NATURAL RADIOACTIVITY IN HUMAN ENVIRONMENT

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ABSTRACT

Since the radioactivity can not be detected by senses, the most usual reaction to it is fear of unknown. The majority of non-professionals share the common concept of radioactivity as something mysterious and dangerous. The main reason could be insufficient education as well as lack of public information on the properties of ionizing radiation and also on its influence on the environment. The fact is that radioactivity is inevitably present in human surroundings and that humanity has been living for millennia without cognition and understanding of ionizing radiation effects. Nevertheless, proper usage of ionizing radiation in many fields of human activity could lead the way of prosperity. Contemporaneously, it should be kept in mind that the negative impact is possible, but it could be minimized by careful and optimal use of ionizing radiation.

The short overview of natural radioactivity in human environment is presented in this paper.

Key words: *Natural radioactivity; environment; biological effects of ionizing radiation;*

INTRODUCTION

Radioactivity is inherent property of material world. The entire nature is radioactive, and human population is exposed to the ionizing radiation from the dawn of humankind. Radioactivity is everywhere, in soil, air, food, building materials, namely in environment. Therefore, even the human body, as an inseparable part of nature, contains certain, although small, amount of natural radionuclides (ISU, web information).

A significant part in human exposure to the ionizing radiation originates from the terrestrial radioactive isotopes (UNSCEAR, 2000). They represent only a part of the total number of radionuclides that existed at the beginning of the world as we know it.

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Due to radioactive decay of the radionuclides with half-life shorter than Earth existence, they can not be found in nature. However, those with sufficiently long half-life such as $^{238}_{92}U$ with half-life of 4,5 billion years, or $^{40}_{19}K$ with half-life of 1,3 billion years still exist on Earth. Also, there are some radionuclides with relatively short half-life, $^{3}_{1}H$, $^{7}_{4}Be$ or $^{14}_{6}C$, that have been produced constantly in natural environmental processes, involving the cosmic-ray interaction with molecules in upper layers in atmosphere.

Besides them, as a byproduct in different human activities, developed in XX century, various artificial (man-made) radionuclides can be found in nature. Artificial radioactivity has been mainly produced in fission processes, by activation with neutrons in nuclear reactors, in heavy ions reactions, and in fusion processes. More than 1000 artificial radioactive isotopes, meant to be used in medicine, science, for military purposes etc, are known today but their potential presence in the nature exceed the subject of this paper.

Concentration of naturally occurring radionuclides

Natural radioactivity has been one of the most important energy source for chemical and biological processes during the evolution on the early Earth. The main contribution to the human exposure caused by natural radioactivity is due to the members of the tree radioactive series with the $^{238}_{92}U$, $^{232}_{90}Th$ and $^{235}_{92}U$ as a predecessors (uranium, thorium and actinium series, respectively). Through the sequence of radioactive decays those three series end with the stable isotopes of lead. Isotopes of radium in all three natural series is followed by gaseous daughter product – radon: $^{222}_{86}Rn$, $^{220}_{86}Rn$ and $^{219}_{86}Rn$ with half-life of 3.82 days, 55.8 sec and 3.98 sec, respectively. Radon isotopes are alpha emitters, with daughter products: polonium, lead, bismuth, thallium and stable lead isotopes. Mean concentration of $^{222}_{86}Rn$ in air is dependent, besides the other factors, on humidity and temperature and usually ranges from 10 Bq/m^3 to 80 Bq/m^3. However, in closed and/or underground spaces, as well as in houses built of materials with enhanced radium and thorium content, the concentration of indoor radon can be even 10^5 Bq/m^3 (UNSCEAR, 2000; Stricht and Kirchmann, 1999). It is well known fact that radon enters the human body through inhalation. Almost 50 % of mean annual dose (2.4 mSv/year) is due to radon exposure (UNSCEAR, 2000).

In order to get an idea of quantitative presence of terrestrial radionuclides in nature, their concentrations in some environmental samples are given in Table 1. The presence of radionuclides in human body is very indicative and can not be underestimated, so their content is given in Table 2.

Table 1. Natural concentrations of some terrestrial radionuclides in different environmental samples

	Specific activity [Bq / kg]		
	^{226}Ra	^{232}Th	^{238}U
soil	40	25	25
granite	100	80	60
coal	< 20	< 20	
fertilizer	< 400	< 20	
water	<1	< 1	< 1
milk	0.003		
food	0.01 – 100		
human	0.03		0.1

Table 2. Natural radioactivity in human body

Radionuclide	Activity [Bq]
Uranium	1.1
Thorium	0.11
Potassium 40	4400
Radium	1.1
Carbon 14	3700
Tritium	23
polonium	37

Enhanced levels of natural activities

There are some regions where the concentrations of naturally occurring radionuclides significantly exceed common mean values. The regions with highly enhanced levels of radionuclide content have been detected in Brazil, India and China. There, the radiological situation has its origin in extremely high concentrations of radioactive materials in the ground. The sand on some beaches in Brazil contains monazite and ilmenite minerals rich with $^{232}_{90}Th$ and $^{238}_{92}U$ and their progenies. Radioactive emission of this sand results in dose rate of 50 μGy/h, which is 400 times higher than usually. (UNSCEAR, 2000)

Furthermore, there are other areas with extremely high levels of radioactivity in Brazil. On the top of local hill, with 30 000 m^2 area, dose rate of 0.01-0.02 mGy/h have been recorded due to 30 000 t of thorium and 100 000 t of other radioactive materials laying bellow. Content of $^{228}_{90}Th$ absorbed from the soil in that area by the plants are also secondary source of X- rays.

In southwest coast in India (Kerala) monazite deposits are even larger than those in Brazil. The same situation is recorded in some parts of China.

In Balkan region there are also some anomaly zones regarding the content of uranium in soil and water, such as Kalna on mountain Stara planina and Donja Stubla in Serbia (Žunić et al., 2009).

Interesting fact is that about two billion years ago, natural nuclear reactor existed on Earth. There were areas with uranium deposits, where spontaneous reactions of chain fission took place. One of this reactors existed in mine Oklo in Gabon, Africa. In those chain fission processes of uranium, great amount of energy has been released during the several hundred millennia.

Radionuclide migration in environment and biological impact

Radioactive elements as a part of environment circulate through eco-system. The manner in which radioactivity is transferred in environment depend on theirs chemical composition and properties. Similarly, radionuclides entered in human body, by inhalation, ingestion, directly in blood stream or by accident, circulate through human body. Interconnections between human population and radioactivity from the environment are presented in Figure 1. (Stricht and Kirchmann, 1999)

Internal contamination as well as external contamination and exposure to ionizing radiation can cause serious biological and health effects induced by the severe damage of tissue.

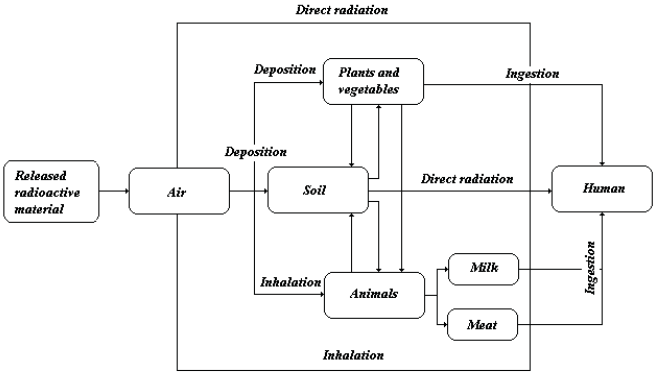

Figure 1. Radioactivity and human

Biological effect of ionizing radiation on human body basically involves damaging of individual cells. Biological and induced health effects of radionuclides entered into the human body depends on type and kind of cells, on activity and type of radiation, as well as on bio-distribution and biological half-life of given radionuclide, which is closely associated with its chemical composition. Certain radionuclides firmly deposits in respective organs with the low rate of excretion.

For example, uranium enters the human body through inhalation and ingestion. After ingestion, small fraction (0.2% - 5%) is adsorbed in blood stream and mostly deposited in bones and kidneys, while the rest are spread in the organism and eventually excrete. After the inhalation, small fraction of uranium enters in alveoli in the lungs, where it can be held for years.

Various health assessment studies showed that in areas with enhanced levels of radioactivity, cases of sickness involving the chromosomes aberration occur with larger probability. (UNSCEAR, 2010)

Instead of conclusion we should stress out that natural radioactivity could not be avoided. Hence, the researching and understanding of the radiation background elevation in the environment, considering the ever-growing anthropogenic influence to the biota, is of crucial importance for the environmental protection.

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