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Non cancer illnesses and conditions in areas of Belarus contaminated by radioactivity from the Chernobyl Accident

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The ecological environment influences the health of people and regulates the development of human society. Ignoring the considerable overall global progress in the business of protection of the environment (and therefore the health of people) there are countries in which there are serious environmental problems. First of all are the countries of the former Soviet Union. The aspiration to catch up and overtake the military and economic development of Western countries forced the former Soviet Union administration to introduce new industrial technologies that left a fatal impact on the environment and therefore the health of people. First of all, it is necessary to consider the Nuclear weapons tests of the USSR.

Pollution by radioactive elements of huge territories in Belarus, Lithuania, Latvia, Estonia, the Ukraine and Russia since the 1960s is the direct consequence. The population of these countries had no information on the existing radiation factor, and it could therefore not naturally protect itself from its influence in any way.

The Radio-ecological problem in Belarus

Since the beginning of the 1960s there have been a great number of Cs-137 radionuclides found in foodstuffs consumed by the inhabitants of these Soviet states for many years [1]

Although the contamination of Belarus by the Chernobyl catastrophe is well known (Fig1) what is less well known is the prior contamination by the weapons test fallout. I present a number of pieces of evidence of the contamination of areas of the USSR in Figures 2.2-2.4. Fig 2.2 shows how, prior to the Chernobyl disaster, Cs-137 levels were high in the 1960s and fell regularly after the atmospheric bomb tests were banned in 1963.

For example, cow's milk is one of the basic products containing high levels of Cs-137 radionuclides for inhabitants of Belarus and the Baltic lands. A “Milk-Caesium

Map" was created – the largest Cs-137 radionuclides contained were observed from 1967 to 1970 in Gomel region of the Republic of Belarus.

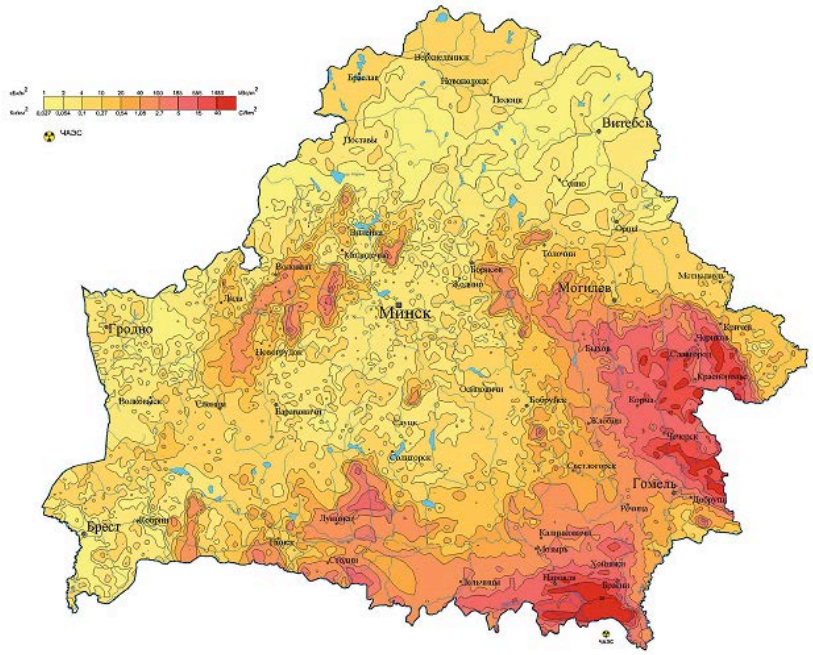


Fig 2.1 Cs-137 pollution in territories of Belarus in 1987

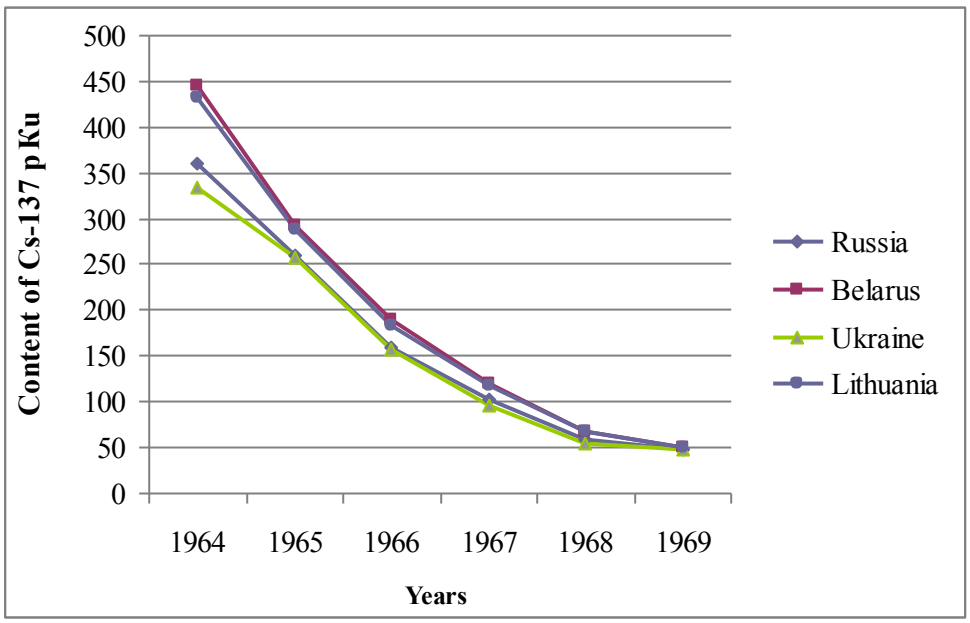


Fig. 2.2 - Cs-137 contents in villagers' daily food allowance in pCi (Marey A.N. and co-authors, 1974)

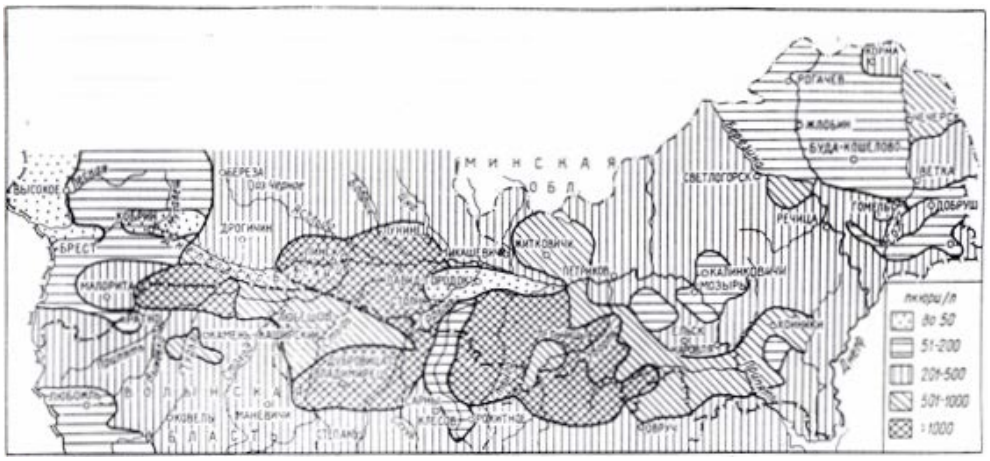


Fig. 2.3 Cs-137 contents in cow's milk (pCi/l) from different districts of Belarus in the sixties of the 20th century

The Chernobyl accident of 1986 intensified a lot the already existing radiation effects on the population of many European countries, focusing on the Republic of Belarus.

The map of Cs-137 radionuclides deposition in the territory of Belarus after the Chernobyl accident in 1992 (Fig 2.1, Fig 2.4) almost corresponds to the map of such radionuclides deposition in the territory of Belarus in the sixties (published in 1974 (Marey A.N. et al. 1974.). It was only due to western public interest that after the Chernobyl accident in 1986 it became possible to speak about the influence of radiation on the health of people in Belarus and another countries.

Judged by its scale and consequences, the Chernobyl accident on April 26 1986 is considered to be the largest man-caused catastrophe in human history. Its social, medical and ecological consequences require detailed study. Above all European countries, Belarus was the worst affected. About 70% of the radioactive substances released to the atmosphere as a result of the accident at the 4th block of the Chernobyl NPP landed in and contaminated over 23% of the territory of the Republic. At present in this zone there live close to 1.4 million inhabitants, including 260 thousand children. The radiation situation in several affected regions is still difficult today. The greatest danger is represented by the consumption of the foodstuffs containing radioactive elements Cs-137 and Sr-90. The contribution of these radionuclides to the internal dose reaches to 70 to 80% (Busby and Yablokov 2009). The increases in death and reduction in birth rates in Belarus have shown as a

negative trend in the demography index since 1993: 2002 -5,9‰, 2003 -5,5‰, 2005 -5,2‰.

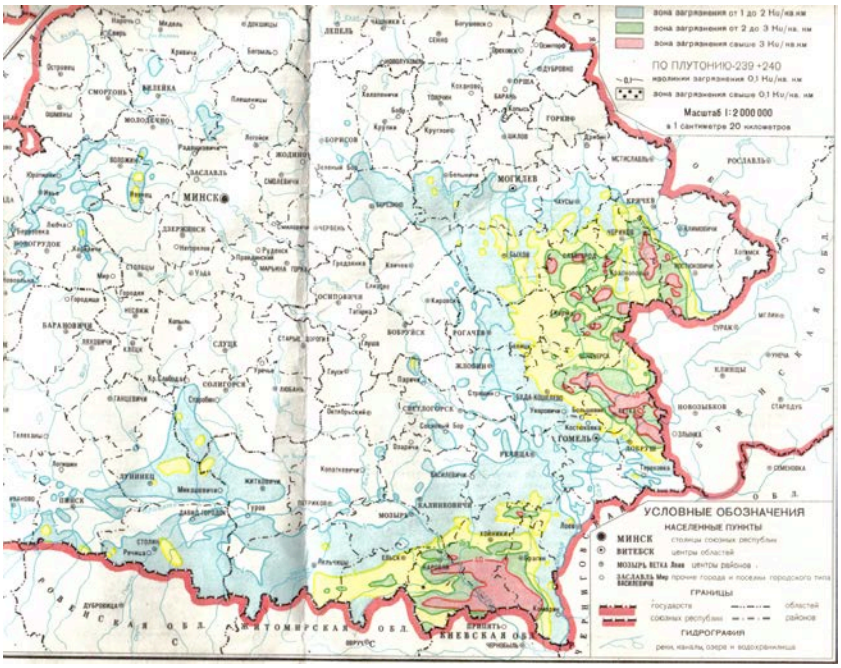


Fig 2.4 Map of Cs-137 deposition in the territory of Belarus in 1992

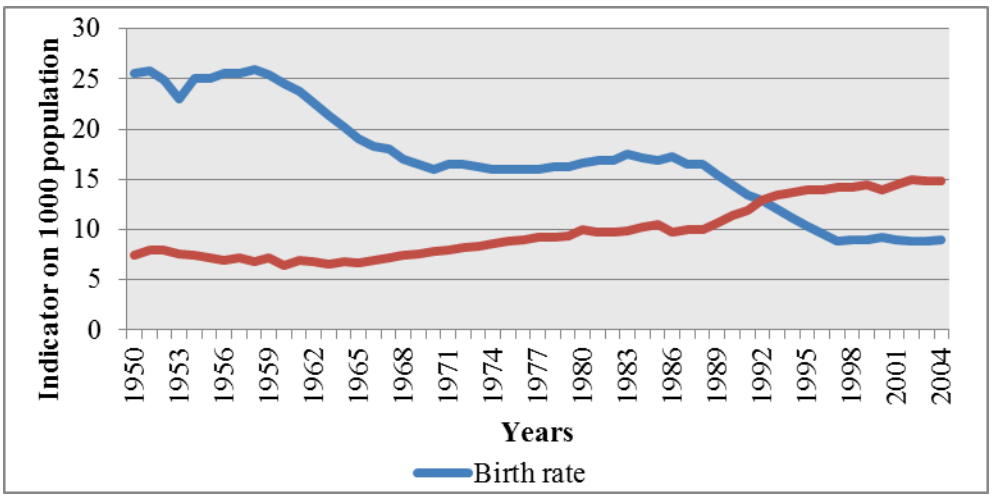


Fig. 2.5 Indices of the death-rate and the birth-rate (per 1000 inhabitants) in the Republic of Belarus

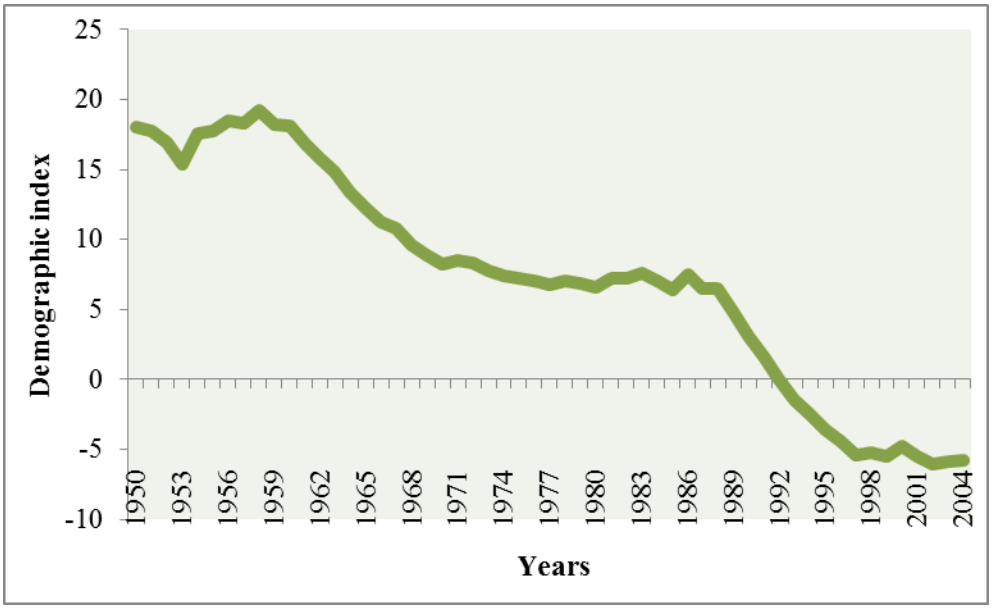


Fig 2.6 Demographic index for the Republic of Belarus, 1950-2004

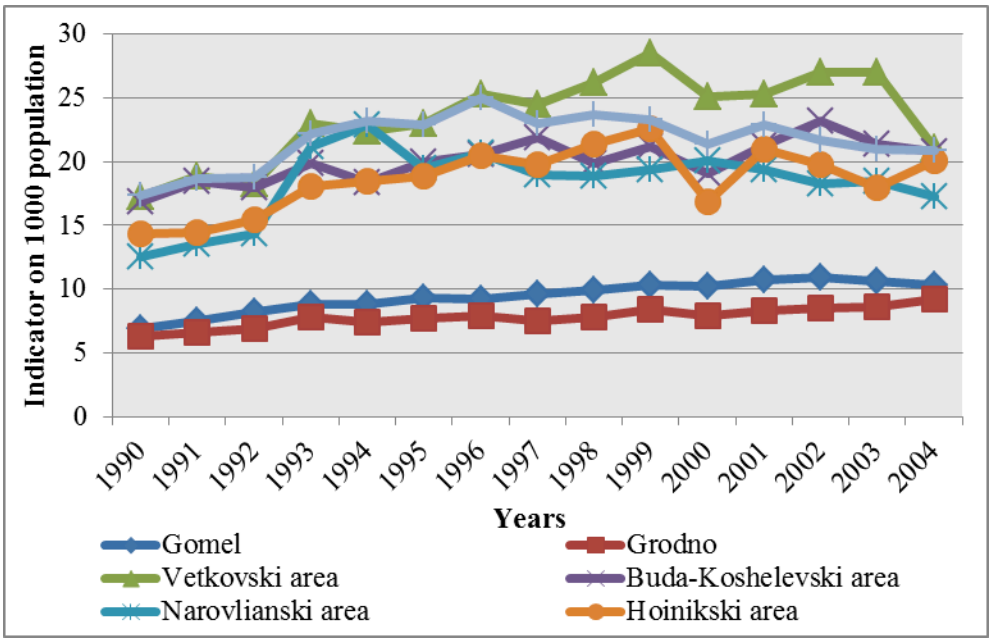


Fig 2.7 The dynamics of the death-rate of the population in different districts of Belarus

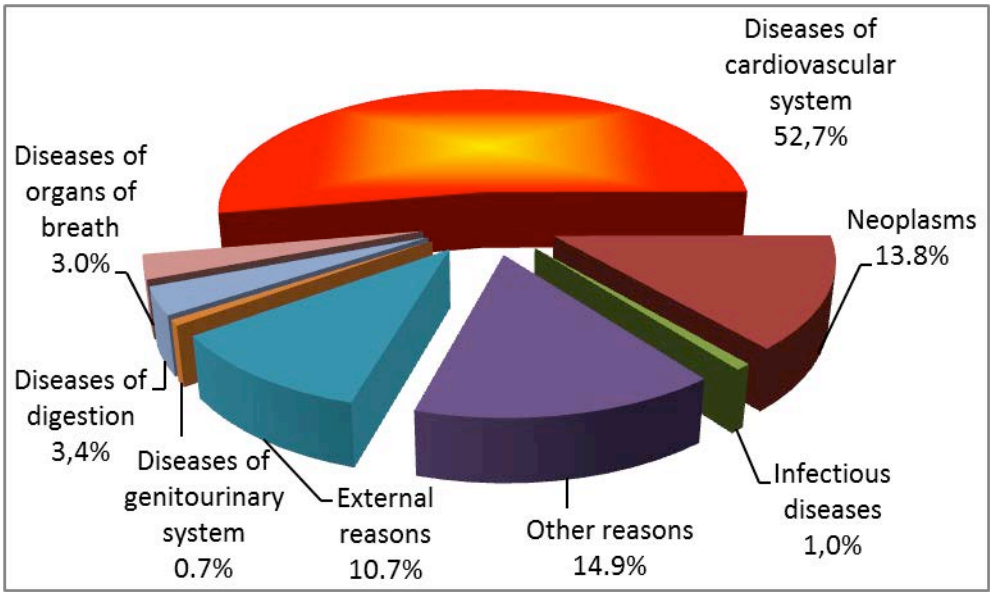


Fig 2.8 Structure of the causes of death in Belarus, 2008

Among the causes of death of the inhabitants of Belarus, cardiovascular and oncologic diseases take the dominant place. The statistically significant increase in the primary incidence of diseases of the cardiovascular system, especially amongst those who dealt with the consequences of the Chernobyl nuclear accident is cause for anxiety (Fig 2.9).

Cs-137 radionuclides under conditions of permanent chronic intake in food are accumulated in vitally important organs: thyroid gland, heart, kidneys, spleen, cerebrum. This affects these organs to different extents.

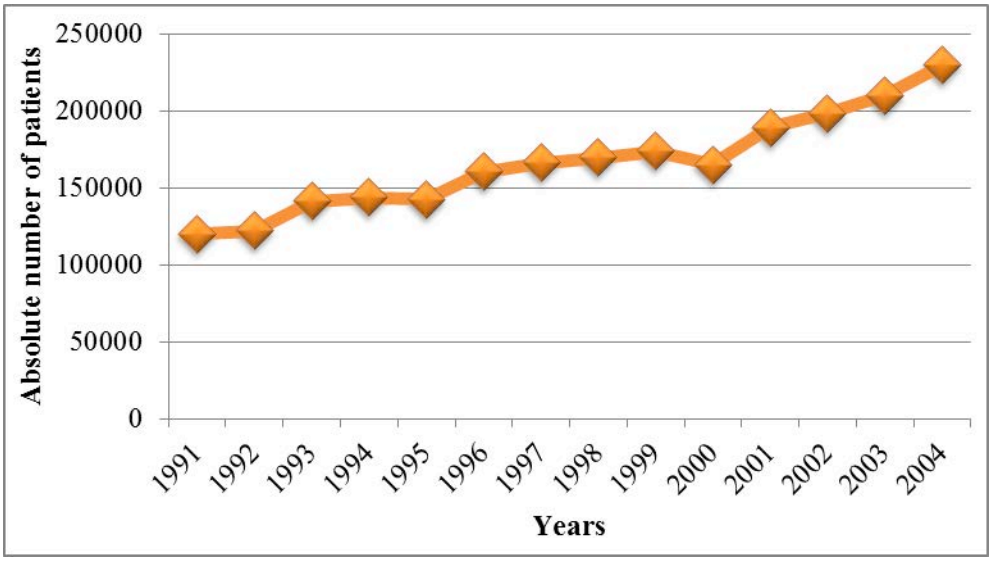


Fig 2.9 The dynamics of cardiovascular diseases in the Republic of Belarus

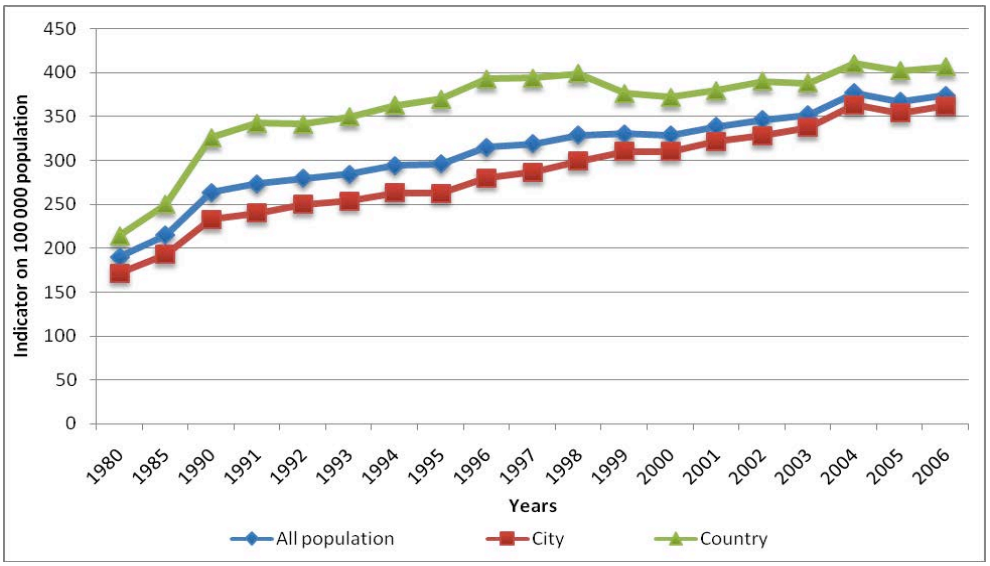


Fig 2.10 Incidence in the population of the Republic of Belarus of malignant neoplasms (per 100000 inhabitants)

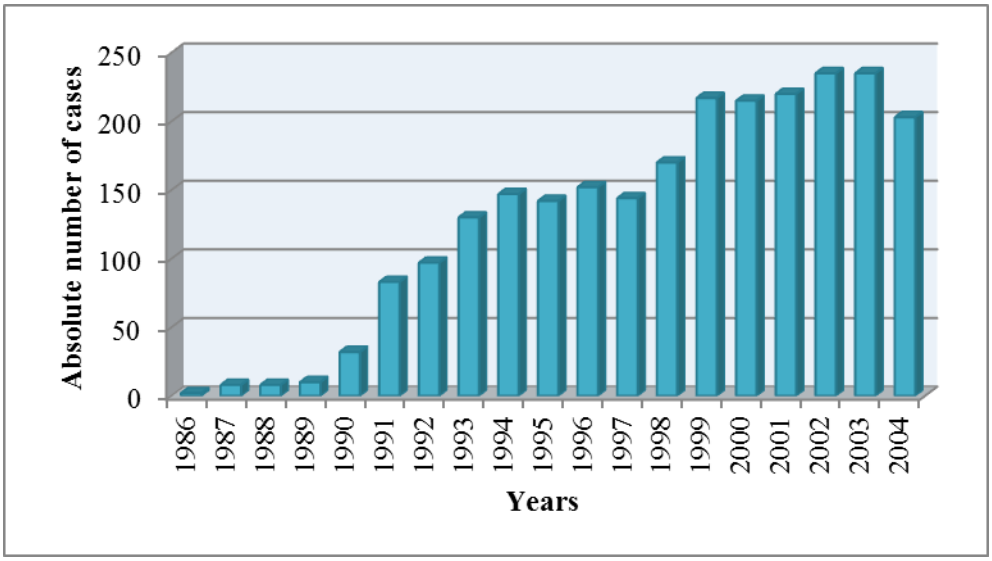
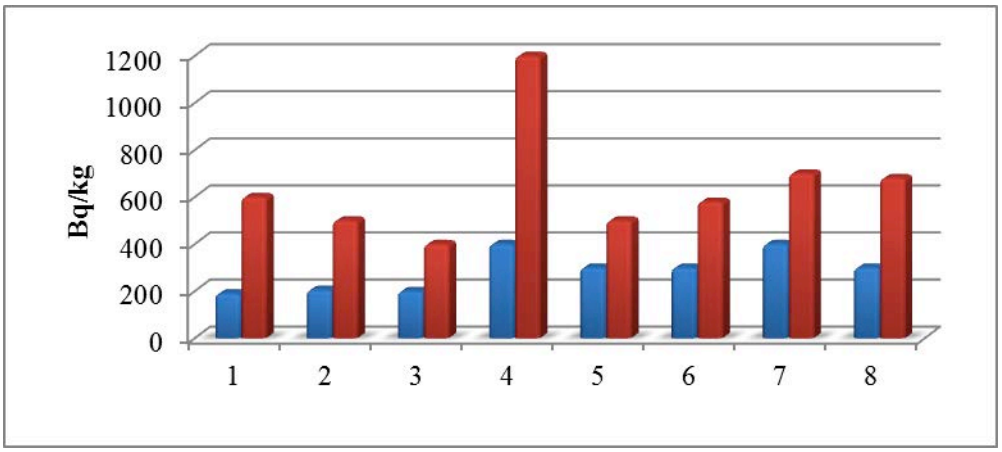


Fig 2.11 The dynamics in the absolute number of cases of thyroid cancer detected for the first time in Belarus



Key: 1 – myocardium, 2 – brain, 3 – liver, 4 – thyroid gland, 5 – kidneys, 6 – spleen, 7 – skeletal muscles, 8 – small intestine

Fig 2.12 Cs-137 contents in adults' and children's viscera according to the data of radiometric measurements of the autopsies of inhabitants of Gomel region in 1997 and 1998 (Yu. I. Bandazhevsky, 1999, 2003)

Cs-137 incorporation leads to metabolism disorders in highly differentiated cells and dystrophic and necrobiotic processes in development. The degree of disorder is the function of the Cs-137 concentration in the organism and in the organs mentioned above. The more intense the process, the higher the degree of disorder. As a rule if several organs are subjected to the radiotoxic effects simultaneously, this provokes general metabolic dysfunction. It should be noted, the organs and tissues with the negligible or absent cell proliferation (e.g myocardium) under physiological conditions suffer to the greatest extent. Cs-137, accumulated in the organism, seems to block the metabolic processes and affects membrane cell structures. The process provokes structure and function disorder in many vital systems but primarily the cardiovascular system. Structural, metabolic and functional modifications in the myocardium correlate with radiocesium accumulation and demonstrate its toxic effects. The energetic system and mitochondrial systems are violated. Deep and irreversible changes (due to the increase in Cs-137 concentration) lead to the necrobiotic processes in a cell. Suppression of the enzyme creatine phosphokinase appears as a consequence of energetic instability (Fig 2.14).

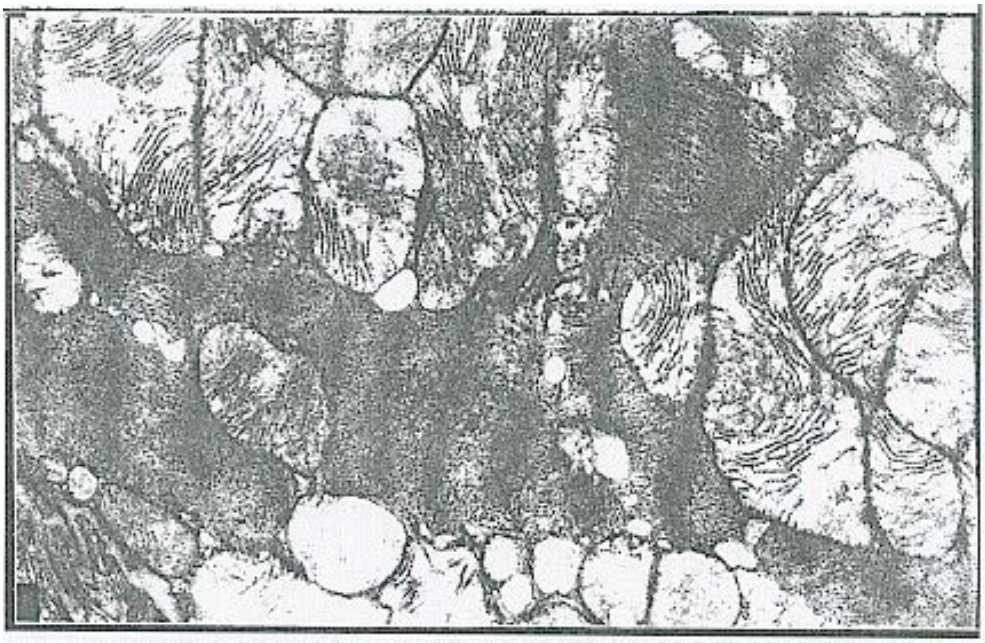
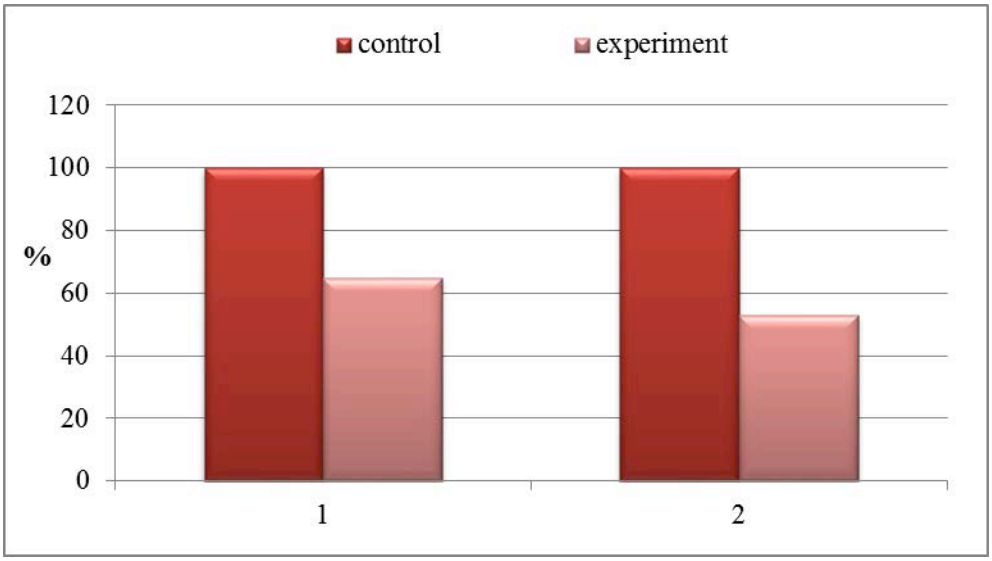


Fig 2.13 - Accumulation of the rat cardiomiocytes mitochondria with radiocesium incorporation 45 Bq/kg Uv. 30 000



K*ey: 1 - alkaline phosphates, 2 - creatinphosphokinase (p <0,05)*

Figure 2.14 Variations of activities of enzymes in myocardium tissue among experimental animals (% versus control)

The effects of Cs-137 are most extreme in the cardiovascular system of the developing organism. Radiocesium concentration over 10 Bq/kg leads to the violated electrophysiological processes in the myocardium of children. Those born after 1986 and continuously living on the Cs-137 affected territories with concentration above 15 Ci/km^2 suffer serious pathological modifications of the cardiovascular system, manifesting itself both clinically and electrocardiographically. Cs-137 radionuclides incorporation in schoolchildren causes the disorder of electrophysiological processes in cardiac muscle shown by the disorder of cardiac beat rate. There found to be a clear dependence between the radionuclide content in the organism and the cardiac arrhythmia rate (Fig 2.15).

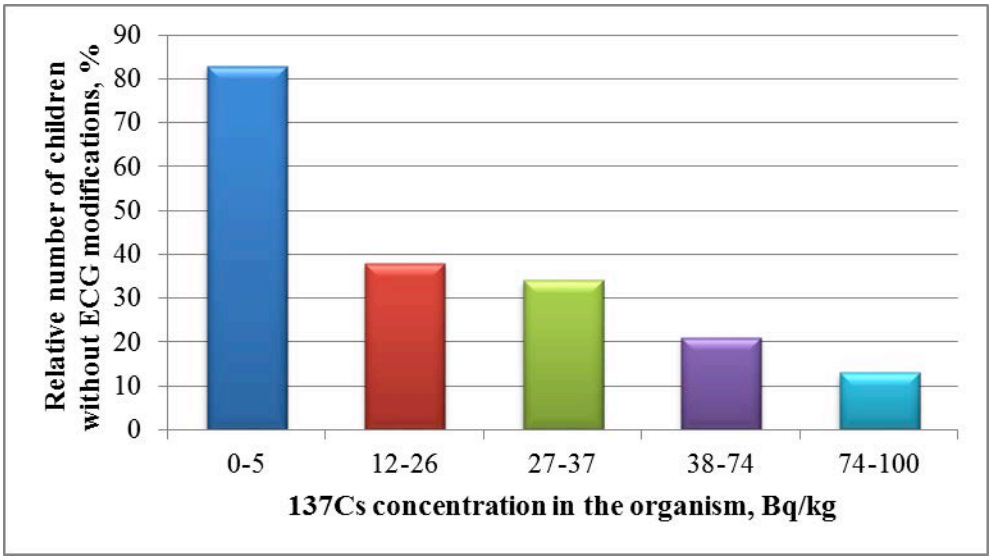


Fig 2.15 Number of children without ECG modifications as a function of Cs-137 concentration in the organism (Bandashevsky and Bandashevsky).

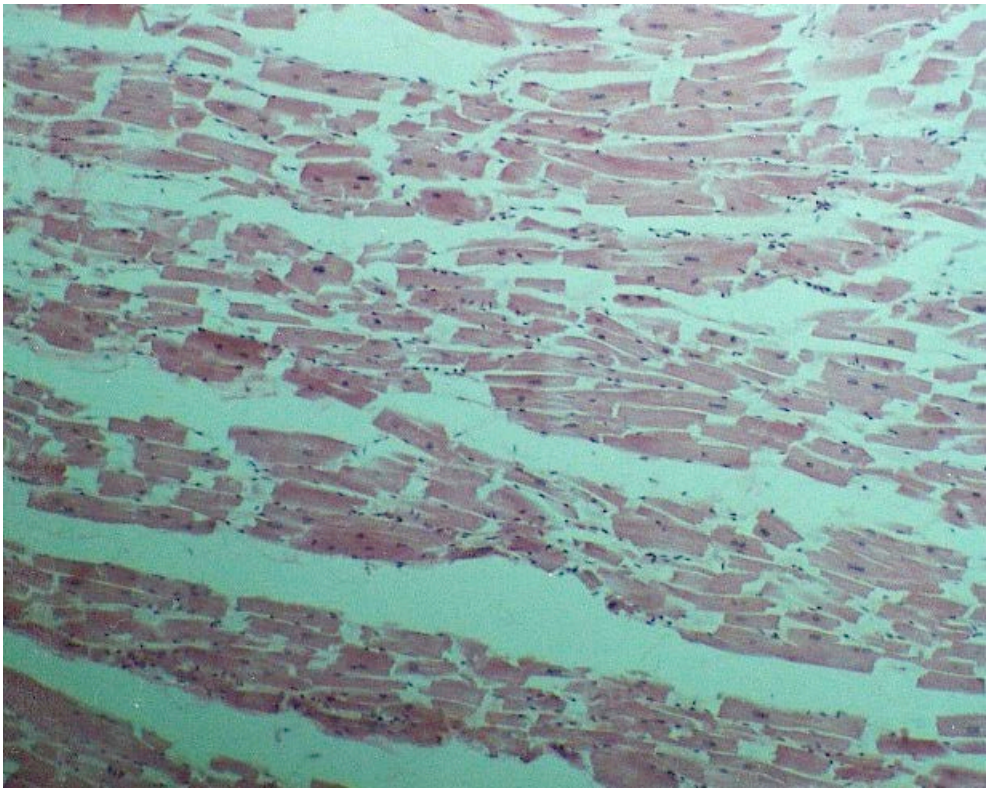


Fig 2.16 - Histological myocardium composition of a 43-year-old Dobrush resident (sudden death case). Radiocesium concentration in heart – 45,4 Bq/kg. Duffisious myocytolis. Intermuscular edema. Fragmentation of muscular fibers. Colored by hematoxylin and eosin. Uv. X 125

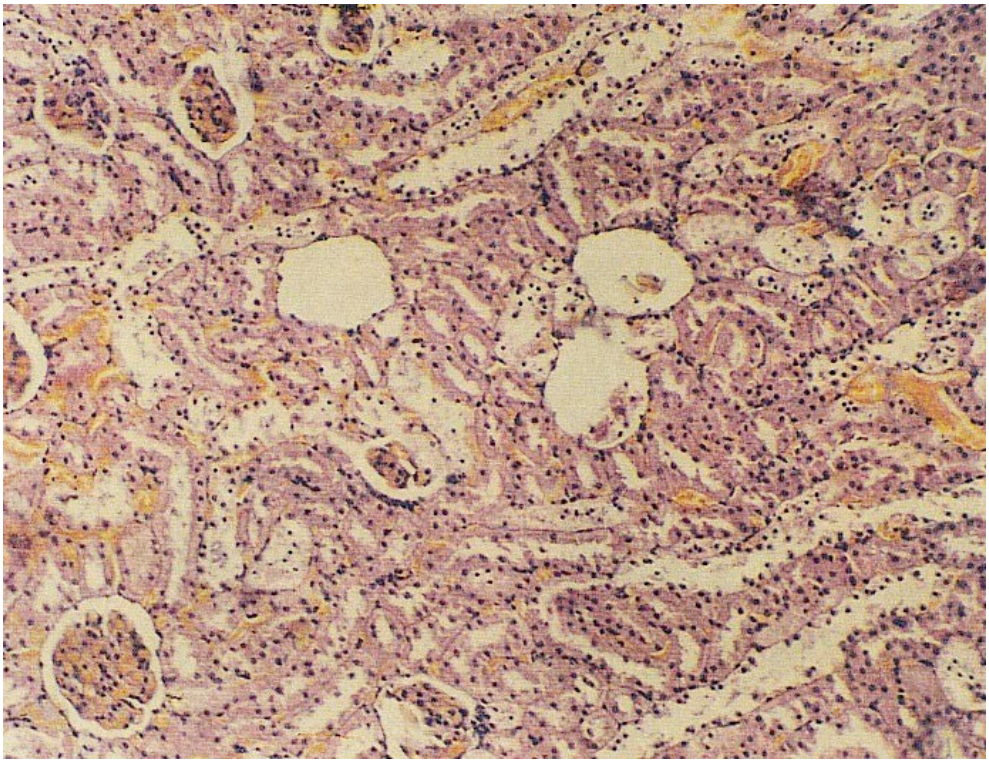


Figure 2.17 - Histological kidney composition of an albino rat with radiocesium concentration 900 Bq/kg. Necrosis and glomerulus fragmentation with cavity formation. Necrosis and hyaline-dropping dystrophy of the canaliculus epithelium. Colored by hematoxylin and eosin. Uv. X 250

The situation is quite organ specific. Fig 2.17 shows the effect in the kidney. Due to the microscopic architecture of the blood supply the radiation induced pathology of the organ has its own specific features. The radiation disease of the kidney is seldom accompanied with nephrotic syndromes, but is more severe and quicker in character when compared to the ordinary chronic glomerulonephritis. The latter is characterized by frequent and early development of the malignant arterial hypertension. Already after 2-3 years radiological kidney damage leads to the development of chronic renal failure and cerebral and cardiac complications**.** Kidney destruction is one of the main effects of Cs-137 in addition to the products of metabolic accumulation in the organism and their toxic effect upon the myocardium and other organs and also of the arterial hypertension. If the cases of sudden death in Gomel are considered, 89% of these are accompanied by this kind of general organ destruction, this state being not registered during their life time. Serious pathological

modifications of the liver are also noteworthy. The progress in toxic dystrophy of the liver with prevailing destruction of the cellular protein and metabolism transformation, results in formation of fat-like substances which contribute to such severe pathological processes as fatty hepatosis and cirrhosis (Fig 2.18).

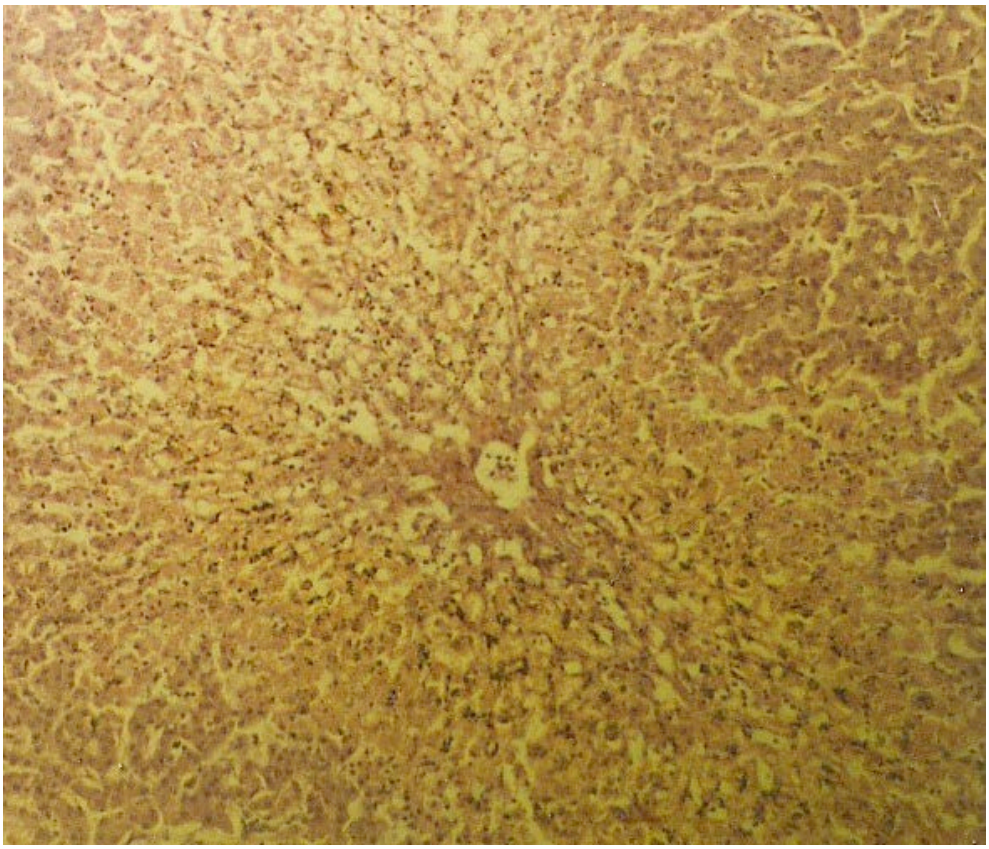
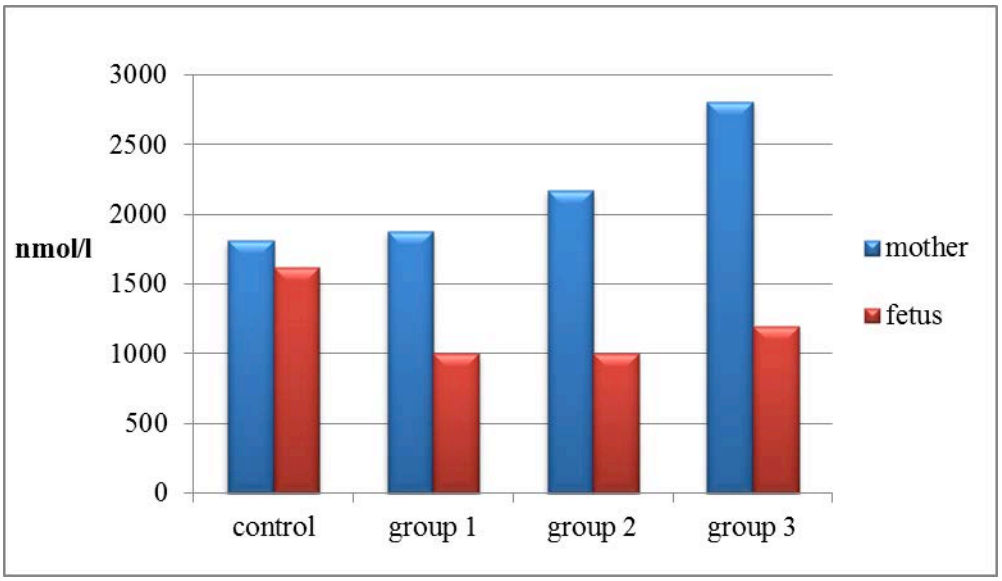


Fig 2.18 - Histological liver composition of a 40-year-old Gomel resident (sudden death rate). Radiocesium concentration in the liver – 142,4 Bq/kg. Fatty and protein dystrophy, hepatocytes necrosis. Colored by hematoxylin and eosin. Uv. X 125

The endocrine system is also exposed to influence of incorporated Cs-137. The adrenal gland also appear affected by the incorporated radiocesium, the level of cortisol being a function of the radiocesium concentration in the organism. The modifications in cortisol production are especially noticeable for the neonates, their mothers having accumulated considerable Cs-137 concentration in the organisms (mainly in the placenta) (Fig 2.19). These children are famous for their ill-adaptation

to the intrauterine existence. The effect is seen in rats whose mothers were fed Caesium 137 (Figs 2.19, 2.20).



Key: Cs-137 concentration in placenta: Group 1 – 1-99 Bq/kg; Group 2 – 100-199 Bq/kg; Group 3 – >200 Bq/kg.

Figure 2.19 - Cortisone concentration in mother and foetus blood in control and test groups

Pathology of the female reproductive system is a product of the violation of endocrine functions. Radiocesium is also responsible for the imbalance in the progesterone-estrogen with women of fertile age in different phases of the oestral cycle, and this is a key factor for the infertility. Radiocesium incorporation in placenta and other endocrine organs during pregnancy gives rise to hormone disorders both in the mother organism and foetus. In particular, the Cs-137 concentration rising, the testosterone contents increases as well as the thyroid hormones and cortisol in blood. Distortion of hormone statues in the mother-foetus system due to radiocesium leads to extended pregnancy time and childbirth and postnatal child evolution complications. In case of natural feeding, radiocesium penetrates the child's organism. Thus, the mother's organism purifies itself, while that of a child's becomes Cs-137 contaminated. Many systems being formed in this period, radiocesium has an extremely negative effect upon the child's organism. The nervous system is the first to respond to the radioisotopes incorporation. Cs-137 incorporation within 40-60 Bq/kg, which is due to the 28-days animals feeding with

oats, causes distinct imbalance of the biosynthesis of monoamines and neuroactive amino-acids in different compartments of the brain, in particular, in the cerebral hemispheres, which is characteristic of mean lethal and super lethal radiation doses. This is reflected in time of various vegetative disorders.

Fig 2.0 Rat foetuses from mother fed Cs-137

The increase of the cases of cataracts in schoolchildren living in the radio contaminated areas should also be mentioned – the frequency of detecting this pathology is like the other conditions found to be in direct relation to the quantity of Cs-137 radionuclides in the organism (Fig 2.21).

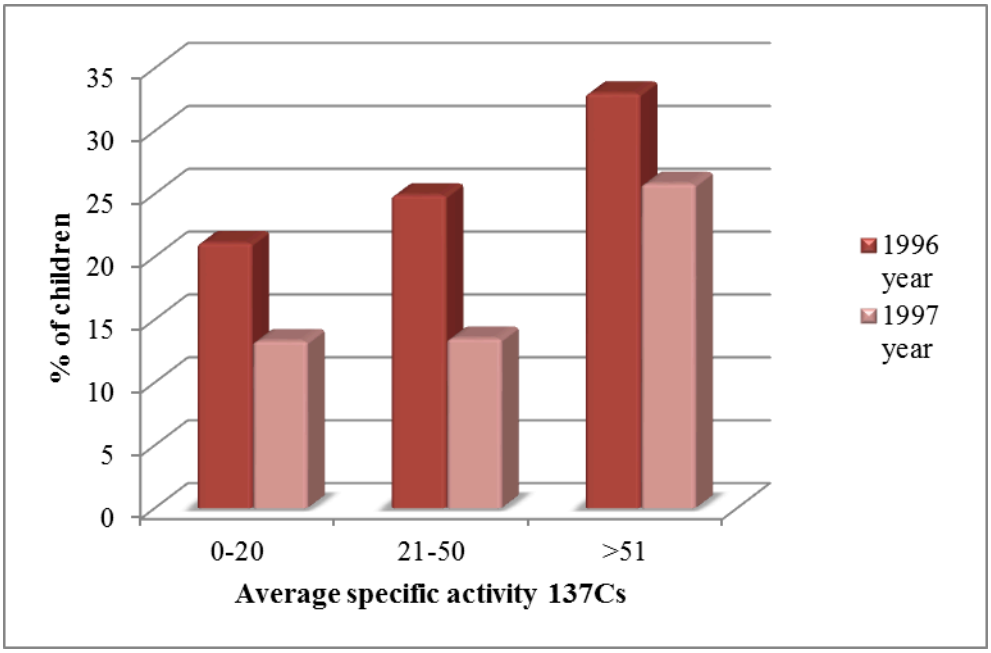


Fig 2.21- The dynamics of the increase of the cases of cataract in the children of Vetka district of Gomel region depending on the level of the average specific activity of Cs-137 (Bq/kg) in the organism (Yu.I. Bandazhevsky and co-authors, 1997, 1999)

To summarise, the long-living radioisotope of Cs-137 affects a number of the vital organs and systems. As a result, highly differentiated cells are adversely affected, the process being dependent on the radiocesium concentration. The basis of the process lies in destruction of the energetic mechanism, leading to protein destruction. In this connection, the characteristic feature of the Cs-137 effect upon the human organism appears a depressed metabolic processes in the cells of vital organs and systems, due to the direct influence and the effects of the toxic tissues (nitrogen compounds) and violation of tissue growth due to the vascular system disorders. The pathological modifications in the human and animals organisms caused by Cs-137 may be joined together into a syndrome which may be termed: "long-living incorporated radioisotopes". (SLIR). The syndrome appears in the cases of radiocesium incorporation in the organism (its degree being the function of the incorporation quantity and time) and the syndrome is characterized by the metabolism pathology, stipulated for the structural and functional modifications in the cardiovascular, nervous, endocrine, immune, reproductive, digestive, urinary excretion and hepatic system. The quantity of the radiocesium, inducing SLIR may vary, depending on age, sex and the functional condition of the organism. Children have been shown to have considerable pathological modifications in the organs and

systems with an incorporation level over 50 Bq/kg. Nevertheless, metabolic discomfort in the individual systems, primarily in the myocardium, has been registered with Cs-137 concentration amounting to 10 Bq/kg.

Conclusions

Twenty three years after the accident at the Chernobyl nuclear power plant, the inhabitants of the Republic of Belarus, living in the territory contaminated by radioactive elements and consuming these radionuclides for a long time, run the risk of the incidence by cardiovascular diseases and malignant neoplasms. The steady rise of this pathology within 23 years after the accident has led to a situation that is close to a demographic catastrophe when a death-rate of the population has begun to exceed a birth-rate by a factor of two times. The current situation requires the immediate decisions at State and international levels directed at the solution of the problem – protecting the state of health of the citizens living in the territories affected by the accident at the Chernobyl.

[1] (Marey A.N. and co-authors, 1974. Rusyayev A.P. and co-authors, 1974. Ternov V.I., Gurskaya N.V., 1974).