.5% for the total content $Q(^{137}\text{Cs})$ of ^{137}Cs is given. In this connection in our study one of the most possible reasons for the underestimation of the total content of ^{90}Sr, $Q(^{90}\text{Sr}) \sim 1.25 \cdot 10^{15}$ Bq, in the 30-km zone of the ChNPP in Ukraine in works [1, 2] in comparison with the commonly accepted estimation of the total content $Q(^{90}\text{Sr}) \sim 3 \cdot 10^{15}$ Bq is considered.

Underestimation of the total content of ^{90}Sr, $Q(^{90}\text{Sr}) \sim 1.25 \cdot 10^{15}$ Bq, in [1, 2] is the result of the error of calculation technique. Thus, at one of the stages of experimental data processing in [1, 2] the arithmetic mean is replaced by the harmonic mean for the density of soil contamination ratio $A(^{90}\text{Sr})/A(^{137}\text{Cs})$.

As the analysis of experimental data of soil contamination of the south Gomel area has shown, for this density of soil contamination ratios it is possible to expect a large deviation ($\sim$2.5 times) of the arithmetic average from the harmonic average.

As a consequence, the conclusion about necessity of reduction of the commonly accepted value of fuel release during the accident in the ChNPP ($\sim$3.5%) by approximately 2 times, drawn in [1, 2], is premature.

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APIE ^{90}Sr IR ^{137}Cs AKTYVUMŲ SANTYKIUS UKRAINOS ČERNOBYLIO AE 30 km ZONOS DIRVOŽEMYJE

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Santrauka

Nagrinėjami Kašparovo su bendraautoriais [1, 2] atlikti skaičiavimai, duodantys du kartus mažesnius ^{90}Sr kiekius Ukrainos Černobylio AE 30 km zonos teritorijos dirvožemyje nei įvertinami jo kiekiai pagal aktyvumų santykį su ^{137}Cs (imant įprastai naudojamą skaičiavimuose 3% išmetamo avarijos metu toliau elektrinės aikštelės branduolinio kuro kiekį). Norint nustatyti, kodėl taip skiriasi teorinis įvertinimas ir realiai matuojami ^{90}Sr aktyvumai, atlikti eksperimentiniai matavimai bei apskaičiuoti aritmetiniai ir harmoniniai vidurkiai. Eksperimentinių duomenų analizė parodė, kad, ypač Gomelio srities pietinės dalies dirvožemyje, vertinant išmatuotų ^{90}Sr ir ^{137}Cs aktyvumų santykius, negalima aritmetinių vidurkių pakeisti harmoniniais, nes tai keičia rezultatus net iki 2,5 kartų. Autoriai mano, kad minėtuose darbuose [1, 2] siūlomą pataisą – du kartus sumažinti ir branduolinio kuro, išmesto Černobylio AE avarijos metu 30 km zonoje, kiekį – reikia labiau pagrįsti.