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Ecology-genetical evaluation of environmental pollution (Heavy metalls, radionuclides) on biota and man

Abstract

By influence of anthropogenic factors is of natural landscape degradation process, less of biota number and links in biocenosis carry out. Environmental factors as pollution have genetical consequences. At the report is showed a research results for more 20 years investigations to evaluation of anthropogenic factors effect on biota and human population.

Key words: anthropogenic, environmental factors, degradation, biota, human population.

Introduction

From 1984 till 1988 were studied species and ecological peculiarities of rodents near the Semipalatinsk nuclear test site (SNTS), Central Kazakhstan. In 1986 we frequently observed aberrant in color morphs of water vole in mountain and forest area of Karkaralinsk. Melanistic forms are homozygous for the recessive allele and they are more resistant to degradation.

Animals with hairdryers spot, on the contrary are less viable and fertile than animals with "normal" genotype. It was also performed cytogenetic monitoring of the population of Kazakhstan (Karaganda, Semipalatinsk, Atyrau, Aktobe regions). The purpose of monitoring is the evaluation of radiation impact and other harmful factors for hereditary apparatus.

In these areas of research were observed various abnormalities in structure of the studied populations of species, including organism (morphology) and genetic (chromosomal) levels. Morphoses were also observed in amphibians and rodents. Frogs are often marked with pathological changes of genetically determined, such as the reduction of the limbs or their elements. They often revealed tumor formation and etc.

Chromosomal abnormalities were observed with high frequency in the moor frog, living in the area of wastewater collection and marsh frog on Bukpa and Sokur Rivers, exceeding those compared to the control at 2-3 times.

In the period of 1993-2000 years were studied the quantitative relationship and the range of structural and numerical chromosome aberrations of 35 people from the same region of Karaganda, adjacent to the Semipalatinsk nuclear test site. Also, surveyed 201 children, including 81 – with perinatal damage to the nervous system, 70 children – from birth defects, 50 healthy children are the control group.

The results of epidemiological and experimental studies are suggested the induction of genomic instability in the offspring of parents exposed to ionizing radiation. This genomic instability is primarily manifested by increased rates of mutation and an increased risk of cancer and other disorders in the offspring.

Gene changes are the main category of mutations, which is known from the literature. So, 50 % of spontaneous abortion is appearance because of dominant mutations. Newborn to 96% of hereditary defect cases is caused by gene mutations. In 4% of cases, there is the action of chromosomal changes in the form of violations of chromosome number or structure [Bochkov NP, NP Kuleshov et al, 1975].

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After the accident at the Chernobyl nuclear power plant was carried out a sample survey of children living in areas near the area. The results indicate a statistically significant increase in individual and group frequencies of aberrant cells and different types of aberrations in the children's age groups, who's living in areas with high background radiation [Shevchenko VA et al, 1989]. As a result of cytogenetic examination of Ukraine's population living in the area of radioactive fallout from the Chernobyl nuclear power plant were found that people significantly increased the incidence of chromosomal aberrations, particularly markers of radiation exposure (dicentrics, ring chromosomes and atypical). It is almost 8 times higher than the reference level for these mutations, accounting for 0.4 and 0.44 per 100 metaphases (control 0.05 per 100 metaphases) [Pilinskaya MA et al, 1993].

Factors leading to chromosomal anomalies a particular importance is attached to ionizing radiation, as all types of radiation induced chromosome aberrations in the germ and somatic cells of humans [Pomerantseva MD et al, 1993]. Japanese scientists have studied the chromosomes in blood leukocytes of people exposed to radiation in the atomic bombings of Hiroshima and Nagasaki Awa and others [1978]. They have shown that chromosomal rearrangements are characteristic of white blood cells of people, even after at least three decades after the explosion. Cytogenetic analysis of white blood cells of people who were exposed was held Sofuni [1997]. It turned out that all the people had irradiated leukocytes, of which more than 10% had chromosomal rearrangements.

Epidemiological and experimental studies suggest induction of genomic instability in the offspring of parents exposed to ionizing radiation. This genomic instability is primarily manifested by increased rates of mutation and an increased risk of cancer and other disorders in the offspring [Khudoley VV, 1994]. Many research scientists have shown that the phenomenon of genomic instability found in the distant progeny of irradiated populations. It is also noted the emergence of different types of chromosomal aberrations in cells and increase the overall level of chromosomal disorders. Antushevich AE et al [1993] found experimentally that prolonged low-intensity radiation is able to cause a significant increase in the number of cells with chromosome aberrations and reciprocal chromosome translocations not only in exposed, but their descendants of the first, and especially – the second generation.

Nowadays, cytogenetics study regularities of a variety of genotoxic agents, and accumulated a great amount of material on the dynamics of output and diversity of types of chromosomal aberrations, the leading cause of formation is considered double DNA strand breaks. Thus, the population living in the region of Semipalatinsk nuclear test site level blood diseases and blood-forming organs at a dose of 90.0 cSv 2-2.5 times higher than in control areas, and a dose of 7,0-35,0 cSv to 1 3 – 1.5. In the structure of diseases of blood and blood-forming organs prevalent iron deficiency anemia, the level of which is irradiated in a dose 90-199,0 cSv 1.5-2 times higher than in the control group.

Along with extensive preventive work among the population to improve nutrition, which is designed to detect mild anemia is essential conduct screening to identify violations at the cellular level and functional changes that define the disease, namely:

– prevent anemia among women and 264,000 children under 5 years in the areas affected by nuclear tests, by improving the knowledge of the pathogenesis of anemia and streamlining supply;

– large-scale prevention of anemia among women and children in the region of SNT – based rational and Nutricia – ferrotherapy;

– study cytomorphometric peripheral blood for anemia of pregnancy to develop early diagnostic and prognostic criteria of anemia and risk allocation;

– analysis of the intracellular mechanisms of anemia of mother and child.

Environmental impact assessment of products of nuclear explosions on the status of the human population and the development of diagnostics, health correction and rehabilitation is a major challenge today. This requires:

• the assessment of the genetic risk of long-term effects of nuclear testing on the gene pool of human populations;

• diagnosis of the physiological state of the body of people who have been influenced by years of nuclear tests;

• diagnosis of the mental state of the body of people who have been influenced by years of nuclear tests;

• rehabilitation of health detoxification using antioxidants.

Nowadays, the state of the ecological system of the Caspian Sea and the coastal zone is characterized as

extremely unfavorable. In the short term, intensive development of oil and gas fields on the continental shelf of the Caspian (Kashagan) may dramatically increase the environmental burden, not only for the Kazakhstan part of the Caspian region, but throughout the area of middle and northern part of the Caspian Sea.

Oil as a pollutant of the environment is an important resource for polycyclic aromatic hydrocarbons (PAHs). PAHs are a broad class of stable in the environment of organic compounds, which are ubiquitous in the marine and terrestrial environments. PAHs containing more than 3 benzene rings tend to accumulate and be retained in the benthos as a result of their low water solubility. PAHs themselves are relatively inert molecules, and it is generally assumed that the toxic and carcinogenic effects of PAHs caused their metabolites. Hence, detection, identification and enumeration of PAH and their metabolites is quite an objective method for assessing environmental risk. Pyrene is always present in the test samples of oil (PAHs), and is a major component that is pyrene, one of the most prevalent PAHs environments. Hence, the definition piren include contamination components in test-objects is an affordable method for assessing the carcinogenic risk of PAHs to the body, the bioavailability and biodegradation of PAH [6, 7, 8].

Aquatic and terrestrial inhabitants (insects) were used as bio-indicators. They were widespread in the study area of the Caspian Sea and Ural River (Fig. 1). The analysis of the ability of aquatic organisms, insects accumulate oils and heavy metals [6, 9].

Objects of research: *Nereis diversicoler*, *Abramis brama*, *Hybomitra piculiaris*, *Dr.melanogaster*, *Unio pictorum*, *Dreissena polymorha*.

Also carried out determination of heavy metals associated oil in marine worms (*Nereis diversicoler*), the results of which are shown in Table 1.

Table 1 – Concentrations of heavy metals in marine worms – species *Nereis diversicoler* (2009)

Sample	Weights, g	Cu, mg/kg	Cd, mg/kg	Pb, mg/kg	Zn, mg/kg	Fe, mg/kg	Ni, mg/kg	Sr, mg/kg
Fixed *Nereis diversicoler*	0,87	6,8	0,098	92,18	30,02	350,71	3,15	7,02

As follows from the table the greatest ability to accumulate in the body polychaetes showed iron, lead, zinc and copper. Our research has shown that the evaluation of marine worms (Nereis diversicoler) as a test object the most sensitive and reliable method is the analysis using high performance liquid chromatography with fluorescence and UV detectors.

Methods of sample preparation for chromatography of polychaetes generally developed and reproduced by us. The resulting sediment is mixed with pyrene by adding the necessary amount of pyrene dissolved in a minimum amount of acetone and mixed in the liquid portion of sediment and artificial seawater. Sediment mixed with pyrene on an automatic mixer, continuously for 5 hours.

Then, after the sediment is deposited, water decant, and cooked sediment exposed at 5 º C for one week prior to use in the experiment. What's marine worms are kept in the sediment for five days. Worms then taken out of the sediment retained in sea water to clean the bowel, at least 4 hours prior to extraction.

Preparing samples of intestinal tissue, which is weighed and transferred to a test tuba. In the presence of methanol, the sample is homogenized, sonicated (10 min) and centrifuged (3000 r / min, 5 º C, 10 min) to precipitate particles of intestinal tissue. The supernatant was filtered and transferred to vessels for high performance liquid chromatography (HPLC), ie HPLC with fluorescence and UV detectors to determine the metabolites of pyrene. The results are shown in Tables 2 and 3.

Table 2 – Content of benzopyrene in tissues of *Nereis diversicoler* from the northern coastal area of the Caspian Sea

Object	Content of benzopyrene, µg/kg	X_{av}, µg/kg
Nereis diversicoler	1,20	1,084
Nereis diversicoler	1,01	
Nereis diversicoler	1,04	

Table 3 – Content of benzopyrene in tissues of mollusks from the coastal zone of the northern Caspian Sea

Object	Content of benzopyrene, μg/ g	X_{av}, μg/kg
Unio pictorum	1,03	1,084
Unio longirostris	0,09	
Unio pictorum	0,02	

Progressive impact of anthropogenic factors on natural populations of animals and plants requires a detailed environmental-genetic analysis. In assessing the state of natural ecosystems play an important role small mammals. We therefore conducted this study to assess the mutagenic potential danger of pollution by oil, oil products and heavy metals, using as a test object, natural populations of the great gerbil (R. opimus). In particular, the studies conducted to assess the genetic risk of petroleum, petroleum products and heavy metals in trophic food chains in natural communities of rodents in the «oil-soil-plant-animal». As noted by Anderson (1985), the power supply is useful for analyzing the structure and functioning of ecosystems.

In all investigated areas Zhyloysk area plants S.nitfraria, T.sibirica have the highest cumulative and sustained ability to heavy metals. These species may well be used as bio-indicators of environmental pollution with heavy metals.

High metal content in the studied areas of oil-contaminated areas of Atyrau region, may be the result of saturation of the lower horizons of the soil or associated with ore-bearing deposit of oil and gas sectors.

According to the literature, in the oil-contaminated plants ecotopes in natural populations lead level exceeds the background values of 2.5 to 5 times, and in our studies in the oil fields and in the vicinity of the road level lead concentrations exceed the range of 1.65 to 13 , 8 times.

As A.B.Bigaliev noted earlier (1986), screening methods for the study of biological systems of rodents to determine mutagenic substances environment allow for the induction of genetic alterations in the cells of small mammals in vitro and in vivo. Frequency of cells with chromosomal aberrations in the bone marrow of rodents is an important characteristic R.opimus genotoxic properties of pollution by oil, oil products and heavy metals, and the intensity of mutation. Number of studies on cytogenetic study of natural populations of animals bit. Such an approach to characterize the state of natural populations involves obtaining cytogenetic data for different types of animals to generate information for the spontaneous level violations and assess response to all kinds of negative impacts.

Therefore, the results of the data, we conducted studies to assess the mutagenic potential pollution hazards Tengiz oilfield and Kulsary oil and oil products, using as a test object, the great gerbil (R.opimus), showed that in all four points of the investigated rodents there are changes in both the frequency aberrant cells and the types of chromosome abnormalities. The maximum values of the studied cytogenetic parameters were observed in highly contaminated areas. The oil industry in paragraph Kulsary (well 135) (6,93 ± 1,3)% at t = 3,83; p <0.003 frequency of chromosome aberrations in the bone marrow of the great gerbil exceeds the reference value of 3.9 times. The correlation coefficient between the content of oil and heavy metals in soil, plants, and the frequency of chromosomal aberrations in bone marrow cells R.opimus is r = 0,97, between the content of oil and heavy metals in soil and plants with a level of chromatid type aberrations r = 0,81 , between the oil and the level of chromosomal aberrations such as r = 0,96. The data obtained, which may, with the increase of chronic oil revenues and associated heavy metals through the diet, in particular, lead increase the frequency of chromosomal aberrations in bone marrow R.opimus.

Identified in this paper, the quantitative and qualitative composition of cytogenetic damage as the distance from the source of pollution in the studied areas indicates the presence of this strong clastogenic effect of oil and oil products, perhaps the sulfur content. The level of genetic damage wild rodents with appropriate extrapolation can be considered as the real maximum mutagenic effect of environmental factors in relation to the people living in these areas.

Thus, it can be concluded that the studied mutagenic agents, heavy metals and oil are not the only reason for the high frequency of chromosomal mutations

R.opimus surveyed areas. It is difficult to say which of these chemicals caused the observed changes. In contaminated areas Zhylyoi district high degree of air pollution and soil carcinogenic and toxic substances causing severe population hepatitis, respiratory diseases and tuberculosis. Deaths from these diseases in 1987 was in the region of 36-37%, and the children – 15-17%.

That, among patients with cancer of the skin, respiratory tract, esophagus, bladder occurs more in people who had contact with the production of oil and oil products. On the studied data for the years 1973-1987. They found that the incidence of malignant tumors in the former was Emba (current Zhylyoy) area – 138.9% to 100 thousand people in Makat – 138.4% when the ratio of Atyrau region was – 195.3%.

The author explains these factors that, in different geographical areas have different rates of incidence of esophageal cancer is 5-6 times higher than in the southern areas of the country.

The data show that oil and petroleum products are highly toxic and complex substances, influence heredity of living organisms. This is reflected in the ecosystem Zhylyoi district of Atyrau region, as well as the entire Northern Caspian: disappear individual genotypes from existing populations of species of plants and animals. Each year, the transgression and regression of the Caspian Sea affect the vast coastal landscape. Therefore, at present there is a problem of sustainable biodiversity conservation, genetic resources and ecosystems are not only local, but also regional. Given the major environmental threat in the region, such studies are needed not only to assess the condition of natural systems under anthropogenic stress, but also to predict the mutagenic and carcinogenic risks of environmental factors for the people living in these areas.

Thus, the environmental problems of oil and gas complex in Western Kazakhstan, is a serious threat to the Caspian Sea region, the scale and nature of the disaster may cause an unprecedented scale, the damage from which is almost impossible to assess.

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