RADIATION IN THE CITY: NATURAL AND ARTIFICIAL RADIATION, REALITY AND MYTHS

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Typical background radiation in a contemporary city is 8-12 μR/hr (microroentgens per hour).

Radionuclides are scattered in the environment and are present in any surroundings, no matter organic or inorganic. This radionuclides radiation together with cosmic radiation creates a natural radiation background. We are not surprised with the radiation level of 10-14 μR/hr (0.10-0.14 μSv/hr (microsieverts per hour), and we know this is a norm for the most areas. We also know that the atmosphere is more permeable to cosmic rays at the height of 10 km (civil airplanes flight altitude) and therefore, the background therein is 200-250 μR/hr (2,0-2,5 μSv/hr). However, we are unaware of the places on Earth, where the natural background is increased significantly, not causing any problems for the inhabitants.

Let us investigate the causes of this phenomenon. Earth`s sources of radiation are more than 60 natural radionuclides. The main contribution to the external radiation dose is made by gamma-emitting nuclides of uranium and thorium radioactive series, as well as of potassium-40. There are radiation anomalies in those areas, where thorium and uranium content in the soil is increased. Here are some examples:

France

The average background runs up to 2 μSv/hr (20 times more than "typical" background) in a number of regions. On average, 7 million French people receive an annual natural radiation dose that is 1.5-2 times more than the world average one. There are areas with the same radiation level in Italy, the USA, Sweden, Madagascar, volcanic islands in the Pacific Ocean. There are regions with the increased natural background in Russia as well – for example, some regions of Altai and Karelia.

India (Kerala State)

7 000 people live in the area with an average background of 0.43 μSv/hr. There are monazite sand seeps along the coastal strip where thorium-232 and decay products content is approx. 10% by weight. More than 100 thousand residents of Kerala and Madras states live under the annual average background of 0.14-3.2 μSv/hr.

Brazil (Espirito Santo and Rio de Janeiro States)

The radiation dose ranges from 1 to 10 μSv/hr along the Atlantic coast, running up to 20 μSv/hr at the sea beaches.

Iran (Ramsar)

There are areas where the dose rate ranges from 0.7 to 50 μSv/hr due to high uranium content in the water.

In other words, the radiation background can be 500 times higher than typical one. However, at the same time, "according to the scientists of the Pan American Health Organization: "...the influence of the relatively increased background on the mortality because of oncopathology, frequency of congenital anomalies, physical development disorders, fertility rate, frequency of congenital pathology, child mortality rate, sex ratio and spontaneous abortion frequency is not ascertained» in these cities [1].

Natural radioactive background accompanies the biosphere through all its evolution. The radiation sources are: external radiation (cosmic radiation and radiation from the radioactive elements, present in the Earth`s interior, atmosphere, water, and living things) and internal irradiation (from natural radionuclides, penetrating into organism with air, food and water). The internal radiation accounts for 60%, the external one – 40% of the natural radiation.

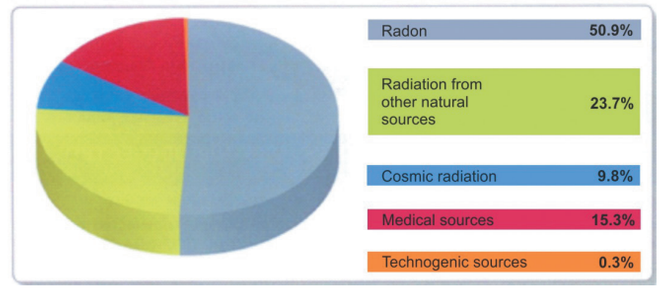
Average irradiation per capita is 3 800 μSv/yr. The medical examination accounts for 600 μSv/yr, nuclear weapons tests in the atmosphere and past accidents – approx. 10 μSv/yr, nuclear power – approx. 2 μSv/yr.

Radon – a colorless, odorless and tasteless dense gas (7.5 times denser than air) – accounts for a half of the annual natural radiation dose from the natural sources of radiation. Radon is a decay product of thorium radioactive series. Person gets a significant part of doses from radon while being in enclosed, unventilated spaces where radon seeps through the foundation and floor from the ground, via inhaled air. A man receives the highest radiation dose in bathrooms when taking a shower, where the radon content is 40 times higher than in other rooms.

The natural radiation background is one of the conditions for biota normal functioning. It is believed that it is necessary for the evolution of life on Earth, for maintaining active self-regulation of the living. That is probably why people live much longer in the mountains, at the sites of granite abruption where the background is of 0.3-0.5 μSv/hr. There are resorts in Brazil and India where irradiation exceeds several times the annual permissible levels.

Hard cosmic radiation, gamma-radiation from potassium-40 of the earth's crust and alpha-radiation from radon-220 and radon-222, which is a product of all three series decay, make the greatest contribution to the irradiation. A radioactive background dose depends on such factors as altitude, quantity and type of radionuclides, present rocks and soil. For example, people living at the sea level, receive an average equivalent dose from cosmic radiation of approx. 300 μSv/yr. External irradiation is several times more for people living 2 km above the sea level. Notably, 5 km are the maximum height where human constructions are present (Peru and Bolivia). Crews and passengers of airplanes are exposed to quite intensive irradiation. At the height of 12 km (maximum flight altitude of transcontinental airplanes) the cosmic radiation dose is 25 times higher.

Besides radon there other sources of internal irradiation – potassium-40, which is absorbed by organism along with nonradioactive isotopes of potassium, vital to the organism functioning. Person receives significantly larger dose of internal irradiation from the nuclides, which are the products of uranium-238 and thorium-232 series radioactive decay. Some of them, e.g. lead-210 and polonium-210 nuclides, are absorbed along with food. They are accumulated in fish and shellfish. There is quite high concentration of isotopes in the reindeer meat, of polonium-210 in particular. Deer absorb these isotopes during winter, when they eat lichen where both isotopes are accumulated. People living in Western Australia, in places with increased concentration of uranium, receive higher irradiation doses when eating sheep and kangaroo meat.



1. Share of various radiation sources in the total irradiation dose received by human per year

Thus, tens of millions of people, including women and children, are constantly exposed to the natural radiation background due to the natural radioactive gas radon, receiving dose of 5-10 mSv/yr (microsievert per year), and in certain areas with the increased natural radiation background – 15-30 mSv/yr throughout the ages, with the average world irradiation dose for human at the level of 2.5 mSv/yr. At the same time, the lifetime dose may run up to 700-1000 mSv without any negative health effects identified through epidemiological examinations in areas with the increased radiation background.

The experience of the past radiation accidents and incidents shows, however, that a high perception of radiation risks by society causes serious socio-economic consequences, even in the case of expected extra irradiation lifetime doses at the level of 100-300 mSv. Such doses are expected for the population across the most part of the so-called Chernobyl areas, legally referred to as "aggrieved" in Russia, Ukraine and Belarus. Legislative and statutory regulation of radiation influence of nuclear power facilities and when using ionizing radiation sources in industry, medicine and other spheres of human activity on human beings at the level of doses several and 10 times lower than natural background irradiation doses is a factor of socio-economic risk, especially in the case of megalopolis.

Extensive use of radioisotope technologies, the threat of radiological terrorism are inevitably accompanied by the potential risks of radiation pollution in the metropolitan areas and infrastructure facilities, supporting life activities. The current radiation protection system of reference for the intervention, at the expected annual doses lower than the variability of exposure from natural background, despite the absence of any proven health risks, can and does lead to large-scale socio-economic consequences; even in the case of small and insignificant doses of the additional exposure. The most recent

striking example of such a situation is the introduction in Japan, as a criterion for the planned evacuation after the accident at the NPP Fukushima-1, the radiation dose for the first year at the level of 20 mSv. The expected life dose in such areas does not exceed 150-300 mSv without any interference and cannot be a significant factor of negative impact on the health conditions.

We carried out the analysis of unintentional and intentional dispersion of radioactive substances at the level of gram (this corresponds to the activity in the order of 100-1000 Curie, depending on the isotopic composition) in the metropolis and resulting socio-economic consequences in the case of implementation of the existing in Russia and other countries criteria of rehabilitation or introduction of various protective measures in annual doses of 0.15 mSv per year (criterion protection Agency U.S. Environmental), criterion 1 curie/km2 for Cs- 137 or 1 mSv per year extra dose in accordance with Russian, Ukrainian and Belarusian Chernobyl legislation on which nearly 8 million people were classified as “affected”. In such a situation, the application of such intervention criteria in the case of dispersion of radioactivity in the metropolis over dozens of square kilometers with a population of hundreds of thousands of people and a huge economic potential, restrictions will be imposed that would lead to a large-scale socio-psychological and economic damage and could destabilize the economy of the metropolis in general, in the absence of any significant health risks. Findings of the similar analysis conducted by experts of the U.S. Pacific Northwest National Laboratory are demonstrated as an example of deliberate dispersion with a radioisotope source of Cs-137 in New York. [1] The results of this analysis are presented in Figure 1; they also demonstrate the dependence of the economic impact of the application of different territory radiation rehabilitation criteria. Such terrorist act could lead to a small number of overexposed people, however, the cost of rehabilitation, and restoration of buildings is quite substantial (up to half of U.S. GDP), the most conservative standard for the rehabilitation of contaminated areas to the level of residual annual dose of 0.15 mSv (Fig. 1).

Thus, the existing super-rigid rating system, which is not based on the actual identified effects of radiation on human health in small doses, becomes a factor of a very high social vulnerability. Given the exacerbated perception of radiation by people and society as a whole, the obvious relation by mass-media – and any radiation accident, any incident with the release of radioactivity, especially in areas with a high population density and economic potential, regardless of the scale of emission, and even in the cases with negligible radiological consequences, are fraught with a large-scale social and economic damage.

Without any doubts, in the public interest the radiation protection standards must be harmonized with the socio-acceptable risk and should be based on the real scientific values of the impact of the radiation on human health and the environment, but not on the unsubstantiated extensive research hypotheses.

Literature

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