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THE ESTIMATION OF EXTERNAL EXPOSURE OF THE RESIDENTS OF MULTI-STOREY HOUSING IN ZHYTOMYR

The accident at the Chernobyl nuclear power plant was a terrible experience of radiation effects on the human body. Almost 29 years have passed but the effects are still felt today. A number of legislative acts to control the radiation background were adopted to protect the public from exposure. No building could be put into operation without a thorough environmental appraisal of housing on radiation safety [2].

At present, according to the radiological and dosimetric monitoring, the dose structure of additional public exposure in different regions of Ukraine has significant distinctions. Residents' exposure ranges from 0.1 to 5.0 μSv for a year. External exposure in areas of Ukrainian Polissia does not exceed 20% of the total dose.

External exposure in buildings is formed by gamma-emitting of natural radionuclides contained in building materials. The levels of gamma radiation increase with the increase of radionuclides content inside the building. If the person is inside the building, the external exposure dose changes under the influence of two oppositely acting factors: shielding of external radiation by a building and irradiation of natural radionuclides that are in the materials the house is built of. The dose intensity in buildings varies considerably depending on the ^{40}K, ^{226}Ra, ^{232}Th concentration in various construction materials [1, 2].

Today people live in the conditions of increased radiation levels and the permissible level of 0.1-0.2 μSv/h is considered normal; the level of 0.2-0.6 μSv /h is considered acceptable; and the level of more than 0.6-1.2 μSv/h is recognized as high [3]. Artificially generated radiation sources constantly increase the level of natural radiation background and therefore it must be adjusted. In addition, some areas of Zhytomyr region are located in the area of the occurrence of Ukrainian crystalline massif with rocks rich on uranium and thorium. Thus, the levels of radioactivity in multi-storey housing of Zhytomyr were investigated.

Measurements of external gamma background in the buildings of 8 Zhytomyr streets were conducted according to the research program. In general, 54 measurements in entrances of buildings and 18 outdoor measurements were conducted. 36 measurements of the total number were conducted in multi-storied buildings (20 measurements conducted in buildings made of red brick and 16 measurements in buildings made of lime-sand brick. Investigated buildings are constructed of different building materials: concrete blocks, red brick, lime-sand brick.

The measurements were performed in a sufficient distance, i.e., about 20 meters from the building considered as an alleged source of radiation. After this, the measurement was performed directly inside the building and next to the building. The

places of basic research (points of measurement) were determined as follows: the first point was the measurement of gamma background next to the building; the second point – measurements on the first floor, the third point – measurements on the middle floor of the building (depending on the number of floors), the last point of measurement was the top floor. Each measurement was performed at least 2 times on each point of the investigation and the average arithmetic value was calculated. Measurements were conducted in the period from 14 pm to 15 pm. All investigations were performed within one week.

Measurements of external gamma background in multi-storied buildings of Zhytomyr were performed with a special appliance RADOS (RDS-30), the value of measurement – μSv/h. This appliance is designed both for the rapid assessment of radiation situation and for the estimation of the dose rates of staff when working with sources of photon radiation at nuclear power plants, at the enterprises of nuclear industry and other radiation-hazardous sites. Dosimeter RDS-30 has an energy range: 0.01-100 μSv/h. The principle of its operation is based on gamma radiation detection by Geiger-Muller counter. The dosimeter error ranges from 0,005 to 0,045 μSv/h [5;6] within the range of 0.12-0.20 μSv /h.

Streets	Number of measurements	Floor	Gamma radiation μSv/h, (M±m)	Average in buildings μSv/h, (M±m)
Buildings of red brick				
Vitruka, 16; Vitruka, 21; Peremohy, 25; Chernyakhovsky, 18; Chapaeva, 36	5	Ground floor	0,12 ± 0,025	0,13 ± 0,005
	5	Middle floor	0,13 ± 0,02	
	5	Top floor	0,13 ± 0,03	
	5	Outdoor	0,20 ± 0,025	0.20 ± 0,025
Buildings made of lime-sand brick				
Gagarin, 22; Peremohy , 29; Kyivska, 16; Chernyakhovskogo 21	4	Ground floor	0,13 ± 0,01	0,15 ± 0,02
	4	Middle floor	0,15 ± 0,025	
	4	Top floor	0,17 ± 0,01	
	4	Outdoor	0,19 ± 0,025	0,19 ± 0,025
Panel buildings				
Korolyova, 44; Korolyova 46; Korolyova , 57; Gagarina, 18; Gagarina, 21; Peremohy , 18; Kyivska, 11; Berdichivska, 78; Berdychivstka, 60a	9	Ground floor	0,16 ± 0,045	0,18 ± 0,015
	9	Middle floor	0,18 ± 0,07	
	9	Top floor	0,19 ± 0,065	
	9	Outdoor	0,19 ± 0,045	0,19 ± 0,045

1. Table Indoor and outdoor levels of external gamma radiation

As can be seen from Table 1, the levels of external gamma radiation depend on the construction materials and the floor of the building.

The data on radiation background in brick and in panel buildings were compared. The buildings constructed of red brick have the levels of gamma radiation in the range of 0.12 to 0.13 μSv/h; the outdoor radiation is 0.20 μSv/h. The gamma radiation levels in buildings constructed of lime-sand brick range from 0.13 to 0.17 μSv/h; the outdoor radiation is 0.19 μSv/h. In panel houses levels of gamma radiation range from 0.16 to 0.19 μSv/h; outdoor radiation is 0,19 μSv/h. It is estimated that radiation levels inside buildings constructed of red brick are 35% lower than the outdoor levels; the levels inside the building constructed of lime-sand brick are 21% lower and the levels inside the panel buildings are 5% lower compared to outdoor values.

The average level of gamma radiation in all buildings does not exceed 0, 20 μSv/h (taking into account the device error). Radioactivity on the top floors of some panel buildings was slightly higher than on the ground and middle floors; the average is less than 0, 20 μSv/h. It is estimated that the maximum dose of external gamma radiation accumulates in panel buildings (an average - 0.18 μSv/h); the average levels of gamma background accumulate in buildings made of lime-sand brick (0.15 μSv/h); the lowest levels of gamma background accumulate in buildings made of red brick (0.13 μSv/h). The comparison of the average outdoor radiation backgrounds showed that the difference among them is not significant: 0.20 μSv/h for buildings of red brick; 0.19 mSv / h both for panel buildings and buildings of lime-sand brick.

Levels of indoor gamma radiation (the norm rate 0.15 - 0.20 μSv/h) does not exceed the outdoor external radiation (the norm rate 0.08 - 0.12 μSv/h). Consequently, the equivalent dose of gamma radiation in Zhytomyr in all studied buildings, including panel buildings, is within the norm (the norm 0.25 - 0.30 μSv/h) [3].

As a rule, the granite gravel is used as filler in the preparation of concrete. It caused the rise of radiation background in buildings made of concrete. The contribution to the total radiation background makes lime-sand brick which is used in facing buildings more often than granite. This is evidenced by the difference in the results calculation of the average dose of gamma radiation in panel buildings and buildings made of lime-sand and red brick.

Thus, the data on the radiation background show that it does not exceed the permissible standards and does not create a risk to stay both in brick and in panel buildings in Zhytomyr. However, the main problem of radionuclides accumulation in studied entrances and multi-storied buildings is the radioactivity of construction materials. These construction materials form external radiation which depends on the rate of material radioactivity caused by the radionuclides irradiation contained in this material.

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