Radiation Risk and Possible Consequences for Ukrainian Population

Alexander Pivovarov
Ukrainian State Chemical-Technology University
8 Gagarin Av.
Dnepropetrovsk 49005
UKRAINE

The paper deals with the values of risk related to environmental pollution with radionuclides from the main sources located both on the territory of Ukraine and outside, which affect the Ukrainian population, in the context of long-range outlook. Ratios of risk for stochastic effects occurrence are given per unit of individual or collective dose, as well as for occurrence of fatal cancer, non-fatal cancer or serious hereditary effects. Besides, the paper mentions not only the impact of ionizing radiation, but severe population stress as well, which in certain regions turns into radiophobia. It is shown that for essential decrease of radiation risk in Ukraine, global problems should be solved, first of all, at the governmental level. Whereas a number of issues connected with the Chernobyl catastrophe are at least partially solved, the problems concerning the effects of radon and other radiation-dangerous factors are still to be tackled.

The count of the history of unsatisfactory radio-ecological condition of Ukraine should be started, on the one hand, from the pioneer works in the field of radioactivity and nuclear research of military (defense) orientation. On the other hand, it may be counted from the greatest man-caused Chernobyl disaster connected with the peaceful use of nuclear energy. All this determines an ambiguous attitude of the population and specialists towards the use of radiation-hazardous technologies. The preconceived brainwashing of the public opinion against the background of the already existing deep psychological shock caused by the disaster added to the development of a wide-scale and continuing population stress, whose structure is characterized by distinct features of radio-phobia specific for the Chernobyl situation. When President of Ukraine Victor Yushchenko proposed to organize a nuclear waste depository in Chernobyl, he was confronted with a quite apparent reaction. Those who decided to express themselves publicly on the subject, as the President himself, preferred not to detail the expression “nuclear waste”. The problem that ecologists have been speaking of for so long is viewed to the majority of casual sideliners as something amorphous and dreadful, whereas the place-name “Chernobyl” aggravates the vague uneasiness, all this happening while there has recently begun to show a positive tendency towards reduction of the psychological stress concerned with the disaster primarily in Ukraine. The President noted that if the costly construction of the mortuary is unavoidable, it could be used for some other purposes, too. Particularly, radioactive waste from all other Ukrainian atomic power plants, such as Rovenskaya, Zaporozhskaya, Khmelnitskaya, and South-Ukrainian APPs could be stored there. While nuclear waste stays at an atomic power plant or in a nearby mortuary, it presents, to a greater or lesser extent, a certain danger only to the population of neighboring areas. Those who live in Chernobyl now are hardly unaware of that. Much more unpleasant prospects open up when it comes to transportation of nuclear cargoes. The trains or ships carrying it on board in any case will cross the “peaceful” territories, where accident risk is far from being equal to zero. And it can be aggravated by hypothetic saboteurs. It should be noted that the latter circumstance is of greater concern to the specialists in the most developed countries who have been for long considering the possibility of capturing nuclear materials by terrorists. Very few people seriously believe that a separate organization could manufacture a nuclear charge from stolen or intercepted nuclear waste. According to the FBI, much more probable is creation of the so-called “dirty bomb”, a container with waste from atomic power plants and regular explosives. Such a device could spray radioactive dust over quite vast areas making them uninhabitable for many years to come. It is understandable that in such a context the materials left without due custody, be it even in another country, arouse natural concern. Such is the situation with the nuclear heritage of Ukraine and with the moral and psychological condition of the country’s population, regardless of its physical state. As for the latter, it can be presently characterized as catastrophic. It is testified by physicians, politicians, officials, and by dry figures of statistical data, which at times are far from being trustworthy.

As a whole, on the territory of Ukraine there are both natural ionizing radiation background and that occurred through man-caused sources of radioactive pollution (Tables 1, 2) [1,2], which entail external and internal irradiation of citizens and, as a result, permanent radiation risk with predictable consequences. Human activity affects the natural ionizing radiation background both in quality and quantity terms. Man-caused aggravation of the background results from extensive usage of fertilizers containing uranium impurities (for example, phosphate fertilizers), more active operations on extraction of uranium ores, and mass increase in air transport service which contribute to space radiation.

Table 1.

Natural Sources of Ionizing Radiation

Source	Average annual dose, mZv	Contribution to dose, %.
Space (radiation at sea level)	0,3	15,1
Earth (soil, water, building materials)	0,5-1,3	68,8
Radioactive elements in human tissues (^{40}K, ^{14}C etc.)	0,3	15,1
Other sources	0,02	1,0
Total average annual dose	2,0	

Table 2.

Man-made Irradiation Sources

Source	Annual dose, mZv	Fraction of natural background, %.
Medical devices (fluorography, roentgenography of teeth, radioscopy of lungs)	1,0-1,5	50-75
Air flights (distance of 2000 km, 5 times per year)	0,02-0,025	1,0-2,5
Viewing TV (4 hours a day)	0,01	0,5
Atomic power plants (at stable operation)	0,001	0,05
Thermal power plants (working on coals) located at the distance of 20 km	0,006-0,06	0,3-3,0
Global precipitations from nuclear weapons tests	0,025	1,0
Other sources (oil production, extraction of ores, building materials' industry)	0,4	-
Total	1,5-2,0	

Following the conservative radiobiological hypothesis, any arbitrary low level of radiation gives rise to certain risk of stochastic effects occurrence. These effects include induction of malignant neoplasms, some congenital malformations and diseases of descendants of radiation-exposed individuals. For quantitative assessment of possible stochastic effects frequency, hypothesis about linear non-threshold dependence of probable long-term effects of radiation dose with risk ratio of $7 \cdot 10^{-2}$ Zv^{-1} [3] is used.

In accordance with data given in paper [4], there is a number of basic stages of radiation exposure of humans conditioned, first of all, by peculiarities of origin of the risk territories:

1. Early stage connected primarily with the action of short-lived isotopes, which duration is measured in months, at most.
2. Late stage, which duration is determined by half-life period for long-lived radionuclides, in particular, ^{137}Cs и ^{90}Sr.
3. Distant stage, which can develop in the course of life of many generations or generally without direct connection with the effects of radiation factor, or against the background of continuing action of plutonium and radiocarbon radiation.

In the authors opinion, the concept of the third (distant) stage is introduced for the first time, and it is, evidently, connected with wide spectrum of data on changes occurred in immunogenotypic structure of the populations exposed to small doses of radioactivity sources. Simultaneously, subsequent risk group, including descendants of people exposed to radiation at early stages, begins to form (with the lapse of time this group turns to the largest one, and further it is to determine all situation as a whole). As it is evidenced by numerous data, genetic effects of small doses, both congenital and inherited malformations and diseases, are developed in descendants of irradiated individuals stochastically. In the domain of doses typical for external and internal irradiation coming from natural sources and man-caused ones, biological action of the radiation is completely limited to inducing stochastic effects.

Let's consider some facts [4, 6]. Characteristic figure of the Ukrainian territory pollution with cesium-137 before the accident at ChAPP is 0.2 Bq/cm^2. As a result of Chernobyl catastrophe, nearly $1.7 \cdot 10^{16}$ Bq of cesium-137 and $4{,}5 \cdot 10^{15}$ Bq of strontium-90 have fallen on the territory of Ukraine. About 60% of cesium-137 and 88% of strontium-90 remain in 30-kilometer zone, and the other part caused pollution of $4.2 \cdot 10^4$ km^2 with cesium of density exceeding 3.7 Bq/cm^2, and $2.7 \cdot 10^4$ km^2 with strontium of over 0.6 Bq/cm^2 density. In the other regions of Ukraine, surface pollution of soil with cesium-137 increased as much as four times, as compared with the pollution level before the Chernobyl catastrophe. Every year, about $5.0 \cdot 10^{11}$ Bq of uranium-238 and about $2.0 \cdot 10^{13}$ Bq of potassium-40 are also brought into soil with fertilizers. Atmospheric air pollution as a result of nuclear tests and radiation accidents occurs discretely, in contrast to that from stationary sources of pollution, such as atomic power plants (APP), thermal power plants (TPP), enterprises on extracting and processing uranium ore, coal firing for domestic heating and other needs, which effects are permanent. APPs of Ukraine discharge into the air nearly $1.0\cdot10^{15}$ Bq of inert radioactive gases, $8.0\cdot10^{13}$ Bq of tritium, $8.0\cdot10^{10}$ Bq of carbon-14, $9.0\cdot10^{9}$ Bq of iodine-131 and $3.0\cdot10^{9}$ Bq of radioactive aerosols annually. Because of firing of coals at thermal power plants of Ukraine and in dwelling houses, as much as $1.3\cdot10^{12}$ Bq of NRN (without radon) and $8.0\cdot10^{11}$ Bq of radon are released into the atmosphere every year. Because of accumulation of radioactive waste during extraction and processing of uranium ore, annual emission of radon from tailing pits is $1.0\cdot10^{16}$ Bq. Existence of these sources results in local increase of radionuclide concentration in the air, and consequently in additional exposure of the natural environment and human beings. Taking into account that man-caused pollution sources are mainly located in the Dnepr river area, radionuclides are intensely accumulated in bottom sediments of Dneprovsky cascade. Now over $4.0\cdot10^{13}$ Bq of cesium-137 are accumulated therein, with 70% of this amount falling at Kiev water basin (Fig.1). Full effective dose per year from natural sources for citizens of Ukraine is 4.5 mZv, which is considerably higher than the world average value (2.4 mZv). Recently, water of poor quality becomes one of the reasons of spreading such diseases as stomach ulcer, cholelithiasis, respiratory tract disorders, stenocardia, cardiac infarction, cholecystitis on the territory of Ukraine.

This statistics with elements of despair with respect to the time factor will be more oppressive, if specific measures on protecting citizens from continuing impact of polluted territories are not taken. Blooming cherry and nightingale country with picturesque forest and steppe lands, fruitful soil and unique pastures became unnatural landscape for indefinite period, without right to existence of living creatures and, first of all, human beings therein. Price of such a proving ground is extremely high, and, undoubtedly, Ukrainians would like to have distinct guarantees of the world community and, in particular, of the World Health Organization (WHO) for experience gained by the mankind in overcoming unprecedented man-caused nuclear catastrophe. The chances of its recurrence in any point of the Earth are rather high, especially for the countries possessing full complex of nuclear power facilities, nuclear weapons, and sources of nuclear waste disposal.

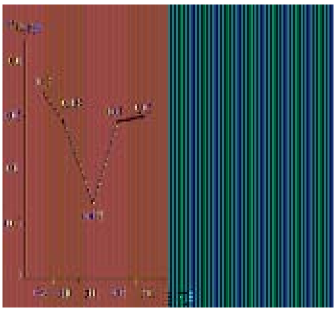

Fig. 1. **Average annual concentrations of cesium-137 in surface waters of Pripyat' river** (tributary of the Dnepr river)

Cancer is the most serious consequence of the humans' exposure to small doses of radiation. Theoretical findings and majority of available experimental data exclude any threshold dose below which risk of cancer is eliminated. Any arbitrary low dose increases probability of cancer incidence for any individual exposed thereto. Besides, it is supposed that probability and risk of disease grow in direct proportion to radiation dose. The International Committee for radiation protection has chosen, as a basic assumption, a linear dependence between the dose and effect under which maximum assessment of risk is provided. Latent period between irradiation and diagnosing of cancer continues several years. On average, this period can come up to 8 years for leukemia, and two or three times longer for other diseases, for example, breast cancer or carcinoma of lungs. Minimum latent period during which a certain tumor appears upon irradiation, comprises about two years for leukemia, and as much as 5-10 years for other kinds of cancer. Linear dependence between equivalent dose *E*, received by an individual and radiation risk *r*, under which probability of induced stochastic effects is understood (namely, occurrence of fatal and non-fatal cancer and serious hereditary effects of radiation exposure), is defined as follows:

$$r = r_E \cdot E, \qquad (1)$$

where r_E is a risk ratio defining probability of occurrence of stochastic effects referred to a dose unit [7].

Connection between collective dose *S* and risk which is in the given case expressed by expected number of effects *R* in the group, is defined by the ratio:

$$R = r_E \cdot S \qquad (2)$$

Here, the ratio of risk for stochastic effects' occurrence per unit of the individual or collective dose for citizens is assumed equal to $r_E = 7{,}3\cdot10^{-2}$ Зв$^{-1}$, that is, deviation from directive value of the risk ratio is insignificant. For fatal cancer, non-fatal cancer and serious hereditary effects risk ratios are, accordingly, $5{,}0\cdot10^{-2}$, $1{,}0\cdot10^{-2}$ and $1{,}3\cdot10^{-2}$ Zv^{-1} [8]. Under exposure of human to the dose of 1 Zv, probability of stochastic effects is equal to $7{,}3\cdot10^{-2}$. In the case of 1000 man.Zv collective dose, stochastic effects (fatal cancer, non-fatal cancer and serious hereditary effects) can be displayed in 73 individuals.

It should be noted that risk ratios used now are far from those established once and for all, since they can be modified depending on new findings and giving a more precise definition to available data. Table 3 gives nominal ratios of probability for certain bio-tissues and organs [7].

Table 3.

Ratios of Probability for Fatal Cancer and Cumulative Damage for Citizens

Tissue or organ	Probability of fatal cancer, 10^{-2} Zv^{-1}	Probability of cumulative damage, 10^{-2} Zv^{-1}
Urinary bladder	0,3	0,29
Bone marrow	0,5	1,04
Bone surface	0,05	0,7
Mammary glands	0,2	0,36
Large intestine	0,85	1,03
Liver	0,15	0,16
Lungs	0,85	0,8
Esophagus	0,3	0,24
Ovaries	0,1	0,15
Skin	0,02	0,04
Stomach	1,1	1,0
Thyroid gland	0,08	0,15
Others	0,5	0,59
Total	5,0	5,92
Probability of serious hereditary abnormalities		
Gonads	1,0	1,33
Total value	6,0	7,3

Together with it, many authors mention serious discrepancies in the intensity of predictable and real levels of disease incidence in people. Prognostic values obtained in accordance with adopted methodology of radiation risk modeling are much less than actual cancer incidence revealed during the certain period. Carcinogenesis observed in the regions which are suffered the most, can not be caused by the radiation factor only, without taking into account atmospheric emissions. Growth of incidence of cancer proves that contribution of continuing and relatively unchanged factors of the natural character, as well as hereditary factors and other causes other than man-caused ones resulting in spontaneous or background level of carcinogenesis, is not an only level of the above disease incidence. In this connection, actively developed methods and theories of ecological risk formally supported by and complying with all the international ecological and medical societies can be considered more acceptable, with respect to problems of public health taking into account radiation exposure and man-caused impacts.

Table 4 includes data on maximum individual and collective doses from the main sources for the Ukrainian citizens for seventy-year period, as well as additional figures on fatal cancer incidence and stochastic effects, which prove that maximum individual dose for seventy-year period can amount to 2,5 Zv (for people living near to tailing dumps of enterprises processing uranium ores) and cause additional 13 events of fatal cancer (18 events of stochastic effects) per 100 exposed individuals.

Table 4

Additional Figures on Fatal Cancer Incidence and Total Stochastic Effects for Ukrainian Citizens

Source	Individual dose, Zv	Probability of fatal cancer	Probability of stochastic effects	Collective dose, man.Zv	Fatal cancer events	Events of stochastic effects
1. Ionizing radiation background for Ukraine, 4,5 mZv/year.	$3{,}15\cdot10^{-1}$	$1{,}6\cdot10^{-2}$	$2{,}3\cdot10^{-2}$	$1{,}6\cdot10^{7}$	$8{,}0\cdot10^{5}$	$1{,}2\cdot10^{6}$
2. "Normal" (world average) radiation background, 2,4 mZv/year.	$1{,}7\cdot10^{-1}$	$8{,}4\cdot10^{-3}$	$1{,}2\cdot10^{-2}$	$8{,}5\cdot10^{6}$	$4{,}2\cdot10^{5}$	$6{,}2\cdot10^{5}$
3. Atomic weapons tests.	$2{,}0\cdot10^{-3}$	$1{,}0\cdot10^{-4}$	$1{,}46\cdot10^{-4}$	$1{,}0\cdot10^{5}$	$5{,}0\cdot10^{3}$	$7{,}3\cdot10^{3}$
4. Chernobyl catastrophe.	0,2	$1{,}0\cdot10^{-2}$	$1{,}46\cdot10^{-2}$	$8{,}99\cdot10^{4}$	$4{,}5\cdot10^{3}$	$6{,}6\cdot10^{3}$
5. Extraction of uranium ore.	$3{,}0\cdot10^{-4}$	$1{,}5\cdot10^{-5}$	$2{,}19\cdot10^{-5}$	6,59	0,33	0,48
6. Processing of uranium ore.	2,52	$1{,}26\cdot10^{-1}$	$1{,}84\cdot10^{-1}$	$1{,}5\cdot10^{3}$	$7{,}5\cdot10^{1}$	$1{,}1\cdot10^{2}$
7. Power generation at atomic power plants.	$3{,}0\cdot10^{-5}$	$1{,}5\cdot10^{-6}$	$2{,}19\cdot10^{-6}$	31,0	1,55	2,26
8. Power generation at thermal power plants.	$1{,}0\cdot10^{-2}$	$5{,}0\cdot10^{-4}$	$7{,}3\cdot10^{-4}$	$2{,}1\cdot10^{3}$	$1{,}05\cdot10^{1}$	$1{,}53\cdot10^{1}$
9. Coal firing by citizens.	$8{,}4\cdot10^{-4}$	$4{,}2\cdot10^{-5}$	$6{,}13\cdot10^{-5}$	$7{,}0\cdot10^{1}$	$3{,}5\cdot10^{2}$	$5{,}1\cdot10^{2}$
Total for Ukraine (not taking into account the natural background).				**$2{,}0\cdot10^{5}$**	**$1{,}0\cdot10^{4}$**	**$1{,}5\cdot10^{24}$**

Living on the territories polluted as a result of the Chernobyl catastrophe, with pollution density of 40,0 Ci/km^2 (for cesium-137) and 3,0 Ci/km^2 (for strontium-90) results in exposure to 0,2 Zv dose, for seventy-year period. The largest value of collective dose, $8,5 \cdot 10^6$ man.Zv, is caused by the radiation background on the Ukrainian territory exceeding the value of "normal" ionizing radiation background. Actually all this excess is conditioned by high concentration of radon in living quarters. Regarding man-caused sources, the largest collective dose results from atomic weapons tests ($1,0 \cdot 10^5$ man.Zv) and the accident at Chernobyl APP ($8,99 \cdot 10^4$ man.Zv), and the least one – from extraction of uranium ore using mining method (6,59 man.Zv).

Man-caused sources' action during 70 years in Ukraine threatens with additional $1,0 \cdot 10^4$ events of fatal cancer ($1,5 \cdot 10^4$ events of stochastic effects). At the same time, because of increased radiation background for the same period, $3,8 \cdot 10^5$ events of fatal cancer ($5,8 \cdot 10^5$ events of stochastic effects) can occur, that is, as much as 40 times more. As to their contribution to occurrence of fatal risk after tests of atomic weapons and Chernobyl catastrophe, the next in order are the sources connected with coal firing, processing of uranium ores, power generation at TPPs, APPs and uranium extraction by mining method. Therefore, we can judge upon realization of the risk for those who were under the first attack of radiation in 1986, only after the year 2016.

Among the late specific medical consequences, reliably connected with the impact of radiation component of the Chernobyl catastrophe, only the cancer of thyroid gland can be surely mentioned as such. Incidence of this disease in Ukraine, in five northern regions of the country, essentially increased from 0,1 in 1982-1985 to 11,5 in 1991-1994 per one million of citizens. Tendency of thyroid gland cancer growth is observed at present time as well. The paper [9] evaluates the number of additional events of this variety of cancer. It is shown that collective dose absorbed in thyroid gland for the Ukrainian population is $5,7 \cdot 10^5$ man.Gr. Ratio of probability for thyroid gland cancer is equal to $0,15 \cdot 10^{-2}$ Gr^{-1}. Consequently, we can expect about $8,610^5$ additional events of cancer of thyroid gland or, on average, 1,7 events per 100 thousand of irradiated people. Spontaneous frequency of occurrence of thyroid gland cancer is equal to one event per one million of citizens a year, or seven events per 100 thousand of people for seventy-year period. Maximum incidence of thyroid gland cancer in Ukraine connected with consequences of the Chernobyl catastrophe, according to forecasts, is expected in 2011-2016 [10], whereas some experts consider the present situation the "peak" one.

Some groups of experts, who analyze possibilities of safe living on the affected territories, state that there are “kinds of agricultural products which can be safely grown on soils polluted with radionuclides". It is just half-truth. Really, there are some plants accumulating much less radionuclides from soil than the other ones. For example, wheat grain on the polluted territory accumulates five times less radioactive strontium, than barley or peas; potato tubers accumulate half of radioactive substances as compared with beet etc. Even various kinds of trees differ as to characteristics of radionuclide accumulation. However, all plant species take radionuclides out of soil (Table 5,) (according to data of the Dnipropetrovsk Regional Sanitary-Hygienic Station, 2005). As long as today's residents of Chernobyl region receive up to 90% of radiation dose from local foodstuffs polluted with radionuclides, it is necessary to perform long-term (for more than one decade) radiation monitoring of foodstuffs and individual accumulation of radionuclides.

Table 5

Content of Cesium-137/ Strontium-90 in Foodstuffs in Bq/kg(l)*

Years	Foodstuffs				
	Milk	Bread	Meat	Fish	Vegetables
1964	0,88 / 0,34	1,94 / 0,93	1,04/0,74	1,63 / 1,26	0,53 / 1,04
1986	3,4 / 1,7	0,4 / 2,1	2,0/2,1	10,6 / 0,19	1,22 / 1,8
1988	2,63 / 0,28	0,86 / 0,1	0,83/0,16	15,0 / 0,1	0,58 / 0,26
1990	0,96 / 0,05	0,35 / 0,18	0,35/0,15	9,02 / 0,6	0,11 / 0,15
1995	0,098 / 0,13	0,2 / 0,125	0,2/0,193	0,21 / 0,3	0,15 / 0,1
2000	0,15 / 0,05	0,36 / 0,22	0,36/0,108	0,029 / 0,15	0,3 / 0,95
2001	1,165 / 0,3	0,525 / 0,412	1,28/0,324	0,62 / 2,263	0,21 / 0,54
2002	0,43 / 0,451	0,18 / 0,231	1,72/0,091	2,35 / 0,22	0,216 / 0,23
2003	0,66 / 0,37	0,2 / 0,18	0,65/0,42	0,96 / 0,8	0,27 / 0,28

* The Dnipropetrovsk Region is one of the most industrially developed and ecologically unstable regions of Ukraine

Over 4 millions of people live in Chernobyl regions of CIS, including about 1 mln. children. Establishment and observance of strict permissible levels of radionuclide content in foodstuffs can become an important protection measure. Pollution of milk with radionuclides represents sufficient evidence of danger for children's health in any population center. According to data of the Ministry of Health of Belarus, as of the year 2001 in 1100 villages content of cesium-137 in milk increased 50 Bq/l, and in 350 villages this figure came up to 100 Bq/l. Adopted normative values (dose limit of 1 mZv per year, permissible content of cesium-137 in milk for adults - up to 1000 Bq/l, for children – 400 Bq/l), established on the basis of risk ratios of Hiroshima and Nagasaki, are not suitable for long-term chronic radiation exposure after Chernobyl event. These norms should be toughened 10-20 times.

State of health of the citizens in Ukraine, as well as in many other CIS countries, came to critical boundary. Since the year 1992, depopulation of the country began. Negative population processes having tremendous sluggishness are set going and gathering strength. Every year, population of Ukraine decreases, on average, by half a million of people. Damage caused to population health, even without further aggravation, shall echo in the first half of the present century. Unfortunately, extreme radiological situations continue to arise with higher frequency, which is evidenced by numerous data [11].

V. N. Nesterenko (Belarus), A. V. Yablokov (Russia) and D. M. Grodzinsky (Ukraine) in their remarks on the margins of the UNO report titled “Chernobyl Continues for People's Health" (2002) declare that any reliable statistical evidence shows that apart from higher death rate, the catastrophe resulted in noticeable increase of the rate of spontaneous abortions and stillbirths. Among other changes in structure of disease incidence on the polluted territories (as compared with that on adjacent territories similar by social and economic conditions) there are following showings revealed: increase in number of weakened and sick newborns; increase in genetic abnormalities and congenital malformations; increase in cancer incidence (apart from thyroid gland cancer); abnormality (deceleration) of mental capacity (nervous-psychical development); growth of rate of psychiatric diseases (including schizophrenia); deterioration of immunity and hormonal (endocrine) status; growth of rate of diseases occurred in blood-circulation organs and lymphatic system, respiratory and urino-genital system, skin integument; diseases of endocrine glands and organs of vision; abnormal growth of children, severe exhaustion; decelerated recovery after illnesses; accelerated ageing.

Full effective dose per year from natural sources for citizens of Ukraine is 4.5 mZv, which is considerably higher than the world average value (2.4 mZv). As mush as 80% of the above value is conditioned by decomposition products of natural radioactive radon gas, being alpha-emitter and therefore particularly dangerous. Radon-222 is the product of radioactive decomposition of elements of uranium-radium series, which are always present in rocks, first of all, in granites, often encountered in Ukraine, and in soils. Here simple principle operates: "Where you come across granites, you meet with increased radon danger". Value of collective dose for seventy-year period stipulated by higher radon concentration in living quarters, as compared with world average value, is $7{,}5 \cdot 10^6$ man.Zv, 75 times more than collective dose ($1{,}0 \cdot 10^5$ man.Zv), conditioned by all man-caused sources of Ukraine including the accident at Chernobyl APP. The mentioned data prove extraordinary importance of radon problem for Ukraine. Ukrainian officials should take over experience of the USA, Canada, Sweden, FRG, Finland, France and other countries where special research programs for radon are underway for several decades, and each apartment house is provided with a certificate of radiation quality (first of all, concerning radon). This certificate is indispensable for any transactions with real estate.

Conclusion. Consequences of the Chernobyl catastrophe in a varying degree affected health of the millions of people living on the territory of Ukraine, Belarus, Russia, as well as the other European countries. Ukrainian citizens are now facing the problem of securing nuclear and radiation safety, which will remain acute for many years to come. At various stages of forming medical post-Chernobyl situation, priority is given to numerous pathologies of thyroid gland, vegetative-vascular dystonia and transient malfunctions in the blood system. At later stages, the signs of changing immunogenotypic structure of population appear, which evidently prove start-up of population mechanisms of natural selection. As based upon the results obtained, we can distinguish radiation factors typical for all citizens of Ukraine (global problems), and radiation factors of local nature (regional problems). These factors include increased content of radon-222 in living quarters, pollution of the territory as a result of the catastrophe at ChAPP and coal firing for heating purposes. Radiation exposure from tailing dumps appeared as a result of uranium processing; radioactive emission of TPPs working on coals, APPs and uranium mines, belongs to regional phenomena. Therefore for essential decrease of radiation risk in Ukraine, global problems should be solved, first of all, at the governmental level. Whereas a number of issues connected with the Chernobyl catastrophe are at least partially solved, the problems concerning the effects of radon and other radiation-dangerous factors are still to be tackled.

References

1. Некос А.Н., Праченко Т.А., Леонов А.Ю. Экология и проблемы безопасности товаров народного потребления. Харьков: ХНУ, 2001. – 248 с.
2. Донченко Л.В., Надыкта В.Д., Безопасность пищевого сырья и продуктов питания. – М.: Пищевая промышленность. 1999. – 352 с.
3. Концепция радиационной, медицинской, социальной защиты и реабилитация населения Российской Федерации, подвергшейся аварийному облучению // Вестник научной программы „Семипалатинский полигон – Алтай” – 1995. - №3(7). – С. 16-22.
4. Коваленко Г.Д., Рудя К.Г. Радиоэкология Украины. Киев: „Київський університет”, 2001.- 167 с.
5. Медико-социальные последствия ядерных катастроф / Васильев Н.Ф., Мальцев В.И., Коваленко В.Н., Шубик В.М. и др. //Київ, Здоров’я, 1999. – 296 с.
6. Лихтарев И.А., Ковган Л.Н. Общая структура Чернобыльского источника и дозы облучения населения Украины. // Международный журнал радиационной медицины. 1999. №1. С.29–38.
7. Radiation Protection. ICRP Publication 60. 1990. Recommendations of the International Commission on Radiological Protection (ICRP) – N.Y., Pergamon Press, 1991.-197 p.
8. Норми радіаційної безпеки України. (НРБУ-97). – Київ. 1997. -121 с.
9. Эквивалентные дозы в органах и тканях при рентгенологических исследованиях: Справочник/ Р.В.Ставицкий, И.А.Ермаков, Л.А.Лебедев и др. – М.: Энергоатомиздат, 1989. – 176 с.
10. Либманн Ж.О. О ядерной безопасности / Институт ядерной и радиационной безопасности, 1997. – 690 с.
11. Материалы X, XI, XII и XIII Международной конференции «Новые информационные технологии в медицине, биологии, фармакологии и экологии» - Украина, Республика Крым, Ялта. - 2002, 2003, 2004, 2005.