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Gamma background level in the western districts of the Bryansk region

P.G. Sorokin

Dosimetric monitoring of external gamma radiation in radioactively contaminated areas is an essential measure to ensure public safety. Accumulated data on radioactive contamination from different periods can be used for scientific forecasting. This study was conducted in July 2024 as part of research on agricultural ecosystems in radioactively contaminated areas of the Bryansk region. The surveyed settlements are among the most affected in Russia following the Chernobyl Nuclear Power Plant accident. They are located either in the zone of residence with the right to relocation, where the current soil contamination density of ^{137}Cs ranges from 185 to 555 kBq/m^2 (5–15 Ci/km^2), or in the resettlement zone, where the contamination density exceeds 555 kBq/m^2 (15 Ci/km^2). A total of 136 measurements were taken. The results were analyzed for compliance with established regulations and presented in tabular and cartographic formats. The equivalent dose rate (EDR) of gamma radiation in the surveyed area averaged 0.48±0.29 μSv/h (M±s), with a minimum value of 0.08 μSv/h and a maximum of 1.50 μSv/h. In 7 settlements within the resettlement zone, the EDR exceeded the maximum permissible value of 0.58 μSv/h. In 16 settlements, including two in the resettlement zone, the EDR was above the normal level of 0.20 μSv/h but did not exceed the maximum permissible value. In 3 settlements, the EDR remained within the normal level.

Key words: *equivalent dose rate, gamma radiation, Bryansk region, radioactively contaminated areas, radiation background map, radioecology, dosimetry, radiobiology, public health*.

Introduction

Dosimetric monitoring of external gamma radiation in radioactively contaminated areas is a necessary measure to ensure public safety. The data accumulated during various periods of radioactive contamination can be used for scientific forecasting. The present study was conducted in July 2024 as part of the investigation of agricultural ecosystems in the radioactively contaminated areas of the Bryansk Region.

The aim of this study is to measure the equivalent dose rate (EDR) of gamma radiation in settlements located in the western districts of the Bryansk Region—areas most affected in the Russian Federation following the Chernobyl Nuclear Power Plant (ChNPP) accident. The objectives include presenting the processed data in tabular and cartographic forms, as well as

P.G. Sorokin: Moscow State Academy of Veterinary Medicine and Biotechnology – MVA by K.I. Skryabin. Contacts: 23 Akademika Skryabina str., Moscow, Russia, 109472. E-mail: philip.sorokin@gmail.com.

analyzing the results in relation to established safety standards. The studied settlements are located within the zone of residence with the right to relocation, where the current soil contamination density with ^{137}Cs is 185–555 kBq/m^2 (5–15 Ci/km^2), and the resettlement zone, where it exceeds 555 kBq/m^2 (15 Ci/km^2) [1, 2].

Materials and methods

The equivalent dose rate was measured using a scintillation dosimeter-radiometer SRP-68-01, which is registered in the State Register of Measuring Instruments of the Russian Federation and had undergone scheduled maintenance [3]. The EDR was measured in 5-second integration mode. Dosimetry was conducted according to the standard methodology [4] on level open areas not smaller than 60×60 m. The dosimeter's sensor was positioned 1 m above the ground surface, maintaining a distance of 1 m from the operator, at least 5 m from other individuals, and 30 m from buildings.

Measurements were performed in dry weather in areas of predominant human activity, at equidistant points located at opposite ends and in the center of each settlement. All measurements were completed within a two-day period. The gamma background map was generated using *Adobe Photoshop 23* and *Google Maps Platform* tools. The results were statistically processed using variation statistics and presented as $M \pm s$, where M is the arithmetic mean and s is the standard deviation.

Results and discussion

Table 1 presents the results of the EDR measurements in settlements of the western districts of the Bryansk Region. Arrows indicate values exceeding permissible limits.

Table 1

Equivalent dose rate in settlements of the western Bryansk Region, μSv/h

Settlement	Average	Std. dev.	Min	Max	n	Type	Status*
Vereshchaki	**0.37**	0.12	0.19	0.56	10	village	A
Vikholka	**0.40**	0.10	0.27	0.50	4	village	A
Vyshkov	**0.66** ↑	0.03	0.63	0.69	3	urban-type settlement	B
Gordeevka	**0.31**	0.10	0.14	0.40	5	village	A
Gorodechnya	**0.29**	0.12	0.15	0.39	4	village	A
Grivka	**0.22**	0.07	0.17	0.27	2	settlement	A
Groznyi	**0.39**	0.12	0.27	0.50	3	settlement	A
Demenka	**0.46**	0.02	0.44	0.48	3	village	B
Zlynka	**0.28**	0.01	0.27	0.29	3	town	A
Katashin	**0.22**	0.06	0.12	0.29	9	village	A
Katichi	**0.42**	0.15	0.16	0.64	13	village	A
Klintsy	**0.11**	0.02	0.08	0.14	5	city	A

* – settlement status – A: zone of residence with the right to relocation; B: resettlement zone.

Table 1 (continued)

Equivalent dose rate in settlements of the western Bryansk Region, μSv/h

Settlement	**Average**	Std. dev.	Min	Max	n	Type	Status*
Kozhany	**0.76** ↑	0.30	0.40	1.30	6	village	B
Krasnaya Gora	**0.14**	0.02	0.12	0.16	3	urban-type settlement	A
Mirnyi	**0.65** ↑	0.05	0.60	0.70	4	settlement	B
Mokhonovka	**0.20**	0.05	0.15	0.24	3	settlement	A
Nesvoevka	**0.36**	0.29	0.19	0.80	4	village	A
Novoe Mesto	**0.36**	0.13	0.27	0.51	3	village	B
Novozybkov	**0.24**	0.11	0.13	0.41	5	city	A
Novye Bobovichi	**0.61** ↑	0.20	0.28	0.78	6	village	B
Peretin	**0.33**	0.01	0.32	0.34	2	village	A
Petrova Buda	**0.32**	0.02	0.30	0.34	3	village	A
Starye Bobovichi	**0.45**	0.16	0.25	0.60	4	village	A
Staryi Vyshkov	**0.69** ↑	0.16	0.52	0.90	4	village	B
Uvel'e	**0.73** ↑	0.26	0.44	1.30	12	village	B
Yalovka	**0.96** ↑	0.29	0.68	1.50	13	village	B

* – settlement status – A: zone of residence with the right to relocation; B: resettlement zone.

Fig. 1 shows a map of the radiation background in the western districts of the Bryansk Region, compiled on the basis of the obtained EDR measurement results. The data are presented as *M (min–max)*, where *M* is the arithmetic mean, *min* is the minimum value, and *max* is the maximum value.

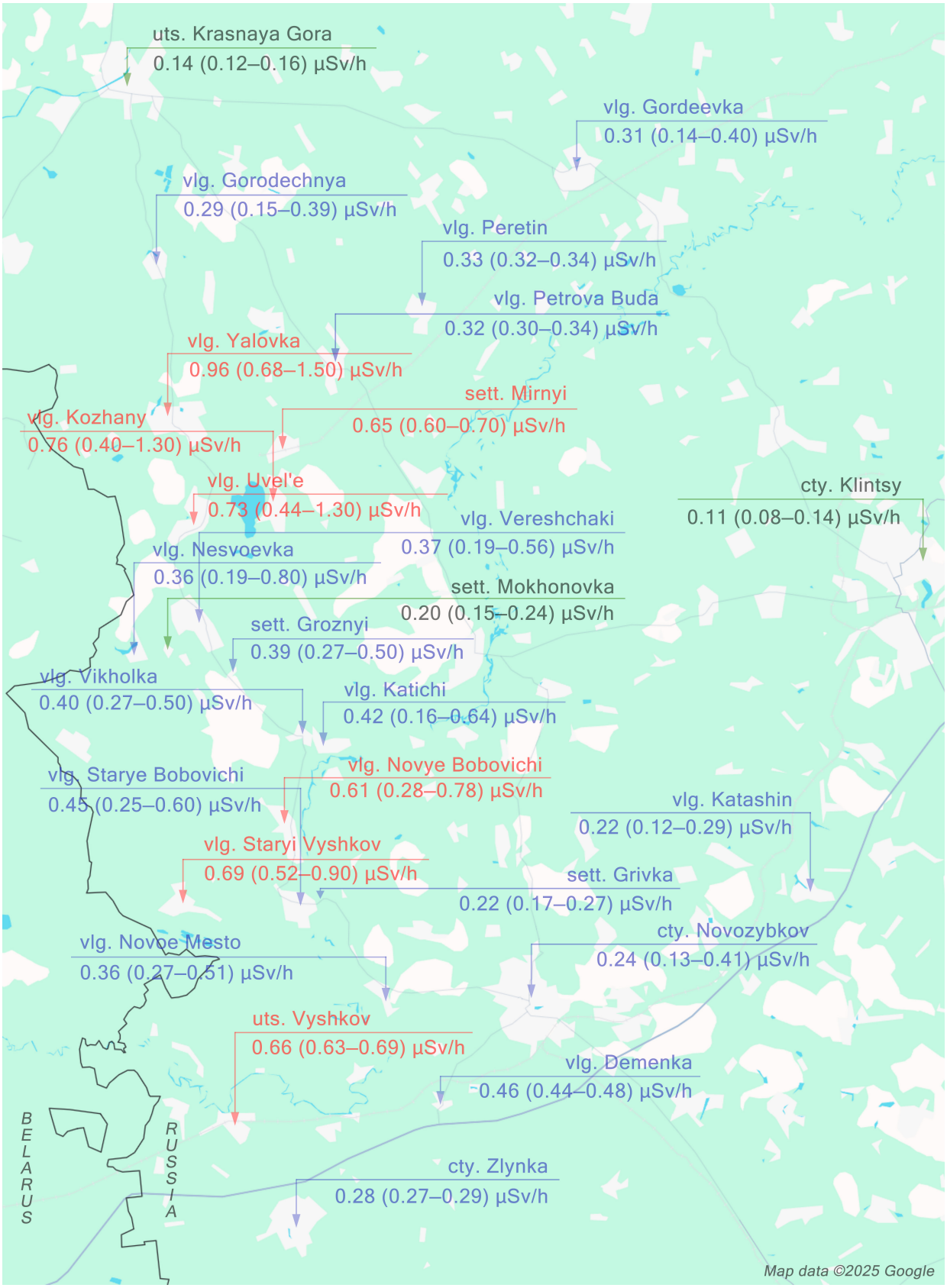

Fig. 1. EDR map of gamma background in the western districts of the Bryansk Region.

The permissible effective dose of exposure to the population from anthropogenic sources is 5 mSv/year, which corresponds to an EDR of 0.58 μSv/h. “Persons moving to this territory for permanent residence shall be informed of the potential health risks associated with radiation exposure” [5]. If the anthropogenically induced effective dose reaches 1 mSv/year (0.115 μSv/h), active protective measures must be taken to reduce population exposure [5].

The background EDR of gamma radiation from natural sources, cosmic radiation, and global fallout from technogenic radionuclides generally does not exceed 0.20 μSv/h across various regions of the Russian Federation. However, the contribution of anthropogenic sources to the total dose must be taken into account and should not exceed 0.115 μSv/h.

When selecting land plots for residential or public construction, areas with EDR values below 0.30 μSv/h are preferred. If EDR exceeds 0.30 μSv/h, the building design must include a radiation protection system appropriate for elevated gamma radiation levels [6].

Citizens living in the zone of residence with the right to relocation where the average annual effective equivalent dose exceeds 1 mSv and who decide to move to another location are entitled to compensation and social support measures [2]. In the resettlement zones, where the average annual effective equivalent dose from radioactive fallout may exceed 5 mSv, compulsory resettlement of the population is required; settlement in these areas is prohibited until the radiological risk is reduced to acceptable levels [2].

According to IAEA recommendations, when conducting a predictive radiation and environmental assessment, it is necessary to ensure sufficient accuracy to reliably determine whether actual doses to the population will exceed the limits established by national regulators. In cases where source data are lacking, conservative assumptions and appropriate safety margins should be applied [7].

In the western districts of the Bryansk Region, the total EDR of gamma radiation is primarily attributed to technogenic factors, particularly fallout following the Chernobyl Nuclear Power Plant accident. Therefore, under current regulations, an EDR value exceeding 0.20 μSv/h is considered elevated but acceptable, while the value of 0.58 μSv/h, taking into account conservative assumptions and adequate safety margins, may be regarded as the maximum permissible level.

Conclusion

According to the results of the study conducted in July 2024, the equivalent dose rate (EDR) of gamma radiation in settlements of the western districts of the Bryansk Region averaged 0.48 ± 0.29 μSv/h, with a minimum value of 0.08 μSv/h and a maximum of 1.50 μSv/h, based on 136 total measurements. In total, 26 settlements were surveyed—classified either within the resettlement zone or the zone of residence with the right to relocation. The findings are presented in both tabular and cartographic formats.

In 7 settlements located in the resettlement zone, the EDR exceeded the maximum permissible level of 0.58 μSv/h. In 16 settlements (including 2 within the resettlement zone), the EDR exceeded the reference level of 0.20 μSv/h but remained within acceptable limits. In 3 settlements, the EDR did not exceed the standard background value established for the Russian Federation.

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