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Experience in studying the consequences of the Chernobyl accident in a rural settlement: case study of the village of Novye Bobovichi, Novozybkovsky district, the Bryansk region

Ksenia V. Gupalo-Osadchaia, Sergey V. Panchenko ✉

Nuclear Safety Institute of the Russian Academy of Sciences, Moscow, Russian Federation
✉anch@ibrae.ac.ru

Abstract. The paper discusses the results of long-term studies of the radiation and socio-economic situation in the village of Novye Bobovichi. The research is based on the analysis of homestead inspections data and records from the house registers. During the first 15 years after emergency contamination the migration of ^{137}Cs can be described as an exponent with a half-life (T½) of 7,5 years and a life (T) of 30 years during the following period. For residential areas contaminated as a result of the Chernobyl accident at the level of 1 MBq/m^2 for ^{137}Cs, conservative estimates of accumulated doses on various population groups show that maximum external exposure doses for the first 35 years after the accident were no higher than 100 mSv.

Keywords: Chernobyl fallout, homestead inspections, external exposure dose, demography, agricultural production

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Опыт изучения последствий аварии на Чернобыльской АЭС в сельском населенном пункте на примере села Новые Бобовичи Новозыбковского района Брянской области

К.В. Гупало-Осадчая, С.В. Панченко✉

Институт проблем безопасного развития атомной энергетики Российской академии наук, Москва, Российская Федерация

✉anch@ibrae.ac.ru

Аннотация. Представлены результаты многолетних исследований радиационной и социально-экономической обстановки в селе Новые Бобовичи, основанные на анализе данных подворных обследований и записей из домовых книг. Миграция ^{137}Cs в населенном пункте, радиоактивно загрязненном после аварии на Чернобыльской АЭС, может быть описана двумя компонентами: в первые 15 лет с периодом полураспада 7,5 года, а в последующие годы с периодом радиоактивного распада – 30 лет. Для селитебных радиоактивно загрязненных территорий на уровне 1 МБк/м^2 по ^{137}Cs консервативные оценки дозовых нагрузок на различные группы населения показывают, что максимальные дозы внешнего облучения за первые 35 лет после аварии не превышали 100 мЗв.

Ключевые слова: чернобыльские выпадения, подворные обследования, доза внешнего облучения, демография, производство сельхозпродукции

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Introduction

Academician R.M. Aleksakhin often called the accident at the Chernobyl Nuclear Power Plant (ChNPP) in 1986 an agricultural disaster, meaning that the main troubles caused by the consequences of the accident fell on the shoulders of agricultural producers and villagers.[1] It is difficult to disagree with the opinion of an authoritative scientist, observing the changes that occurred in the radioactively contaminated territories after the accident. In the first two years, villagers had little understanding of what had happened and therefore felt a sense of oppressive fear. The measures taken by the state more often caused additional anxiety, and the seconded specialists working in some villages could not relieve it and reassure the population adequately. These circumstances caused the first wave of outflow of young people and specialists (doctors, teachers, zootechnicians, etc.) working in rural areas. About three years after the accident, when social tensions seemed to be subsiding and life was returning to its usual course, an anti-communist campaign swept across the country, in which rural residents unwittingly became the main hostages. The public consciousness trained during the Cold War, oriented towards the nuclear threat as the most powerful force for the destruction of life, was now used consciously or not, in some cases, as a means of fighting against communist power. At the same time there was a substitution of notions: the frightening nuclear danger was replaced by radiation danger. Attempts by individual scientists to explain the difference between the two were crushed by a militant group – the so-called democrats – who took over most of the media. All this bacchanalia around the unfolding power struggle further undermined the country's economy and hit the countryside the hardest. In neighbouring Belarus, a second wave of mass resettlements took place, partly affecting the Bryansk region as well.

Materials and methods

Despite state support for the territories classified as affected by the radiation accident, the general decline in production, coupled with demographic problems, was eroding and destroying established rural life. In the Novozybkovsky District of the Bryansk region, only 60 out of 120 settlements (1986) remained 15 years later, and the rural population dropped from 18,424 (1989)[2] to 10,815 (2022) people.[3]

The article considers the situation on the example of one settlement of Novozybkovsky District – the village of Novye Bobovichi and the collective farm located in it – state farm "Reshitelny". Figure 1 shows the dynamics of the population of the village in the period from 01.01.1986 to 01.01.2023 according to the records in the house books.

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[1] Aleksakhin RM, Sanzharova NI, Fesenko SV, Spirin EV, Spiridonov SI, Panov AV. Chernobyl, agriculture, environment. *Materials for the 20th anniversary of the accident at the Chernobyl nuclear power plant in 1986*. Obninsk; 2006. 35 p. (In Russ.).

[2] *All-Union Population Census 1989. Population of the USSR, RSFSR and its territorial units by gender*. (In Russ.). Available from: https://www.demoscope.ru/weekly/ssp/rus89_reg1.php (accessed: 25.07.2024).

[3] Population of the Russian Federation by municipalities as of 1 January 2022. *Federal State Statistics Service (Statistical Bulletin)*. Moscow; 2022. (In Russ.). Available from: https://rosstat.gov.ru/compendium/document/13282 (accessed: 25.07.2024).

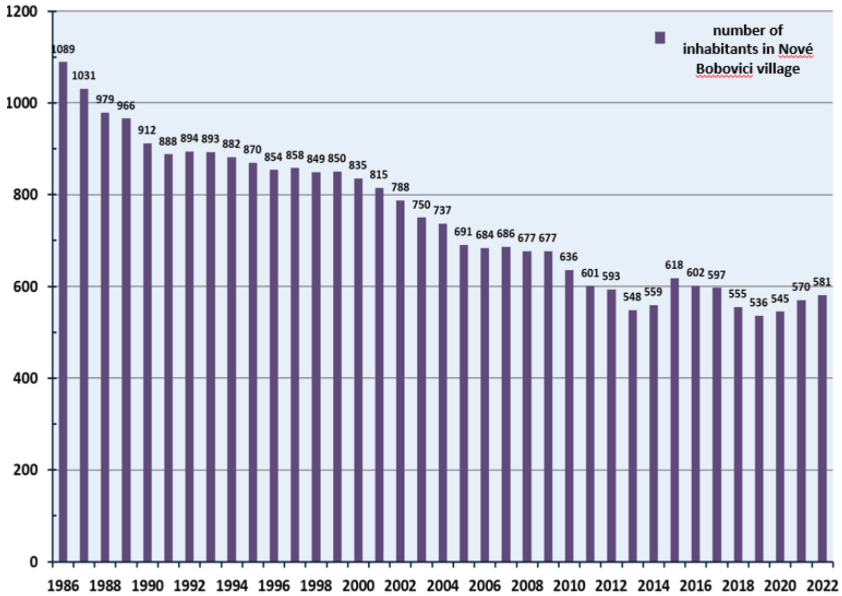

Figure 1. Number of officially registered of the village of Novye Bobovichi in the period 1986–2022
Source: compiled by K.V. Gupalo-Osadchaia, S.V. Panchenko.

The decline in production and deterioration of living conditions of the population occurred not only in Novozybkovsky District, but also in the whole country. For the villagers of some farms located on the radioactively contaminated territories, for a short period of the early 1990s there was even some improvement of the situation due to the state support of the contaminated areas. During this period, due to the receipt of fertilisers and agricultural machinery, grain yields increased, milk yields and overall milk production increased (Figures 2, 3). However, this surge was short-lived; the collapse of the USSR and the general economic recession, perhaps, had the sharpest impact on agricultural producers. A period of sharp decline in the quality of life on the poor lands of Novozybkovsky District, aggravated by demographic problems, began. There was an outflow of young people and qualified personnel in the period 1986–1988 and in 1990, which, due to the lack of meaningful prospects, has not been completed to the present day.

If the total milk yield in the farm was 2,209 tonnes in 1991, in 2000 it decreased to 891 tonnes, in 2010 – to 360 tonnes, in 2020 – to 135 tonnes, and in 2021 – to 63 tonnes, i.e. milk production has decreased 35 times in 30 years.

In 1986, there were 248 dairy cows in private farms in the village, of which only one cow remained in 1990. In 2022, only one private farm had 7 cows; dairy products produced in this farm were mainly used for the needs of individual villagers. The rest of the villagers used purchased dairy products.

The experience of the past years has shown that the most large-scale consequences of the accident were realised not in the radiological, but in the socio-economic sphere. This is confirmed by the recommendations formulated in the report of the UN mission "Humanitarian consequences of the accident at Chernobyl

NPP: rehabilitation strategy”,[4] and the conclusions of the Chernobyl Forum, presented at the final conference on 6–7 September 2006 in Vienna [1]. The Chernobyl Forum emphasises the need to place economic development aimed at the economic and social viability of the territories affected by the accident at the core of the strategy for overcoming the consequences of the accident at the ChNPP in the medium and long term.

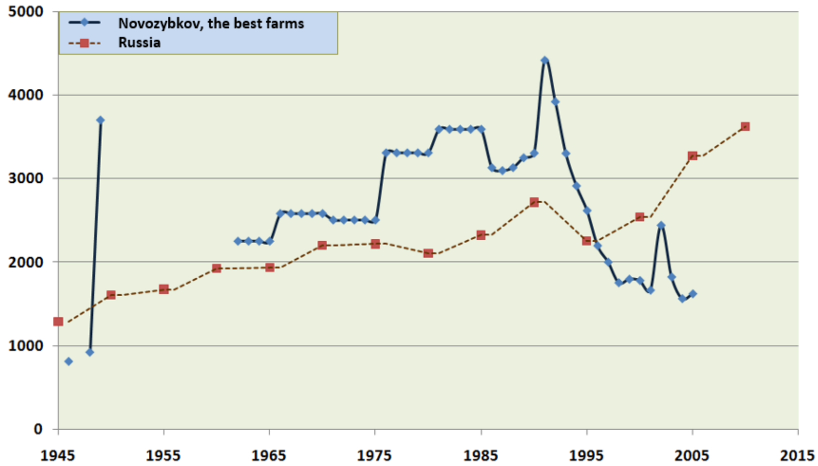

Figure 2. Dynamics of milk yield per cow in the best farms of the Novozybkovsky District: “Wave of Revolution” (1945–1985) and “Resolute” (1986–2010) in comparison with the average data for the Russian Federation
Source: compiled by K.V. Gupalo-Osadchaia, S.V. Panchenko.

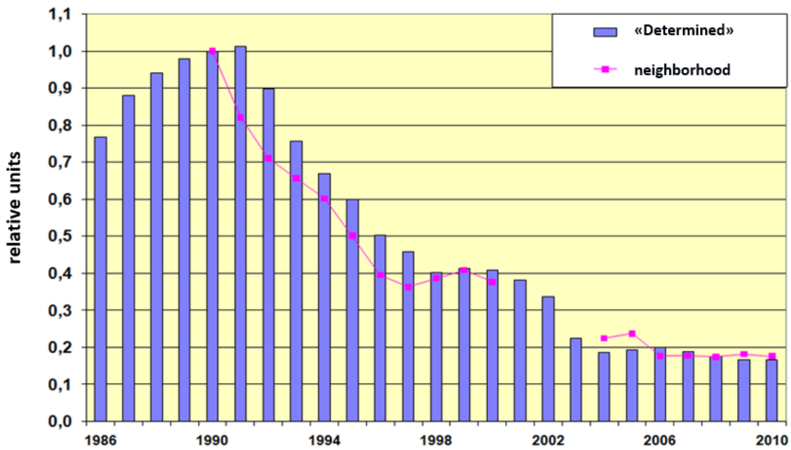

Figure 3. Dynamics of milk production in the collective farm “Reshitelny” (in the village of Novye Bobovichi) and in the Novozybkovsky district of the Bryansk region, 1986–2010
Source: Muratova NA. (ed.) et al. *Chernobyl a quarter of a century ago. Statistical collection*. Feder. government service. Statistics (Rosstat), the Territorial body of the Federal State Statistics Service for the Bryansk Region. Bryansk: Bryanskstat; 2011. 175 p.

[4] Humanitarian Consequences of the Chernobyl Nuclear Power Plant Accident. Rehabilitation Strategy: Report commissioned by UNDP and UNICEF with the support of UN OCHA and WHO. Minsk: Unipak publ.; 2002. 75 p. (In Russ.).

It is important that this approach was based not only on the opinion of international experts and the governments of the three countries (Belarus, Russia, Ukraine) most affected by the Chernobyl accident, it also responded to the urgent problems and concerns of the residents themselves.[5] However, the situation after such recommendations and individual efforts undertaken has not changed dramatically. The question about the prospects and even about the further existence of the settlement is still extremely topical.

Regardless of the described course of events, the assessment of received radiation doses of the population living in the most radioactively contaminated territories and preserving the established way of life, along with other indicators, is of undoubted both scientific and social interest. The present work deals with the results of long-term farmstead surveys in Novye Bobovichi village in terms of external dose estimates. These studies were based on the radiation parameters measured in the period 1986–2022, as well as on various data on the village residents, obtained on the basis of records in house books.

Radiation situation and household surveys in Novye Bobovichi village

The study of the radiation situation in Novye Bobovichi village due to radioactive fallout from the accident at ChNPP started with the measurement of contamination levels of generalised milk from the state farm on 12 May 1986. However, to some extent due to coincidence in the area of the Experimental Station (branch of the All-Russian Institute of Fertilizer and Agrosoil Science) in the town of Novozybkov, which can be considered as settlements of “the same fate”, the first measurements of the exposure dose rate were made on the day following the radioactive fallout that formed the contamination of the territory under consideration as a result of heavy precipitation in the evening of 28 April 1986. Subsequent dose rate measurements performed until the end of May showed a rapid decline due to the decay of short-lived radionuclides (Figure 4).

The calculated values of the dose rate in Novozybkov town were made using the results of cluster analysis in reconstruction of radionuclide composition of fallout in Gomel (north-eastern part), Mogilev (south-eastern part) and Bryansk (western part) regions[6] (Table 1).

The levels of ^{137}Cs deposition in Novozybkov (697 kBq/m^2) and at the Experimental Station (1 050 kBq/m^2) were noticeably higher than 370 kBq/m^2. On this basis, the radionuclide composition of the deposition characteristic of the area was reconstructed, from which the exposure dose rate in Novozybkov was estimated using the coefficients from [2] for early deposition. It can be assumed

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[5] Gerasimova NV, Abalkina IL, Marchenko TA, Panchenko SV, Simonov AV. *Socio-economic consequences of the Chernobyl accident (case study: Bryansk region)*. Moscow: Comtekhprint; 2006. 32 p. (In Russ.).

[6] Panchenko SV, Savkin MN, Shutov VN. *Radiation-hygienic situation and radiation doses to the population.* Preprint No. IBRAE-97-10, IBRAE RAS, Moscow; 1997. 19 p. (In Russ.). Available from: https://ibrae.ac.ru/docs/109/9710.pdf (accessed: 25.07.2024).

with great confidence that the parameters of the radiation situation in Novye Bobovichi village were similar to the situation in Novozybkov, which allows us to estimate the dose rate based on the proportion of ^{137}Cs depositions in these territories.

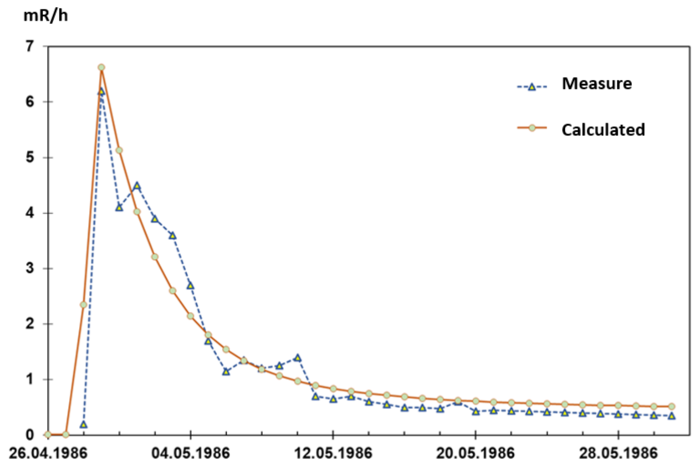

Figure 4. Measured and calculated values of exposure dose rate in Novozybkov in April–May 1986
Source: compiled by K.V. Gupalo-Osadchaia, S.V. Panchenko

Table 1. **Ratio of a number of radionuclides in fallout in the Mogilev Region (eastern part), Gomel Region (north-eastern part) and Krasnogorsk District of Bryansk Region (as of 26.04.1986)**

^{137}Cs contamination density, kBq/m^2	Mogilev region (eastern part)	Gomel region (north-eastern part)	Krasnogorsky District, Bryansk Region
	^{131}I / ^{137}Cs	^{95}Zr / ^{137}Cs	^{90}Sr / ^{137}Cs
18	38.2	0.71	0.3
115	12.8	0.16	0.05
370	10.5	0.09	0.022
1580	7.6	0.04	0.013

Source: compiled by S.V. Panchenko based on [7].

It was previously shown that the initial deposition of ^{137}Cs was [3]:

– to the territory of Novye Bobovichi village 1095 ± 261 kBq/m^2;
– to agricultural land around 1100 ± 378 kBq/m^2;
– to nearby forests 1920 ± 310 kBq/m^2.

Thus, immediately after precipitation, the average gamma-ray background in Novye Bobovici (in the open area at a height of 1 m from the ground surface) was about 13 mR/h.

Various aspects related to the formation and evolution of radiation environment parameters have been discussed in more detail in the scientific works[7] and [2].

[7] Bolshov LA. (ed.). *Radiation Protection and Radiation Safety in Nuclear Technologies: Proceedings of the X Anniversary Russian Scientific Conference, 22–25 September 2015, Moscow, Obninsk.* Moscow: SAM Polygraphist publ.; 2015. 142 p. (In Russ.). Available from: https://ibrae.ac.ru/pubtext/108/ (accessed: 25.07.2024).

Materials and methods

At this stage of the study, individual external doses were estimated for 984 residents (432 men and 552 women) of Novye Bobovichi village, Novozybkovsky district, Bryansk region, who lived in the village during the Chernobyl accident and did not leave in the first years after the accident. By the middle of 2023, 499 people (233 men and 263 women) from among the old residents had died. The average age of death for men was 65 years, and for women – 79 years.

The calculations of external dose were based on the results obtained in the previous door-to-door surveys [3], as well as new measurements of dose rate made in July 2022 during the door-to-door surveys. All surveys to maintain similarity were conducted in accordance with the 1990 Methodological Recommendations for Assessment of Radiation Situation in Populated Areas by the year 1990.[8]

In 2022 the following verified instruments of the Scientific and Technical Support Centre (STSC) of IBRAE RAS[9] were used to measure the dose rate on the ground and indoors:

– DKG-02U “Arbitr” was used in this study to measure the ambient dose equivalent rate at local points;

– individual dosimeter DKG-RM1610 was used as a backup for route recording of continuous γ-radiation dose equivalent rate for each of the expedition participants;

– MKS-AT6101 was used for enroute gamma-ray imaging.

In addition, each researcher had a Polymaster dosimeter attached to his or her belt, which continuously recorded dose rates in files with an averaging interval of 180s.

All instruments measure the ambient dose rate. The lowest actual background dose rate values in the range from 0.08 to 0.22 μSv/h were recorded in the centre of asphalt roads. In the same dose range were the results of measurements in both brick and wooden houses. The highest values were recorded over areas of undisturbed soil surface. The results of dose rate measurements at local points are given in Table 2.

In the course of work under the research programme on migration of ^{137}Cs in the structure of a settlement[10] the parameter $M_{137}(t)$ was proposed – the ratio of the average dose rate at a height of 1 m for a characteristic surface type $P\gamma(137)$,

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[8] *Methodological Recommendations on Assessment of Radiation Situation in Populated Areas.* 1990. (In Russ.). Available from: https://www.feerc.ru/radsafety/archive/PDF_archive/radmonitdocs/histordocs/polozh_metod_ukaz/nasPointsObstan.pdf (accessed: 25.07.2024).

[9] *Centre for Scientific and Technical Support (CSTS) of IBRAE RAS.* (In Russ.). Available from: https://ibrae.ac.ru/contents/89/ (accessed: 25.07.2024).

[10] *The French-German Initiative: Results and Their Implication for Man and Environment.* CD-ROM with the main project results. Ukraine; 2004; Panchenko SV, Arakelyan AA, Gavrilina EA. *Dynamics of radiation situation parameters in a rural settlement polluted as a result of the Chernobyl accident in April 1986.* IBRAE preprint no. IBRAE-2014-06, Moscow; 2014, 35 p. (In Russ.). Available from: https://ibrae.ac.ru/docs/109/2014i06.pdf (accessed: 25.07.2024).

to the density of the integral nuclide content in soil calculated at the time of dose rate measurement – σ_{137}:

$$M_{137}(t) = P_\gamma(137)/\sigma_{137}\ [\frac{\mu Sv/h}{kBq/m2}], \quad (1)$$

where σ_{137} – calculated density of ^{137}Cs surface contamination, kBq/m^2 at the time of dose rate measurement; $P_\gamma(137)$ – the difference between the measured dose rate at the point $P\gamma$ and the background value of this rate $P\gamma(0)$, which was before the accidental contamination: $P\gamma(137) = P\gamma - P\gamma(0)$. As $P\gamma(0)$ for Novye Bobovichi was taken the value equal to 0.09 μSv/h[11].

Table 2. **Mean dose rate values at characteristic points of the village of Novye Bobovichi in July 2022, μSv/h**

Surface Type	Number of Dimensions	Mean dose rate, μSv/h
Unperturbed surface	12	0.43±0.02
Grass cover from road to site	261	0.28±0.01
Bench at the gate (at home)	96	0.25±0.003
Soil on the street and in yards	16	0.27±0.01
Asphalt	87	0.15±0.01
Vegetable garden	67	0.31±0.01
Garden	27	0.30±0.01
The house is wooden	33	0.12±0.01
The house is brick	18	0.13±0.01

Source: compiled by K.V. Gupalo-Osadchaia, S.V. Panchenko.

A relationship can be used to estimate the effective external dose (H_{Ex}) at a particular point for selected occupational and age groups:

$$H_{Ex} = R_k \cdot \int \dot{D}(t) \cdot dt, \quad (2)$$

where $\dot{D}(t)$ – dose rate per year obtained by interpolation between measured $P\gamma(137)$ in individual years in the period 1990–2023; R_k – dose reduction factor, which for different population groups can be defined as:

$$R_k = \sum_j L_j \cdot p_{kj}, \quad (3)$$

where L_j – the factor of place[12], p_{kj} – the factor of employment of the k-th group of population [3]. For each age and occupational group the values of the parameter – p_{kj} are selected (Table 3).

The analysed data from the house books of Novye Bobovichi village. Novye Bobovichi, as well as the desire to use the known dependence of dose coefficient values on the age of residents [2] allowed us to identify 6 main population groups.

Group No. 1 – preschool children up to 7 years of age were included.

[11] Konstantinov YuO. et al. *Current and retrospective assessment and verification of internal and external radiation doses for all contingents.* Final Report. S. Petersburg; 1992. (In Russ.).

[12] Gusev NG, Belyaev VA. *Radioactive Emissions in the Biosphere: Reference Book. 2nd ed., rev. and supplement.* Moscow: Energoatomizdat publ.; 1991. 256 p. (In Russ.).

Group No. 2 – school-age children. Children aged 7 to 17 years.

Group No. 3 – people older than 17 years, constantly working outdoors: shepherds, tractor drivers, field workers, etc.

Group No. 4 – people over the age of 17 who work outdoors intermittently rather than continuously.

Group No. 5 – people over 17 years old, their lifestyle can be called "work-home", as they spend 9 hours working indoors, 2 hours travelling (including visits to shops and other places), and the rest of the time is taken up by household chores.

Group No. 6 – pensioners who also have a lifestyle that is not typical for other groups. It was accepted that until 9 o'clock representatives of the group spend up to 9 hours in the fresh air, doing work in the vegetable garden, communicating with other pensioners, and the rest of the time they spend at home.

For the reference members of each population group, the distribution of living time in different locations is presented in Table 3.

Table 3. **Time spent by different population groups in different locations, hour/year**

Localization	Population group					
	1	2	3	4	5	6
Unperturbed surface			2053	1369		
Grass cover from road to site	1800	1721				
Bench at the gate (at home)						182
Soil on the street and in yards	885	391	319	684	339	365
Asphalt			274	456	157	913
Vegetable garden	600	194			259	
Garden	5475	5280	6068	6205	5632	7117
The house is wooden		1174	46	46	2373	183
∑ hours	8760	8760	8760	8760	8760	8760

Source: compiled by K.V. Gupalo-Osadchaia, S.V. Panchenko.

To estimate the dose rate before 1990, we will use the dependence [4]:

$$\dot{D}(t) = \sum_i \sigma_i \cdot G_i(t) \cdot \exp(-\lambda_i \cdot t), \quad (4)$$

where σ_i – the initial density of surface contamination with the *i*-th radionuclide (kBq/m^2); $G_i(t)$ – conversion rate from σ_i to dose rate $\dot{D}_i$ as a function of time, (nSv/h)/(kBq/m^2); λ_i – the radioactive decay constant of the *i*-th radionuclide; *t* – the time after contamination.

Conversion rate ($G_i(t)$) for 1986 were taken for a 3 mm soil layer, and for subsequent years (1987–1989) for a 5 cm layer from [2].

The parameter $M_{137}(t)$ was used to estimate external doses after the year 1990.

Results and discussion

Figure 5 presents the dynamics of the M_{137} parameter value for different localisations of Novye Bobovichi village over the entire observation period, considering the data obtained in 2022 (36 years after the accident). The points for the first numbers of May 1986 (initial points) are taken from reference publications.

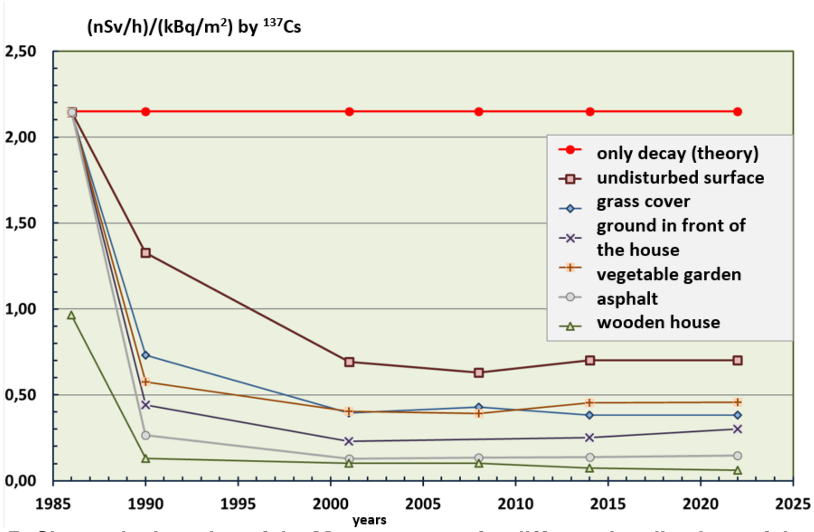

Figure 5. Change in the value of the M_{137} parameter for different localizations of the village of Novye Bobovichi due to the migration of ^{137}Cs in the period 1986–2022
Source: compiled by K.V. Gupalo-Osadchaia, S.V. Panchenko.

As can be seen from Figure 5, the general characteristic of the processes is the actual cessation of the decline in the values of the parameter M_{137} for all localisations after 2001. In other words, after 15 years the migration of ^{137}Cs, which influenced the formation of the external dose rate in the settlement in the first years, actually ceases, and only the decay of this isotope remains.

For the subsequent stages of reconstruction of the accumulated dose due to external exposure, the absolute value of the anthropogenic component for each characteristic point of localisation also matters. Therefore, the dynamics of these values (Figure 5) is an important parameter for calculating the accumulated dose to the inhabitants of the settlement.

The following expression was used to calculate the average annual dose loads for the *j*-th recipient:

$$D_j = \sum_{i=1}^{8} \dot{D}(t) \cdot t_i, \quad (5)$$

where t_i – the time spent by the *j*-th recipient at a particular point, in fractions of a year.

In our case the following local points are defined: undisturbed surface (forest), grass cover, bench, ground in front of the house, vegetable garden, asphalt, wooden and brick houses. To estimate $\dot{D}(t)$ – the dose rate that the recipient can receive, being in a particular point in the year under consideration, we will use the dependence obtained earlier, for which for each year the calculated value of $P\gamma(137)$ is multiplied by $M_{137}(\tau)$, where τ is the calendar year. The results of calculations are presented in Figure 6.

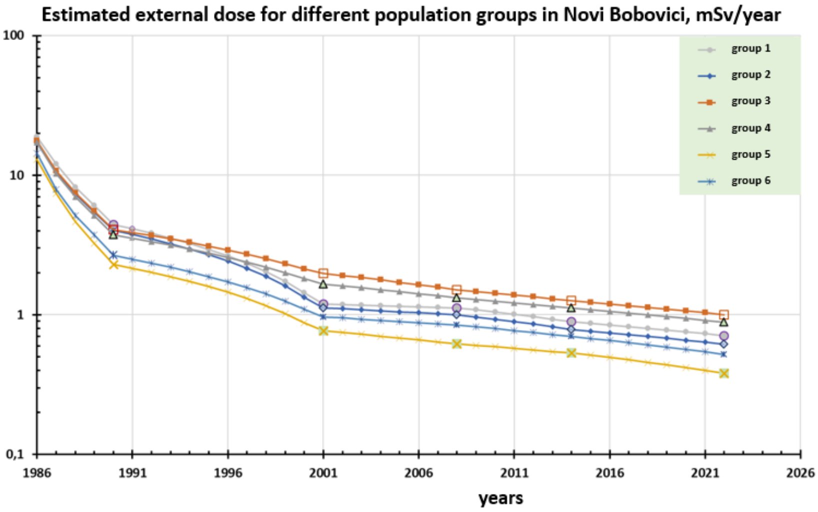

Figure 6. Reconstruction of the external radiation dose caused by 137Cs for 6 reference populations of the village of Novye Bobovichi for the period 1986–2022
Source: compiled by K.V. Gupalo-Osadchaia, S.V. Panchenko.

The dose integral for the period 1986–2022 was estimated taking into account that persons in Group 1 in 1986 first moved to Group 2 and then to Group 4. Persons in Group 2 then moved to age Group 4, and persons working (Groups 3, 4, 5) moved to group 6 when they reached retirement age Figure 6. The results of calculations were carried out for each resident separately considering his age at the moment of the accident at ChNPP. The averaged values of annual doses by groups for those villagers, who lived without leaving the whole investigated period, are given in Figure 6. This approach gives numerical reference points of possible external doses for residents belonging to different age and social groups. It should be noted that the approach is somewhat conservative, since practically all villagers were away from the territory in question for various periods of time during the period under study. In principle, such an account is partially possible, as there are records in house books, where the most significant periods of departure (military service, studies, work outside the village, etc.) were recorded. However, such work would be appropriate if there were medical observation data on individual health of villagers.

Table 4. **Estimation of external radiation doses of various age and occupational groups of the population of the village of Novye Bobovichi for the period 1986–2022 due to the “Chernobyl” ^{137}Cs**

Indicator	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
Dose for the period 1986–2022, mSv	99	89	107	97	58	68

Source: compiled by K.V. Gupalo-Osadchaia, S.V. Panchenko.

The performed assessments show that the differences in the received external dose of different groups of the village population do not exceed two times (Table 4). Further increase of the total external dose considering demographic factors will be very insignificant.

Error estimation

The errors in the estimation of individual external doses to the population are formed mainly not so much by errors in the measurement of radiation parameters as by the incompleteness of our knowledge of the spatial distribution of many short-lived radionuclides in the first year after contamination and the corresponding values of the place factor (L_j) and the occupancy factor (p_{kj}). Our assumption about the stability of the radionuclide composition of wet deposition, although based on rather convincing arguments: the relatively small area of the settlement zone (about 2 km^2) compared to the size of the thunderstorm cloud and the radioactive plume; the single-moment nature of the main deposition (low contribution of dry deposition before and after rain), good homogeneity of ^{137}Cs deposition, still has no experimental confirmation. The situation with the establishment of the error for the parameters L_j and p_{kj} in the case when we deal with individual dose estimation is even more difficult. For the first year, the quantitative value of the error can be justified only by expert judgement, and it is this error that will largely influence the estimate of the error in the accumulated dose.

Conclusions

Long-term observations of radiation situation parameters in a rural settlement have shown that migration of ^{137}Cs in the settlement in the first 15 years after accidental contamination was quite active and can be described as exponential with a period of 7.5 years. However, then the role of the migration component in the formation of external dose actually became invisible against the background of ^{137}Cs decay.

For the farmsteads contaminated as a result of the accident at ChNPP at the level of 1 MBq/m^2 by ^{137}Cs, even conservative estimates of dose loads on different population groups show that the maximum external doses, difficult to eliminate without serious costs, for the first 35 years after the accident did not exceed about 100 mSv , which is noticeably lower than the criterion of the threshold of 350 mSv per lifetime proposed by national scientists[13], but lower than the level of radiation exposure per lifetime adopted in the Law on Radiation Safety[14] – 70 mSv per 70 years of life.

Assessing the situation as a whole, it can be concluded that the decisions taken and partially implemented efforts to reduce the consequences of radioactive contamination of the territory only to a small extent affected the lifetime dose from external exposure of the population of the settlement under consideration.

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[13] Decision No. 587 of the Governmental Commission on Liquidation of the Consequences of the ChNPP Accident Concerning the 35-Ber Concept of Population Living in Contaminated Territories, signed by the Chairman of the Governmental Commission on Liquidation of the Consequences of the ChNPP Accident V.X. Doguzhiev.

[14] Federal Law of 9 January 1996 No. 3-FZ "On Radiation Safety of the Population". *Garant: website.* Available from: https://base.garant.ru/10108778/?ysclid=lz1ksrh2h0635868102 (accessed: 25.07.2024).

References

[1] Linge II, Melikhova EM, Panfilov AP. Consequences of the accident at the Chernobyl nuclear power plant based on the results of the work of the Chernobyl Forum. *Bulletin on Atomic Energy*. 2006;(4):24–29 (In Russ.) EDN: SCHUZY

[2] Bellamy MB, Dewji SA, Leggett RW, Hiller M, Veinot K, Manger RP, Eckerman KF, Ryman JC, Easterly CE, Hertel NE, Stewart DJ. EPA-402-R-19-002. External exposure to radionuclides in air, water, and soil. *Federal guidance report No. 15. Office of Radiation and Indoor Air U.S.* Environmental Protection Agency Washington, DC 20460; 2019. 335 p.

[3] Panchenko SV, Gavrilina EA, Shvedov AM, Arakelyan AA. Dynamic of radiological situation in the rural settlements contaminated by cesium-137 caused by the Chernobyl accident in April 1986. *Medical Radiology and Radiation Safety*. 2016;61(4):5–18 (In Russ.) EDN: WHAWJT

[4] Merwin SE, Balanov MI. The Chernobyl papers. Vol. 1. Dose to the Soviet population and early health effects studies; 1993. 439 p. ISBN 978-1883021023.

Bio notes:

Ksenia V. Gupalo-Osadchaia, Engineer of the Radioecology Laboratory, Nuclear Safety Institute of the Russian Academy of Sciences, 52 Bolshaya Tulskaya St, Moscow, 115191, Russian Federation. ORCID: 0009-0004-0791-4638. E-mail: gupalo.kv@ibrae.ac.ru

Sergey V. Panchenko, Head of the Laboratory of Radioecology, Nuclear Safety Institute of the Russian Academy of Sciences. 52 Bolshaya Tulskaya St, Moscow, 115191, Russian Federation. ORCID: 0000-0002-2750-0940, eLIBRARY SPIN-код: 6148-6635. E-mail: panch@ibrae.ac.ru