FORMATION OF ENVIRONMENTAL COMPETENCE OF PHYSICS STUDENTS IN TEACHING NUCLEAR PHYSICS

Eliboy Norboyevich Khudaiberdiev*

* Associate professor,
Navoi State Pedagogical Institute,
UZBEKISTAN

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ABSTRACT

The problem of the energy crisis is one of the global problems. According to the conclusions of world experts, the reserves of coal, oil and gas formed in the bowels of the earth for millions of years have been almost completely exhausted by mankind over the past 200-300 years. Therefore, scientists and experts from all over the world have come to a consensus that only nuclear energy can meet the needs of industrial production for electric energy. When using atomic energy, the problem of radioecology arises. This article analyzes the task of implementing environmental education by studying the effects of ionizing radiation on living organisms.

KEYWORDS: *Global Problems, Alternative Sources, Nuclear Energy, Radioecology, Ionizing Radiation, Living Organisms, Maximum Permissible Dose, Absorbed Dose, Radiation Sickness, Environmental Education.*

INTRODUCTION

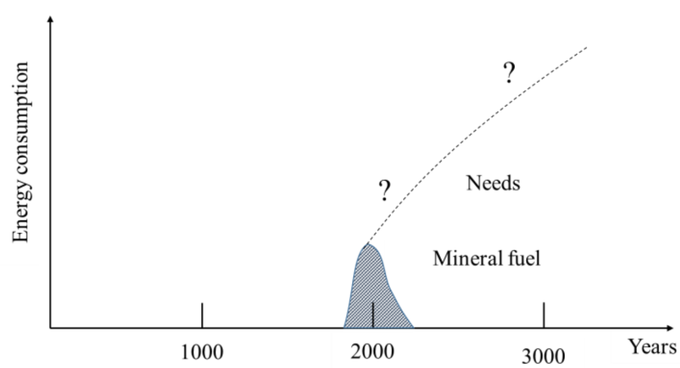

Fig.1. Comparison of a short period of minerals and energy needs.

Currently, special attention is paid to the research of nuclear processes all over the world, including in our Republic. The reason for this is: firstly, that humanity has received modern ideas about the surrounding space thanks to nuclear physics, and secondly, the intensive development of the practical significance of the achievements of nuclear physics. Although the weapon of destruction created as a result of nuclear research is a negative phenomenon and is criticized by the peoples of the whole world, the peaceful use of huge energy hidden inside the core is one of the urgent problems of our time. This is also due to the fact that the problem of the energy crisis is one of the global problems. According to the conclusions of world experts, the reserves of coal, oil and gas formed in the bowels of the earth for millions of years have been almost completely exhausted by mankind over the past 200-300 years. Expert estimates show that these reserves are decreasing day by day and the daily needs of humanity are increasing dramatically and that the continuation of this state will lead to the fact that energy reserves are exhausted in 60-70 years (Fig.1)**[1].**

Every state and citizens of this state, first of all scientists and intellectuals who care about the future of humanity – the future of the younger generation should assist scientists and researchers who conduct scientific research to find alternative ways of generating electric energy. As a result of these studies, alternative methods of obtaining electrical energy, such as methods of using solar, wind, and geothermal energy, are currently being successfully used. The decree of the President of the Republic of Uzbekistan on the launch of solar power plants in each region of the republic has been adopted. As part of this resolution, a solar power plant with a capacity of 100 MW was launched in the Karmaninsky district of Navoi region, which generates 252 kV·hour of energy. Due to the launch of this power plant, 80 million cubic meters of gas will be saved and the emission of 160 thousand tons of harmful gases into the atmosphere will be suspended.

Despite the fact that alternative methods of production are reasonable from an environmental point of view, due to the low power, they cover only 8-10% of the total electric energy demand. Therefore, scientists and experts from all over the world have come to a consensus that only nuclear energy can meet the needs of industrial production for electric energy. With this in mind, Uzbekistan has decided to build a nuclear power plant (NPP) consisting of two power units with a capacity of 1.2 GW each. This decision is the first step to stabilize the energy system of the republic and provides for covering ~25% of energy consumption at the expense of these power units. Based on this decision, the "Uzatom" agency was established in the republic under the Ministry of Energy, and a branch of the Moscow Engineering Physics Institute was opened. In the leading universities of the republic, new directions of the master's degree in nuclear physics and technology have been organized, the volume of hours of studying nuclear physics in the programs of pedagogical higher educational institutions has been increased. The purpose of the measures envisaged is to train personnel for the project of using nuclear energy for peaceful purposes.

One of the main tasks of personnel training for the nuclear power industry is the formation of perfect knowledge on radiation safety and radioecology of future specialists. In this regard, when teaching radioecological problems and radiation safety, there is a need for a thorough study of the methods of recording devices and the basics of dosimetry.

Environmental problems of energy and the importance of radioecological education

It is known that environmental problems are one of the global problems. In turn, environmental problems can be classified by origin, and consequences in many directions**. [2]** For example, one of these areas is radioecological problems. The task of implementing environmental education by studying the nature of ionizing radiation and the effects of radiation on living organisms is analyzed below.

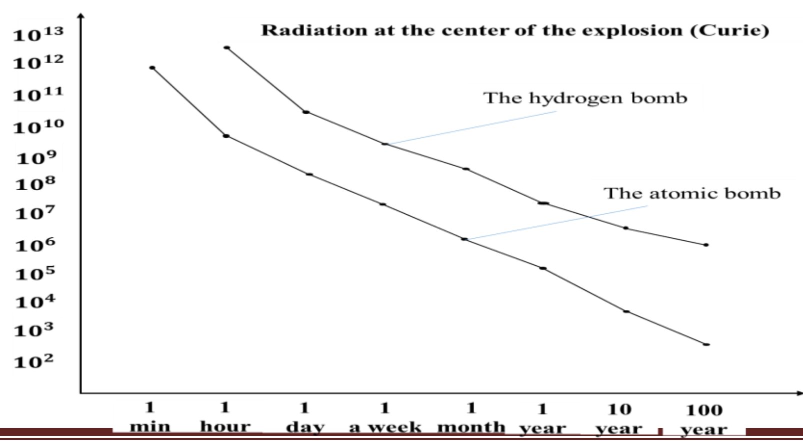

Fig.2. The change in activity after the explosion of atomic and hydrogen bombs in time

As you know, the phenomenon of radioactivity is divided into natural and artificial radioactivity. Natural radioactivity creates a radioactive background due to cosmic rays, due to the radiation of various underground and terrestrial radioactive elements, and it is impossible to limit the radioactive background. One of the features of radioactive contamination is that the vast majority of radioactive elements are long-lived. Therefore, radioactive radiation after nuclear explosions and accidents persist for many years. Figure 2 shows a graph of changes in activity after the explosions of atomic and hydrogen bombs.

When studying the basics of dosimetry, knowledge of registration methods, basic dosimetric values, units of measurement, the effect of ionizing radiation on living organisms, etc. is important.Despite the fact that there is sufficient literature in this area, due to language difficulties or due to the fact that many books are designed for a narrow circle of specialists, students have certain difficulties. Since the main requirement of education is the possession of future specialists-teachers with perfect knowledge in their specialty, pedagogical research in this area is of great importance. To increase the effectiveness of training, it is necessary to systematize and simplify numerous information. To this end, below we provide basic information on dosimetry and on the effect of radiation on living organisms in a systematic and generalized form**. [3]**

The effect of ionizing radiation on living organisms

The influence of ionizing radiation on living organisms was noticed seven years after the discovery of X-ray radiation (1895) and radioactivity (1896). By this time, systematic changes were recorded on the skin of scientists working with ionizing radiation. After that, the concept of a safe radiation dose for scientists working with radiation was introduced. This dose is called the maximum permissible dose (MPD) of radiation. By definition, the maximum permissible dose is a dose that does not lead to noticeable changes throughout a person's life. The value of the maximum permissible dose in different years from the experts of the International Commission for Radiation Protection (IPPC) is determined differently (Table 1).

TABLE 1

№	Year	Experts	MPD maximum permissible dose
1	1902	S.Rollinz (England)	10R/days (R-Rentgen)
2	1915	M.Mitcheller (USA)	100 mR/days
3	1934	(IPPC)	200mR/days
4	1936	(IPPC)	100mR/days
5	1948	(IPPC)	50 mR/days, 6 Zv/40 g (Zv-Zivert)
6	1953	(IPPC)	0,6Zv/30g 6mR/days
7	1997	(IPPC) A, B- categories of professional workers	A) -20 μZv/g, 6 mR/days
			B) -2 μZv/g 0,6 мР/days
			Population -1 μZv/g 0,3 mR/days

All living organisms take a certain dose of radiation during their lifetime due to natural or artificial radioactivity. In the diagram Fig.3, the power of various radiation sources is compared with the maximum permissible dose (MPD) set for professional workers.

Table 2 shows the generally accepted types of radiation doses, their definitions, units of measurement and the relationship between the types of radiation. **[4]**

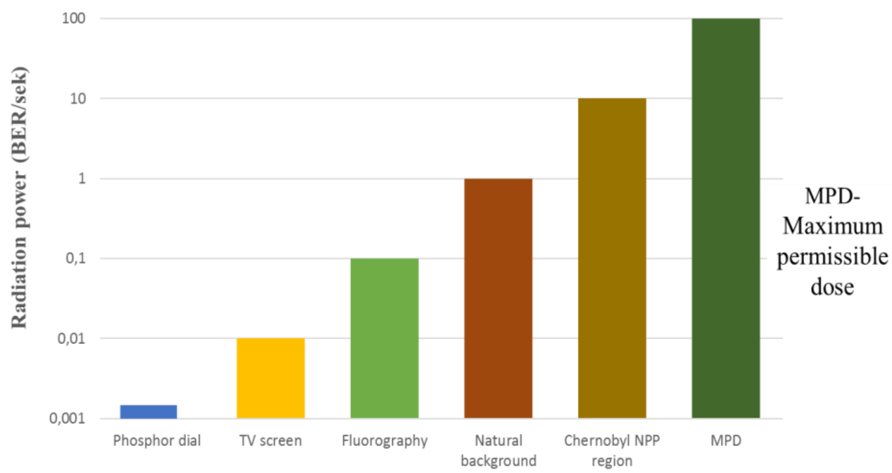

Fig.3. Comparison of the power of various radiation sources.

TABLE 2.

№	Dose type	Definition	Unit of measurement	Relationship between units of measurement
1	Exposure dose	The value equal to the total charge of the same type of ions in a unit mass $D_{exp} = {}^{q}/_{m}$	Kl/kg $[D_{exp}] = \text{Kl/kg}$	Absorbed dose 1R~0,0091Gr~0,96 rad
			R 1 Rentgen $(R) = 2{,}58 \cdot 10^{-4}$ Kl/kg	Equivalent dose 1R~0,0091Zv~0,91ber
2	Absorbed dose	Energy coming to a single mass $D = \frac{w}{m}$	Gr (Grey)	Exposure dose 1Gr~100rad~110R
			Rad	Equivalent dose 1Gr~1Zv~100 ber
3	Equivalent dose	The absorbed dose, taking into account the quality factor for a specific radiation. $H=D\cdot W_p$ W_p- quality factor or comparison factor.	Zv	Exposure dose 1Zv~110R
			Ber	Absorbed dose 1Zv~100ber~1Gr

It has been experimentally established that the effect of radioactive radiation on living organisms depends on the type of radiation and their energies. Therefore, in dosimetry, to take into account this circumstance, the concept of a comparison factor or a quality coefficient is introduced. Table 3. shows the values of the quality coefficient (W_p) for radiation at different energies.

TABLE 3.

№	Type of radiation and energy range	W_p	№	Type of radiation and energy range	W_p
1	Photons of arbitrary energy (Gamma and X-ray radiation)	1	**6**	Neutrons (100 keV ÷2 MeV)	20
2	Electrons (positrons) and muons of arbitrary energy	1	**7**	Neutrons (2 MeV ÷20 MeV)	10
3	Protons(with energy W>2 MeV)	5	**8**	Neutrons (W÷20MeV)	5
4	Neutrons (W<10 keV)	5	**9**	Alpha particles, fission fragments, Recoil nuclei	20
5	Neutrons (10÷100 keV)	10			

It should be noted that the effects of a certain equivalent dose on different organs and tissues differ. To account for this effect, the concept of a tissue weighing factor - W_t and the concept of an effective radiation dose (E) are introduced. In this case, the effects observed when irradiating the body as a whole is equal to the sum of the effects observed when irradiating each organ separately with this radiation. The effective radiation dose is determined by the following expression:

$$E = H \cdot W_m$$

Here W_t -is the weighting coefficient. The values of this coefficient for various organs are given in Table 4.

TABLE 4

Tissue or organ	Gonads (sex glands)	Red Bone marrow	Large intestine	Lungs	Stomach	The bladder	Mammary gland	Liver	Esophagus	Thyroid gland	Skin	Bone surface	Other tissues and organs	The whole body
$\boldsymbol{W_t}$	0,2	0,12	0,12	0,12	0,12	0,05	0,05	0,05	0,05	0,05	0,01	0,01	0,05	1

It can be said that by now the effects of strong and medium-power radiation on living organisms have been studied in detail, but the genetic effects of low-power radiation have been little studied. Table 5. shows the maximum radiation doses that cause non-stochastic effects in living organisms.

TABLE 5

№	Organ, tissue	Dose, Gr	Non-stochastic (deterministic) effect	№	Organ, tissue	Dose, Gr	Non-stochastic (deterministic) effect
1	The whole body	0.5	Vomiting	**4**	Lungs	5.0	Pneumonia
2	Bone marrow	1.0	Death	**5**	Lungs	10	Death
3	Skin	3.0	Burn, temporary hair removal	**6**	Thyroid gland	10	Disorders, destruction of the gland

The biological effect of radioactive radiation is evaluated and controlled by international sanitary rules and regulations (San.R.R.), as well as radiation safety standards. A dose exceeding 250 times the radioactive background from cosmic rays and radiation from the bowels of the earth is considered safe for the human body. Nevertheless, it has been established that one-time irradiation with a dose of 500 X-rays is dangerous for a person, with passive treatments without bone marrow transplantation, in 50% of cases it ends in death. Therefore, in order to control radiation safety, the international agency has developed norms of maximum permissible doses for the population and for professional workers.

The traffic rules for professional workers are 10 times higher than the traffic rules for the population and these workers have certain benefits. In Table 6. the maximum permissible dose for various segments of the population is compared with the natural radioactive background.

TABLE 6

№	Classification according to the biological effect of radiation	Radiation dose value				
		Rad.	Rentgen	BER	Kl/kg	J/kg(Grey, Zivert)
1	Natural radioactive background (for 1 year)	0,08	0,097	0,097	$2{,}5 \cdot 10^{-5}$	$8 \cdot 10^{-4}$
2	MPDfor the population (for 1 year)	0,5	0,61	0,61	$1{,}6 \cdot 10^{-4}$	$1{,}6 \cdot 10^{-4}$
3	MPD for professional workers (for 1 year)	5	6,05	6,05	$1{,}6 \cdot 10^{-3}$	$5 \cdot 10^{-2}$
4	Radiation sickness dose (for 1 time)	200	242	242	$6{,}4 \cdot 10^{-2}$	2
5	Lethal dose (for 1 time)	400	484	484	484	4

From the above information, it follows that the natural radioactive background due to cosmic rays and natural radioactivity delivers 0.08 ~ 1 rad per year. At the same time, the absorbed dose of human radiation for 70 years is 7 rad. Table 6 shows that according to the decision of the International Commission on radiological protection of traffic regulations for the population, 10% of the traffic regulations of professional workers were adopted**. [5]**

CONCLUSION

In conclusion, it should be noted that it would be wrong to consider radiation doses below the SDA safe and that small doses will not lead to changes in living organisms. From a scientific point of view, any dose of radiation is biologically dangerous, because chromosomes that have been exposed to radiation and have suffered a mutation are restored with changes. Therefore, any small dose of radiation accelerates the rate of mutation and in 3% of cases of childbirth lead to anomalies. Therefore, the damage of nuclear tests and accidents at nuclear power plants must be assessed not only economically, but also from the point of view of the danger of an increase in the radioactive background that threatens the lives of peoples around the globe. In-depth study of radiation dosimetry in integration with biological actions and their consequences contributes to improving the quality and effectiveness of education, and thereby the implementation of environmental education. The formation of a specialist with in-depth knowledge of nuclear physics is important for the implementation of the task of training personnel for nuclear power.

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