LOW DOSES OF RADIATION: EPIDEMIOLOGICAL INVESTIGATIONS

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Influence of small dozes of radiation was investigated with the help epidemiologic evidence. Correlation analysis, regression analysis and frequency analysis were used for investigating morbidity of various cancer illnesses. The pollution of the environment and the fallout of radionuclides in 1962 and 1986 years have an influence upon morbidity of cancer. Influence of small dozes of radiation on health of the population is multifactorial. Therefore depending on other adverse external conditions the influence of radiation in small dozes can be increased or is weakened. Such character of influence of radiation in small dozes proposes the differentiated approach at realization of preventive measures. Especially it concerns regions with favorable ecological conditions.

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1. INTRODUCTION

Nuclear Power Plants (NPP) and various power objects, as well as large-scale manmade human activities affect the ecosystem [1]. Factor of radiation provoke inadequate perception in the public mind and is a barrier to choosing the type of energy source [2-4].

Levels of natural radiation vary within wide limits, and the living organism is not only ready for radiation exposure, but also to a large extent this radiation formed his: immune and genetic mechanisms of reparation are the tool of evolution as a result of the background radiation.

Now it is an accepted thesis that there is no way to generate electricity, not associated with the risk. The coal-fired electric power stations have more high specific radioactive release into the environment per unit of electricity than NPP. Coal contains natural radionuclides: - thorium, two isotopes of uranium and their decay products in the form of radium, radon, polonium, as well as long-lived isotope of ^{40}K. All of these radionuclides emit into the environment. Except soot and ash the emission of carbon dioxide is accompanied during combustion of coal, that leads to greenhouse effect and toxic gases (carbon monoxide, sulfur and nitrogen) and cause acid rain. Complex polycyclic aromatic hydrocarbons (benzopyrene, formaldehyde), a pair of hydrochloric and hydrofluoric acids, toxic elements (arsenic, cadmium, mercury, lead, thallium, chromium, antimony, beryllium, vanadium, etc.) are integral components of emissions. Apparently, the further development of thermal energy by means of organic fuels (coal, oil, gas, peat, oil shale) will contribute to large changes in climate and atmospheric properties.

Thermoelectric power stations (TPS) emit 5-10 times more of active emissions than nuclear power plants. The natural radionuclides in coal are concentrated in the slag dumps of TPS that [5].

Radioactive environmental effects of hydroelectric power station (HPP) are about 20 times higher than in case of nuclear power plants with equal power also.

Production of electric power by NPP in Ukraine corresponds to the fifth place after France, Britain, Russia and Germany.

Radioactive waste of NPP formed during the fission of uranium-235,238 and by neutron activation of different materials of buildings, fuel, coolant, etc. Most of the activity is determined by the short-lived radionuclides, which realize a significant radiation dose in nuclear power plant buildings. However, it should be noted that these radionuclides decay rapidly and do not a serious danger. The most dangerous are radionuclides with half-lives longer than a few hours.

In terms of radiation exposure of humans and the environment the normally operational nuclear power plants can be considered as zero-emission production. But if we ignore the effects of radiation factors on the ecosystem, it is necessary to bear in mind the thermal and chemical pollution, mechanical impact on the flora and fauna of the water, adjacent to the NPP area.

On the recommendations of the Kyoto Protocol, emissions of carbon dioxide must be reduced by almost half. Change in the Earth's climate is mainly dependent on income in the atmosphere large amounts of carbon dioxide. Therefore, the rational use of the earth's resources for energy production can be an indicator of the standard of living and life expectancy. The accident at the Chernobyl nuclear

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power plant and large-scale natural disaster at the station „Fukushima“- a tsunami of high power - could seriously undermine the nuclear energy. Therefore, it is necessary increase of competence in the description, explanation, prediction and risk management in atomic industry.

Therefore, production and environmental monitoring of nuclear power plants, including the control of air, surface and ground water, soil, will provide an opportunity to distribute in the first place child population of administrative regions in terms of environmental well-being. In terms of environmental factors can be carried out a correlation with the prevalence of various diseases of the population.

In the process of adaptation to the environment the maintaining homeostasis is achieved by dynamic balancing of all organs and systems to the changing conditions of existence. The severity of these changes and ways to balance different people depend on gender and age. One of the important problems of public health in this century is to conduct a timely and adequate diagnosis and prevention of possible violations, especially in children.

It is clear that humanity cannot abandon achievements of civilization, so the study of regularities and relationships of the environment and humans is an important problem to detection of factors of regulating pollution of the biosphere by chemical elements.

The new trend in medicine „environmental pathology“and „environmental diseases“was generated, whose goals are to find chemicals that activate hidden health problems.

The major hazards of industrialized cities are carbon dioxide, carbon monoxide, sulfur dioxide, nitrogen dioxide, mercury, lead, silicon, manganese and chromium oxides, ammonia, phenol, benzene, toluene, formaldehyde, aluminum dust. These chemicals affect almost all body systems.

Congenital malformations due to environmental pollution showed that the speed of mutation of industrially polluted regions was significantly increased: in Zaporozhye - 1.2 times, in Mariupol - 1.5 times.

Environmental contamination by different elements primarily affects children, as intense accumulation of various toxic and heavy elements are accumulating in the placenta. This leads to the development of birth defects, immunosuppression, the development of various chronic pathologies, and problems of mental and physical development.

Some industrial areas with especially intense pollution of the environment can be man-made microelementhoses zones. As a result, appears of generation of weak people susceptible to infection with high risk of cancer.

The main forms of natural endogenous microelementhoses be considered congenital and hereditary, that is, diseases caused by disorders of chromosomes or genes. Natural exogenous microelementoses - is endemic disease occurring in certain geographical loci. Manmade microelementoses most commonly associated with the production of human-and so they are found in the area or in the vicinity of a production. Microelementoses can sometimes occur even at a considerable distance from the production due to transport of microelements (ME) by air or by water. Finally, iatrogenic microelementoses recent sharp increase, due to the intensity of treatment with different drugs containing ME.

The toxic effect of a chemical element in the body is determined by a number of mechanisms - this effect on membrane permeability, the substitution of natural substrates, transfer material to inactive metabolites and inhibition of enzymes.

In recent decades, the deterioration of the state of public health associated with exposure to socio-economic and environmental issues. This negative process on the one hand, reflected in an increase in chronic diseases and increased mortality, especially in the working groups and the children, on the other hand - in reducing birth rates and increased life expectancy.

A special place in violation of physiological processes and the formation of pathological manifestations in humans belong to the environment. Increasing concentrations of toxic elements in the environment, such as Pb, Cd, Hg, As and other lead to a deficiency of essential trace elements Fe, I, Se, Zn, that creates a hostile environment for human life, growth and development of the child population.

An important factor in the further development of nuclear energy is also a study of the effect of low doses of the health of the population [6-11].

Total annual effective dose from natural sources for the Ukrainian population is $4.6\,mSv$, which is significantly higher average value - $2.4\,mSv$. About 80% of these values are the decay products of radon, including the concentration of radon in dwellings.

The combination of low-dose effects associated with various environmental factors has a lot of its features [12,13]. The main feature of the biological effects of low levels of ionizing radiation is the body's ability to adapt to their action, while maintaining physiological regulation functions. Higher levels of radiation exposure cause a qualitatively different biological effect, which is characterized by the development of a pre-disease state control and reduce adaptive capacity of the organism, greater dependence on the total dose. Changes caused by low levels of ionizing radiation, are inconsistent with the notion of a linear dependence on the magnitude of the biological effect of radiation exposure. Ionizing radiations are highly carcinogenic activity.

In the case of incorporation of radionuclides by tumors develop in areas of the deposit or the transit of radionuclides - in bone, lung, kidney, thyroid, and in tissues that are in the range of the ionizing particles, including the hematopoietic and epithelial tissues in the case of incorporation of osteotropic radionuclides. In case of a local or total ionizing radiation cancers arise even in highly resistant tissues (carcinoma of the esophagus, cancer of the central nervous system).

Experimental researches have shown that the ra-

diation with high linear energy loss of ionizing particles (LET) (fission neutrons, alpha particles) are more effective in inducing tumors than low-LET radiation (X-rays, gamma rays). For low-LET radiation the lower dose rates are less effective in the induction of tumors than high dose rates. Complete summation of radiation damage during exposure of ionizing radiation with a high ionization density (alpha particles) and the absence of recovery processes indicate that from a practical point of view is inessential, for what period of time corresponding to the accumulated radiation dose. Epidemiological research of high levels of radiation has been effective. Similar studies for doses less than $100\,mGy$ and less than $10\,mGy$ has the feature.

Evaluation of stochastic effects, mostly carcinogenic, is currently based on the linear no-threshold concept (LNT). It is assumed that the ionizing radiation is independent of dose and dose rate are absolutely harmful factor. Exposure at any dose different from zero, due to the risk of a possible carcinogenic effect, will manifest itself in the subsequent periods after irradiation. The severity of stochastic effects, thus, does not depend on the dose. ICRP support this concept. The direct evidence of such an approach to the assessment of low radiation doses and low dose rates not exist.

Many researchers believe that for stochastic effects, there should be a threshold. The adoption of this representation would have a significant social impact, financial and legal implications for radiological protection. Also important phenomena of radiation-induced genomic instability (RIGI), which can serve as a basis for predicting cancer risk in relation to the predicted by LNT. However, it should be noted that there are indications that the radiation-induced genomic instability for exposure of rarely ionizing radiation has, at least, a practical threshold effect, and irradiation in small doses, a more or less normal cells is absent [14].

Therefore new approaches are necessary. Unification of epidemiology with basic biological research processes of cell damage, which leads to a breach of human health, allow to determine the most vulnerable points of defeat. Such information will implement realistic biological and mathematical models to extend risk assessment at dose levels below which direct human data are not available.

Impact of low-level radiation on live organisms is very interesting both in theory and in practice. It is important for those working in the nuclear industry, but is particularly important for the millions of people who live thousands of miles from the accident with radioactive substances. Radiobiologists well researched the effects of high doses of ionizing radiation on biomacromolecules, cells, and organisms. But there is no tangible data and theoretical understanding of impact on the living world around us of slight increase of anthropogenic radioactivity (e.g. 2-4 times). Results of studies have clearly shown that the known laws in radiobiology and that previously acquired knowledge is not enough to explain these effects, and should be offered a fundamentally new mechanism.

There are known investigations for low doses of radiation, where detect bimodal dose-response [15]. For low doses the influence of radiation was increasing, reaching a maximum. At higher doses effect of radiation was reduced (in some cases the sign of the effect is reversed), and then with increasing doses resurged. The value of low-dose maximum and a dose of its achievement were depending of the nature of the object and the dose rate. General appropriateness of dose dependency is shift of maximum of effect under lower doses during reducing the intensity of exposure. In this case, chromosome damage and malignant transformation of cells at low doses of an order of magnitude higher than would be expected by extrapolation from the effects of high doses.

There are a considerable number of studies that suggest the need for natural background existence of the biosphere [16, 17]. The authors of these studies explain some facts reduce the incidence of cancers in the radiation values of expansions that exceed the natural background radiation, radiation gormezisa launch [17]. The most common point of view, according to these authors, is associated with increased immunity under the influence of low doses of ionizing radiation [18].

The aim of this work was to try to determine the effects of radiation on the human body in small doses on the basis of the study epidemiological data from various diseases in Ukraine.

2. MATERIALS AND METHODS

This study was based on material sites of Medical Statistics of Ukraine, WHO and the statistics, which published in specialized journals of the inventory of cancer in Ukraine from 1976 to 2011 yr., and overall infant mortality, as well as statistics on Ukrstat air pollution. Were used the data about radioactive fallout from the Chernobyl accident, which were presented in the United Nations Scientific Committee on the Effects of Atomic Radiation. Also, were used the data on global warming of the Earth from the site (http://berkeleyearth.org/).

Correlation and regression analysis were calculated by standard programs Mathcad 12, time series analysis was calculated by program Statistica 6.0.

3. RESULTS AND DISCUSSION

The morbidity of thyroid gland cancer of population from specific contaminants that are by-products of chemical plants in different regions of Ukraine is shown in Fig. 1. The high levels of morbidity of thyroid gland cancer in regions with low levels of contamination one can see. The morbidity decreased at higher levels of pollution with the maximum at $5.4\,t/km^2$.

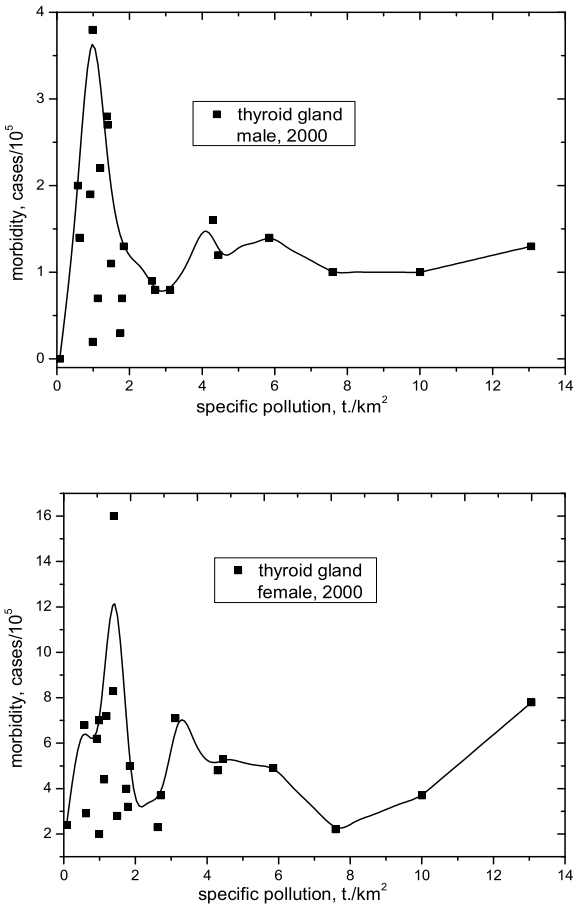


Fig.1. *The morbidity of thyroid gland cancer of population from specific contaminants in different regions of Ukraine in 2000 year*

The morbidity of thyroid gland cancer increased for large values of specific contaminants again. Apparently, in many respects, these indices relate to the consequences of the Chernobyl accident. However, according to the literature [19], the same relationship of thyroid gland cancer rates from the effects of specific air pollution was observed in 1993, when the effects of small doses of the accident has been significantly reduced.

The morbidity of thyroid gland cancer from the age of the population of Ukraine in 2000 year and 2009 years is shown in Fig. 2 (above). The spectral density of the first derivative of thyroid gland cancer rates of women in 2009 year is shown in Fig. 2 (below). The dependence of thyroid gland cancer rates after single differentiation with two peaks at 13 and 26 years one can see. Maximum values of thyroid gland cancer rates in women appeared at 52.5 years in 2000 and 62.5 years in 2009 year. The difference is 10 years, which is almost the same as the difference in time of observation 2009-2000 = 9 years.

Less prominent peaks are observed in the morbidity at 62.5 years in 2000 year and 72.5 years in 2009 year. The results can be explained by long-term effects of radioactive fallout in 1962 year and their impact on children aged 0...4 years. This statement is not in doubt. The maximum of morbidity of thyroid gland cancer is observed in 62.5 years in 2009 year and 52.5 years in 2000 year for men.

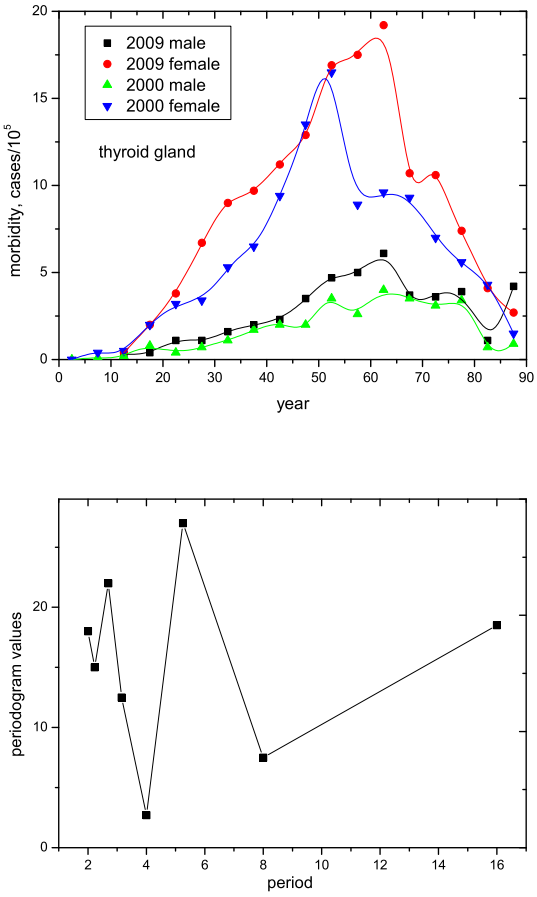


Fig.2. *The morbidity of thyroid gland cancer from the age of the population of Ukraine in 2000 year and 2009 year (above). The spectral density of the first derivative of thyroid gland cancer rates of women in 2009 year (below)*

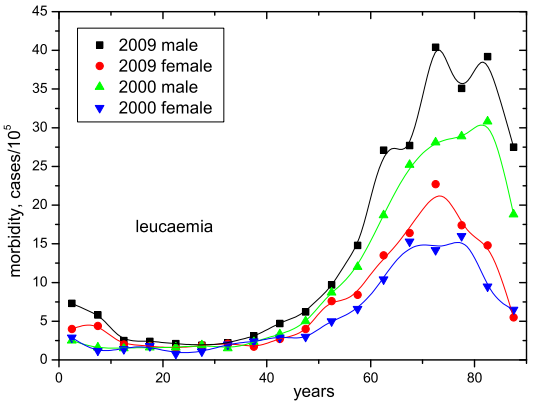


Fig.3. *The leukemia incidence for men and women from age in Ukraine*

This index revealed resistance to the effects of sexual incorporation of iodine-131: Girls were less resistant

in puberty. The irregularity of thyroid gland cancer rates in women aged 32 years in 2009 year and 22 years in 2000 year, confirmed the impact of the Chernobyl accident on the female population in puberty.

Fig. 3 demonstrates the leukemia incidence for men and women from age. The irregularity of leukemia in men aged 62.5 years in 2009 year, and a weak irregularity at 52.5 years in 2000 year in this case can be explained by lower resistance of boys in puberty by exposure of radioactive fallout in 1962 year.

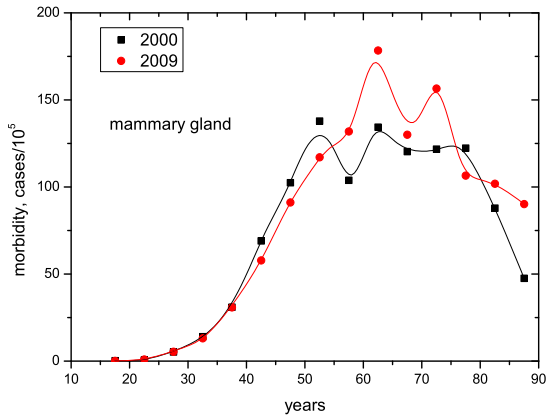


Fig.4. *The incidence of breast cancer in women from age in Ukraine*

Fig. 4 shows the results according to incidence of breast cancer in women from age. The characteristic peaks for the age of 52.5 and 62.5 years in 2000 year and 62.5 and 72.5 years in 2009 year confirming the impact of radioactive fallout in 1962 year on the child's body, followed by induction of the disease.

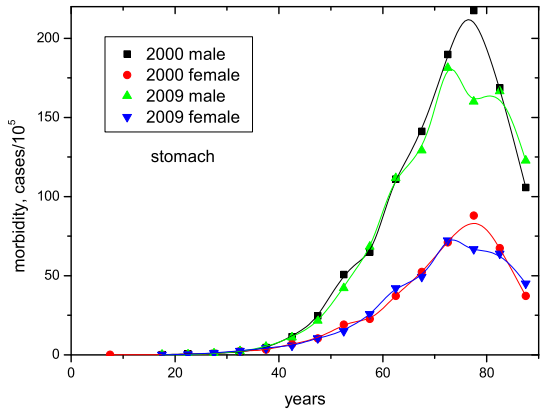


Fig.5. *The incidence of stomach cancer for men and women in Ukraine*

At the same time, the effect of radioactive fallout in 1962 was manifested in the irregularity of stomach cancer in men and women at 52.5 and 62.5 years in 2000 year and 62.5 years in 2009 year (Fig. 5).

Impact of radioactive fallout containing ^{90}Sr and ^{137}Cs in the Dnieper water consumed by the population in different regions of Ukraine you can see in Fig. 6, where were shown the results of the correlation analysis for total cancer rates. High correlation coefficient of overall cancer rates for men and women aged 40-50 years coincided with the period radionuclides fallout in 1962 year. Moreover, there is a strong dependence of the total cancer rates at age 50 from ^{90}Sr in water. Correlation analysis indicators reflect the most pronounced effect of ^{137}Cs on human health at an early age, and ^{90}Sr - later in life, apparently due to a cumulative accumulation of radionuclides in the tissues, which cause both early and late somatic damage. That distant somatic effect of incorporated radionuclides is the development of tumors. There is a high correlation coefficient of cancer rates in men aged 17.5 years from incorporated radionuclides ^{90}Sr and ^{137}Cs in water.

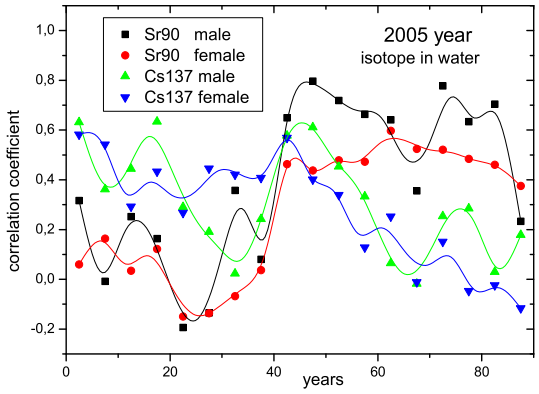


Fig.6. *The correlation between the overall cancer incidence and the content of strontium-90 and cesium-137, depending on age*

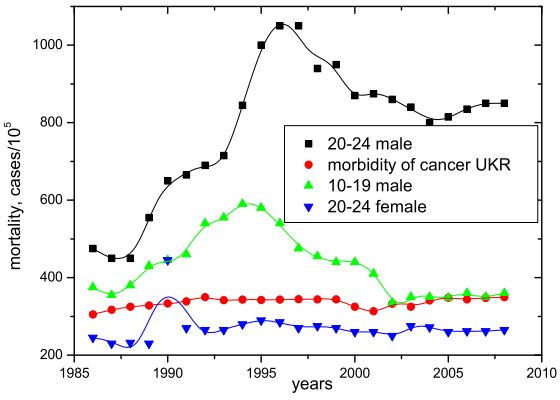


Fig.7. *The mortality selected groups in Kiev*

A similar dependence of the stronger effect of radioactive fallout on the health of the male population at an early age is shown in Fig. 7. Evidence of a car-

cinogenic effect of radionuclides and external radiation sources are one of the major causes of mortality dynamics of selected groups in Kiev [20].

The natural decline in life expectancy in 1996-1997 with increasing doses of radionuclides observed in men aged 20...24 years. This index exceeds the average life expectancy in Ukraine is about 5 times, and for 10...19 year olds - 8 times, in women aged 20...24 years – 4 times.

These data leads to important information: damage during childhood and adolescence due to radionuclide fallout in Kiev in 1986, related to the cumulative effect of which is summed over time, which is the result of the absence or weak expression of the recovery processes for this age group (women, these processes more pronounced due to early puberty).

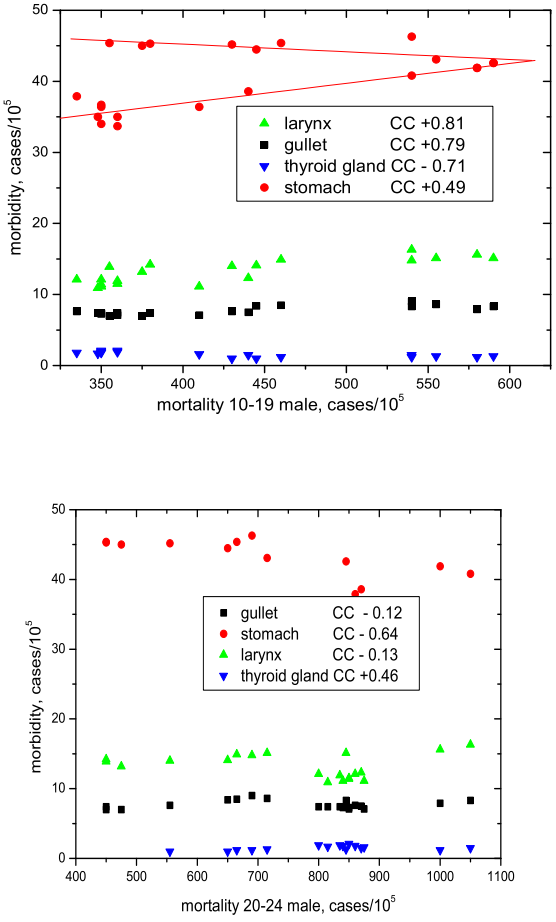


Fig.8. *The incidence of cancer of the esophagus, larynx, thyroid, and stomach according to all deaths in the age 10...19 years (above), and 20...24 years (below)*

The incidence of cancer of the esophagus, larynx, thyroid, and stomach according to all deaths in the age 10...19 years (Fig. 8, above), and 20...24 years (Fig. 8, below) is shown in Fig. 8. The correlation coefficients for these groups change their sign, which may be due to non-specific stimulation of protective and compensatory reactions in these age periods. Dependence on the incidence of gastric cancer mortality in the age 10-19 years decays into two curves, which do not preclude the development of various forms of long-term effects. This fact is confirmed by the following dependencies, shown in Fig. 9, 10.

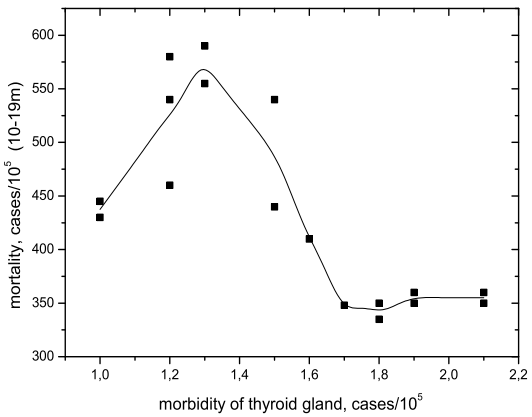


Fig.9. *The dependence of mortality at age 10...19 years from morbidity of thyroid cancer (male)*

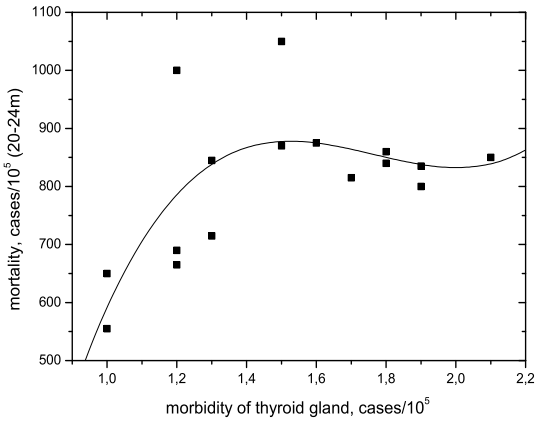


Fig.10. *The dependence of mortality at age 20...24 years from morbidity of thyroid cancer (male)*

The dependence of the mortality of thyroid gland cancer at the age of 10...19 years and 20...24 years are radically different. The dependence of the mortality of aged 10...19 years has a maximum, and at age 20...24 years its rise, ending a plateau. Age and gender influence the induction of benign and malignant tumors of the thyroid gland. The frequency of thyroid gland tumors dominated for women (in average of 4 times). This is due to the hormonal status of women, significant variations in system of pituitary - thyroid gland and secretion of thyroid-stimulating hormone.

Nuclear tests in 1962 year and the Chernobyl accident in 1986 year reveal the influence of incorporated radionuclides on life expectancy in Ukraine (Figs.11, 12). Remote consequences of influence of incorporated radionuclides appear in the mortality of the population in the age of maturity in 2000 year and 2009 year. Leveling the remote radiological con-

sequences for the population in middle age could be attributed to men's addictions (alcoholism, smoking, etc.) [21]. However, the difference for 20 years show an increase in mortality of women, which does not allow to accept such an explanation.

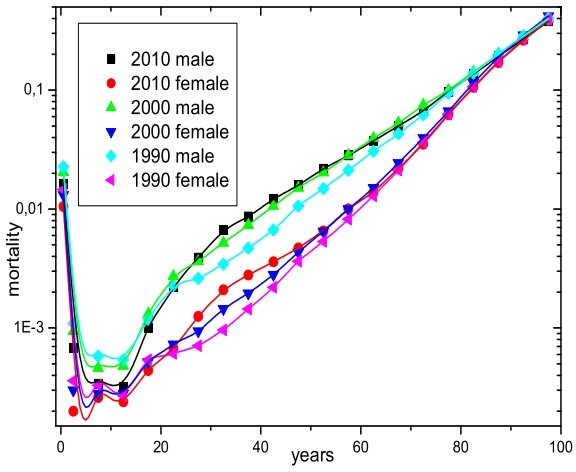


Fig.11. *Ukraine mortality by age*

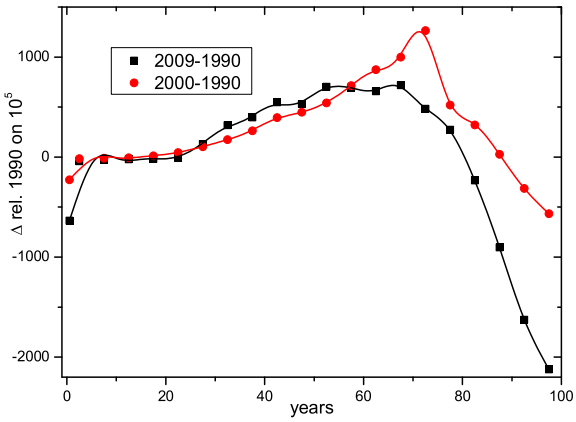


Fig.12. *The difference in mortality rate in Ukraine by age (2009...1990, 2000...1990)*

Fourier analysis of the 20-year difference in mortality finds (first derivative) the presence of two peaks at 12 and 22.5 years (Fig. 13) in men and in women from 10 years (the first derivative) (Fig. 14). The time dependence is caused by impact adverse factors.

Eleven isotopes of iodine are produced during nuclear fission. From a toxicological point of view, the most dangerous of which is iodine-131, which is a β-emitter with $T_{1/2}$=8.05 days. Contribution of iodine-131 in radiation dose rates particularly in the initial period after the Chernobyl accident have been the most significant. Iodine-131 was one of the dominant radionuclide in the mixture for weeks. Due to jet streams at high altitudes significant amounts of radioiodine reach significant areas. Carriers of iodine-131 were submicron particles, the size of 0.3...0.4 microns. These particles are most penetrating into the body.

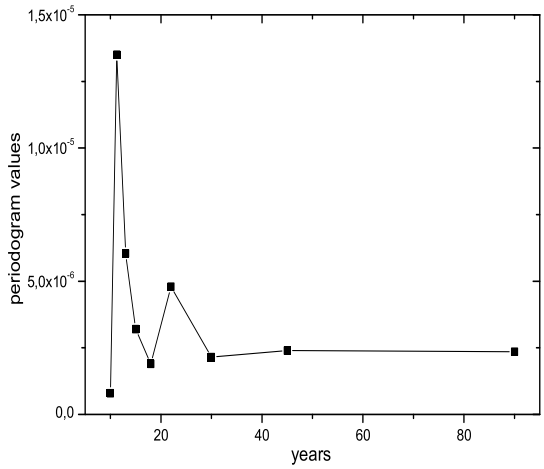


Fig.13. *The spectral density of the first derivative of difference in mortality for men (20 years)*

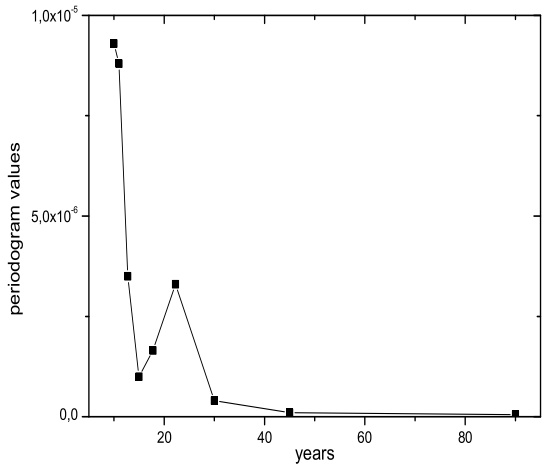


Fig.14. *The spectral density of the first derivative of difference in mortality for women (10 years)*

The morbidity of various proliferative lesions of the thyroid gland for all the regions of Ukraine depending on the average dose of iodine incorporated is shown in Fig. 15. This dependence has an oscillatory nature for women: the incidence increases with increasing doses of incorporated iodine-131; in men - this dependence has a smooth character with a tendency to increase in cases at very low and very high doses.

The thermal and nuclear power plants emit in the atmosphere not only radioactive substance, but also particulates (dust, soot, metals), as well as gaseous substance (carbon monoxide, sulfur dioxide, nitrogen oxides, etc.) - all this creates a burden on the population dose . Emissions of oxides of carbon may reach hundreds of thousands of tons per year and increase the number of human diseases.

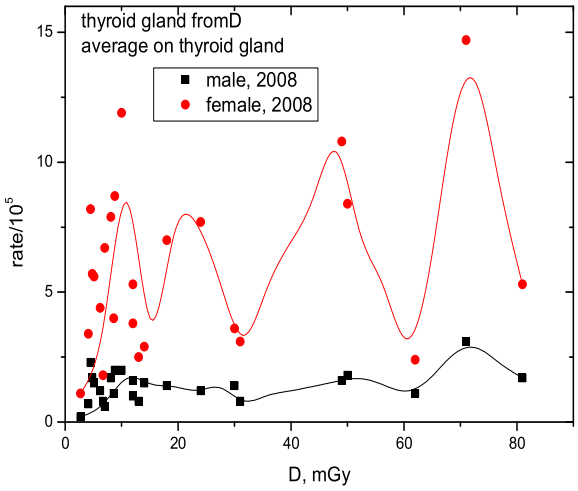


Fig.15. *The morbidity of various proliferative lesions of the thyroid gland for all the regions of Ukraine depending on the average dose of incorporated iodine*

In Fig. 16 shows the morbidity of proliferative lesions of the thyroid gland depending on the concentration of carbon oxides, which are emitted into the atmosphere, along with the products of combustion and metal oxides form a product-carcinogenic benzopyrene. Nature of the effect is similar to the previous one.

Complex relationships involving radiation impact of adverse external factors are presented in Figs. 17, 18. The ratio of thyroid gland cancer rates in men/women in the contaminated areas of Russia is irregular [22] and is largely due to the influence of more extreme air temperature (both positive and negative) [23]. Similar character corresponds to the child mortality in Ukraine.

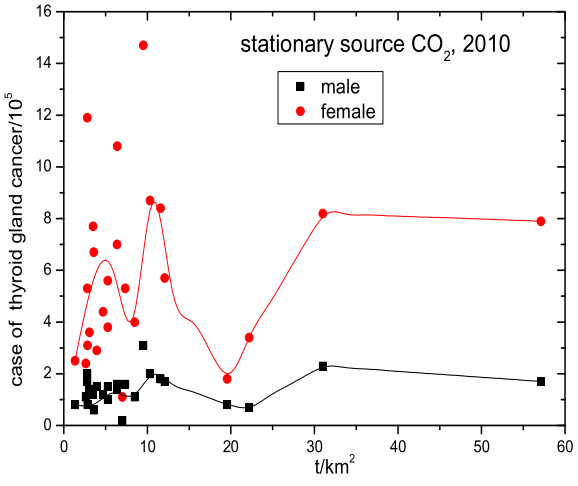
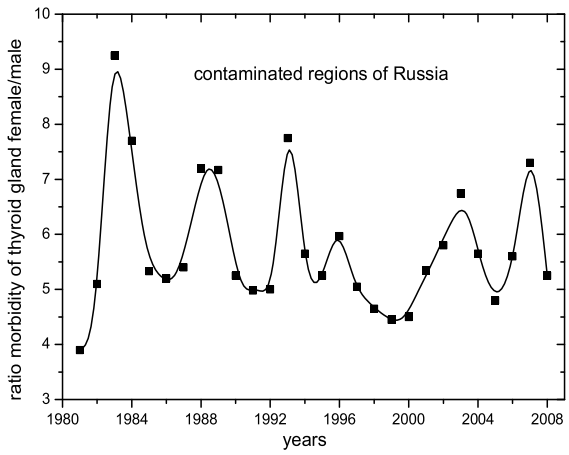


Fig.16. *The morbidity of proliferative lesions of the thyroid gland depending on the concentration of carbon oxides, which are emitted into the atmosphere*



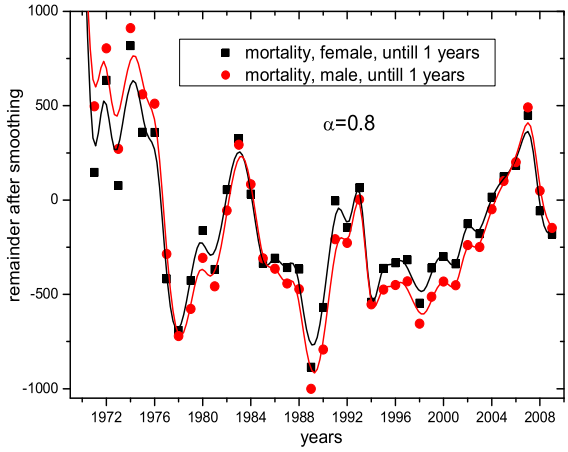


Fig.17. *The ratio of thyroid gland cancer rates in men/women in the contaminated areas of Russia (above). The child mortality in Ukraine (below)*

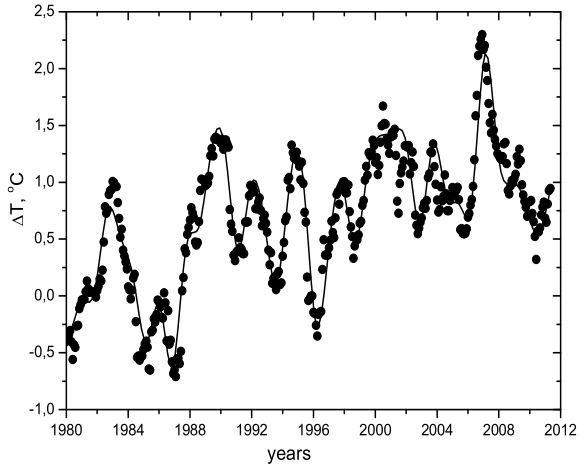


Fig.18. *The change of temperature in Ukraine relative to the average value [23]*

Under extreme ambient temperatures the infant mortality (girls/boys) increased (Fig. 19).

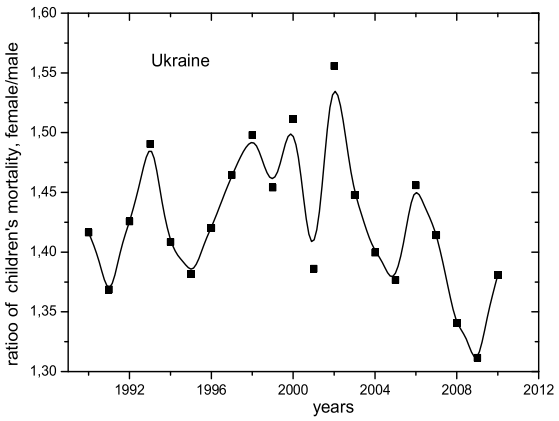


Fig.19. *The ratio of infant mortality (girls/boys) in Ukraine*

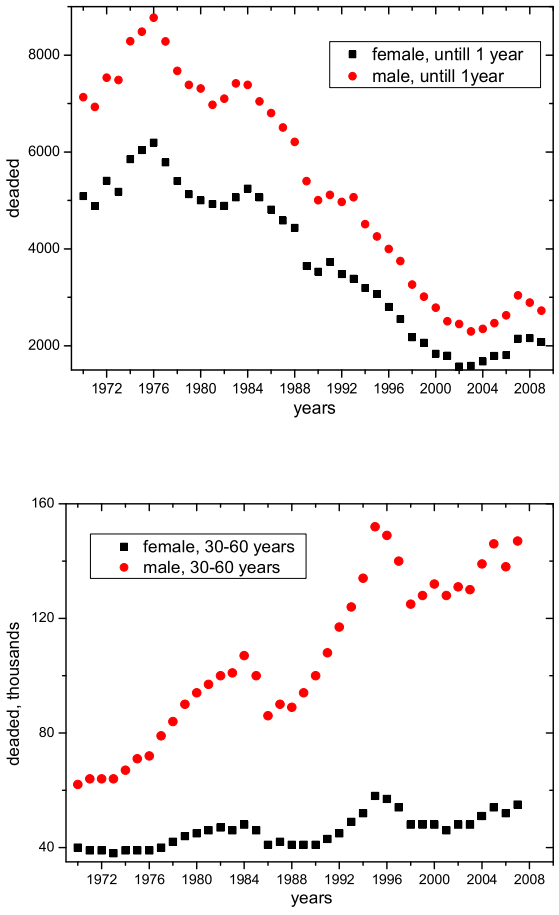


Fig.20. *The dependence of mortality up to one year (above) and aged 30...60 years (below) in Ukraine according to years of life*

All of these researches cannot exclude the influence of psychological factors and social conditions of the population. In Fig. 20 is presents the dependence of mortality up to one year (above) and aged 30...60 years (below) in Ukraine according to years of life [24]. The diametrically opposite dependence of mortality according to age is observed. Seemingly the so-called „difficult years“determine the psychological factor. For middle-aged male population observe steady increase of mortality in Ukraine.

A huge number of publications were devoted to studying the effect of low doses of radiation and environmental factors on the human body [25]. Unfortunately, the common point of view on this problem does not exist. Supporters of the nuclear industry have been arguing about the „positive“effects of radiation on human health, „green“- the opposite argument. The present studies suggest a multifactorial nature of the influence of ionizing radiation and its various effects on the human body. The influence of concomitant factors (pollution, temperature, specific agrochemical pollution with pesticides, herbicides, improper use of fertilizers, pharmaceuticals, etc.) can enhance or to reduce the effect of radiation, depending on the intensity of exposure.

Radiation and chemical mutagens which accumulate in the biosphere are a danger to gene pool of human. Realization of „adaptive response“of the body to the action of various pollutants usually is accompanied by decrease radio sensitivity.

Ionizing radiation in most cases has no threshold and shows the dependence from the dose for the reproductive period of life (30 years). Effect of environmental pollutants also shows dependence from the dose. The character of the complex of factors is more complicated.

Monitoring of such total impacts will allow estimating the impact of the chronic low-dose radiation and of environmental factors that lead to negative irreversible processes and create growing threat to the very existence of humanity.

In this regard, preventive measures to reduce exposure to low doses of radiation are caused by a complex of measures. Apparently, the most important event of radiation exposure compensation is to improve the living conditions (food, lifestyle, recreation, etc.). Enhancement of the immune status of the population in the „clean“areas under the influence of radiation (accidents, etc.) deserves attention as well.

4. CONCLUSIONS

1. Effects of radiation in small doses on the human body are characterized by a multi-factor and in most cases is highly carcinogenic activity. Cancer diseases can be caused by the influence not only of radiation, as well as factors such as anthropogenic pollution by chemical elements, pesticides, herbicides, nitrates, precipitation and aerosols, temperature variations, etc. These factors, depending on the intensity of exposure can result in as intensification, so and to reduce the effect of radiation.

2. Revealed different mechanisms of non-specific reactions to the effects of low doses of radiation, as well as the low and the high degree of contamination, according to sex and age.

3. Effect of total effects of low doses of radiation and incorporated radionuclides caused different tumor induction in humans.

4. Priorities of nuclear power to compensate losses of the environment and health of the population of Ukraine which caused by operation of TPS were shown. Environmental monitoring by use of modern nuclear-physical methods of analysis will assess the state of ecosystems and adaptation abilities of individuals sufficiently.

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МАЛЫЕ ДОЗЫ РАДИАЦИИ: ЭПИДЕМИОЛОГИЧЕСКИЕ ИССЛЕДОВАНИЯ

Н.П. Дикий, А.Н. Довбня, Е.П. Медведева

Влияние малых доз радиации исследовалось при помощи эпидемологических данных. Заболеваемость различными раковыми болезнями изучалась посредством корреляционного, регрессионного и частотного анализов. Обнаружено существенное влияние на заболеваемость раковыми болезнями загрязненности воздушного бассейна и радиоактивных осадков в 1962 и 1986 годах. Влияние малых доз радиации на здоровье населения является многофакторным. Поэтому, в зависимости от других неблагоприятных внешних условий воздействие радиации в малых дозах может быть усилено или ослаблено. Такой характер влияния радиации в малых дозах предполагает дифференцированный подход при осуществлении профилактических мер. Особенно это относится к регионам с благоприятной экологической обстановкой.

МАЛІ ДОЗИ РАДІАЦІЇ: ЕПІДЕМІОЛОГІЧНІ ДОСЛІДЖЕННЯ

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Вплив малих доз радіації досліджувався за допомогою епідеміологічних даних. Захворюваність різними раковими хворобами вивчалася за допомогою кореляційного, регресійного та частотного аналізыв. Виявлено істотний вплив на захворюваність раковими хворобами забруднення повітряного басейну й радіоактивних опадів у 1962 і 1986 роках. Вплив малих доз радіації на здоров'я населення є багатофакторним. Тому залежно від інших несприятливих зовнішніх умов вплив радіації в малих дозах може бути посилений або ослаблений. Такий характер впливу радіації в малих дозах припускає диференційований підхід при здійсненні профілактичних мір. Особливо це відноситься до регіонів зі сприятливою екологічною обстановкою.