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Influence of heavy metals on an environment and health of population

The literary analysis of influence of heavy metals is Given on an environment and organism of man. Heavy metals are the basic pollutants of environment of industrial cities. Connections of heavy metals possess high biochemical activity, ability to accumulate in an environment and living organisms. The important role of microelements is educed as catalysts of many biological reactions and pathogenic influence of heavy metals on the organism of man. The basic sources of receipt of heavy metals in an environment are extrass of industrial enterprises and exhausts of motor transport. The high concentrations of heavy metals in an environment can result in the decline of adaptive reactions of organism and development of the sickly states.

Key words: contamination, influence, factors, environment, heavy metals are lead, zinc, cadmium, concentration, level, toxic influence.

The modern economy is characterized by intensive take-off of industry, growing number of road transport, energy and agriculture. It causes significant pollution of the environment, which in its turn affects the state of health of the population.

The complex of environmental factors has an impact on the formation of health among population which is connected with change of social and economic conditions, accompanied by a weakening of control over the quality of habitat, deterioration of demographic situation, changes in the structure of nutrition among population. Analysis of quantitative dependencies in the «Environment – Health» system was worked out within the development of criteria and methods of quantitative assessment of the impact of environmental factors on human health [1–4].

In recent years, prior environmental pollutants of environment in industrial cities are heavy metals; they significantly leave behind such pollutants as oxides of carbon, nitrogen, sulfur and oil products.

Heavy metals is a group of chemical elements with the properties of metals, with significant atomic weight or density, high toxicity, wide propagation in the natural environment, as well as involvement into technogenic cycles. These include more than 40 metals with atomic weight higher than 50 atomic units: V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Mo, Cd, Sn, Hg, Pb, Bi and others. Important characteristics of heavy metals are high biochemical activity and ability to accumulate in the tissues and organs of living organisms having a negative effect on the body.

The main sources of heavy metals in the environment of human are industrial gas emissions and exhaust emissions of road transport. High concentrations of heavy metals and the change of microelement composition of the environment can lead to the so-called technogenic biogeochemical provinces and, consequently, to a violation of protective and adaptive reactions of the organism, the emergence of new pathologic states, the so-called microelementosis.

It is known that imbalance of macro- and microelements in the environment gives the way to the development of diseases which are characteristic for both natural and artificial biogeochemical provinces, as evidenced in the researches of V.I.Vernadskiy, A.P.Vinogradov, V.I.Voynar, G.A.Babenko, A.P.Avtsyn, A.A.Zhavoronkov, A.V.Skalniy, W.Mertz, P.J.Aggett. In the literature, there are numerous data on the relationship of amount of metals in environment and industry and their content in the blood serum. Thus, there is a positive correlation between the content of cadmium in the air, food and its content in the blood [4], the lead content in the air of cities and its content in the blood. During the mining, smelting and processing of non-ferrous alloys, workplace air contains high concentrations of lead and copper, which leads to their higher content in the blood serum [5, 6]. The research of V.L.Suslikov [7] obtained relationship between deficiency of iodine, fluorine, cobalt, zinc and molybdenum in the diet and their content in the blood of population. At the same time, the determination of microelements in human blood suffers from certain disadvantages. Daily and weekly fluctuations in the concentration of microelements may vary considerably, making it difficult to determine their average content. Besides, the concentration of certain microelements is extremely small, and their levels in the blood can be associated both with specific and non-specific biotransformation in the pathogenic processes such as stress, increased physical activity and etc. (metally-dependent enzymes). However, from our point of view, the content of metals in the blood is that stable biological environment which informatively characterizes changes in the balance of microelements in the body.

In the economic space of the CIS Kazakhstan plays a leading role in the production of chromite ore. The leading ones are polymetallic dusts of complex chemical composition and aerosols containing all the main components of ore [8]. Peculiarity of airborne dust of polymetallic mines is that they contain highly toxic metals (Zn, Cr Cu, Pb, Co and etc.). They have significant general toxic, hepatotrophic and carcinogenic effect [9].

Currently, we identified the main or structural elements, whose presence in the living matter is primarily connected with their high content in the biosphere. They are vital for the human body, but their effects should be assessed taking into account the biogeochemical situation in the external environment. Increase of anthropogenic contamination, including microelements, is so serious that it cannot be ignored [10]. Microelements have a significant impact on the homeostasis. It is known that, for zinc, manganese and copper there is no importance how they get into the body (inhalative, alimentary, parenteral). These microelements freely penetrate into the blood and are also selectively eliminated with urine. For other elements (lead, cadmium and etc.) the processes of absorption into the gastrointestinal tract depend on the availability of special media — metallothioneins [11–13]. Hair reflects cell metabolism, as well as any tissue (visceral and ectodermal) as microelements get involved in the proximal end of the growing hair as it exits from the follicle. The principal endogenous sources of microelements in the hair are matrix and the connective tissue of papilla with its blood vessels. The sebaceous glands of the skin make less contribution. They deliver microelements from the body tissues and epidermis. There is no doubt that if the hair is used as biopsic material to assess the effect of microelements of the environment, than the groups, carefully selected for their place of residence, must be compared. As a result, we have proposed this experiment.

Balkhash region is one of the leading industrial regions of Kazakhstan. Environmental situation in Balkhash region is mainly determined by the Balkhash Mining and Metallurgical Plant (BMMP), which is a major source of air pollution, as it accounts for about 85 % of all industrial enterprises emissions of the city [14]. Industrial emissions of this plant contain a large amount of solid dust particles, which contain metals. As the city has no clear boundary between industrial area and the city the soaring urban dust has all the metals presented in industrial dust, such as lead, mercury, cadmium, copper, chromium, zinc and etc. When they accumulate in the body they have a toxic effect.

The studies of M.A.Mukasheva [15, 16] evaluated the degree of accumulation of metals in the organism of experimental animals. The dust consisted of the following metals: lead, zinc, nickel, chromium, copper, beryllium, tin, cobalt, manganese, wolfram, titanium, selenium. The concentration of metals in dust ranged from $3\cdot10^{-3}$–$5\cdot10^{-4}$ %. Dispersity of dust up to 5 microns was 80 %, up to 8 microns — 20 %. Organic part of the dust was a complex composition of the polynuclear alkyl-substituted and humic acids which form chelate compounds with metals. Fluoros showed that the highest concentration of heavy metals were found in the organs, which have a high sorptive activity — kidneys, liver. Thus, the largest content of metals was found almost about all studied elements in the liver. Respectively the control the increase was observed for Ni — 50 times, V — 30 times, Mn — 24 times, Cu — 20 times, Pb — 12,5 times, Zn — 4,4 times and Cr — 1,7 times. In the kidney, the excess over the control was observed for Mn — 315 times; V — 83 times, Cr — 71 times, Cu — 60 times, Pb — 12,7 times, Ni — 12 times, Fe — 8,5 times and Zn — 8,5 times. Copper is accumulated in the lungs, heart and brain more intense than in the liver and kidneys — in 214; 36 and 29 times respectively. Accumulation of Mn, Ni, Pb and Cr in the lungs was observed at 33, 26, 20 and 3 times respectively. Increased accumulation occurs on the same elements and in the heart Pb — 11 times, Mn — 6, 7 — times, Cr — 5 times. The most intensive accumulation of metal in the heart in comparison with other elements had Zn — 36 times. Ni in the heart could not be detected. However, this element had the highest content in the brain, 33 times relatively to control. Such studied elements as Pb, Cu, Mn, Zn, Cr had excess relatively to control at 32; 29; 11; 6; 2, 8 times respectively. Content of Be in animal's organs is considerably less than lead, but because of the strong toxicity of this metal danger is even a small concentration. Accumulation of this element reaches the highest values in the kidneys (2.0 mg / kg).

The nature and level of accumulation of metals in various biological media of human reflects the degree of pollution in the natural anomalous geochemical provinces, and allows us to study technogenic burden [17].

The situation in Kazakhstan causes a complex multi-factorial impact of the environment on human health. It creates necessity to take actions aimed at the adoption of specific solutions to control the status of heavy metals in the environment in the «habitat — man» system [18, 19].

When heavy metals get into the body they accumulate in various tissues and then have toxic effects on the body. These substances in small doses have nonspecific effect which is realized through the accumulation of asymptomatic changes in tissues and organs, and manifest quickening and complications of somatic pathology. Informative diagnostic indicator for this is the study of heavy metals in biological media.

By us revealed that shaft miners had excess in: lead 2.4 times, copper 2 times, zinc 1.9 times, manganese 4.2 times; stope miners — lead 2.6 times, copper 2.1 times, zinc 1.5 times and manganese 4.2 times; scrapermen and crushers — lead 2.3 times, copper 1.8 and 1.4 times, zinc 1.3 and 1.5 times and manganese 1.7 times in comparison to the control group.

Various data exist in the literature on the content of chromium in human blood and its distribution between plasma and erythrocytes. It is known that the concentration of chromium in the organism of people, unlike the other elements, decreases with age. However, having studied the content of chromium in the whole blood by the method of quantitative spectral analysis at a parallel study with atomic absorption method, we found a higher concentration of this element in the control group and the examined workers, compared with the present standard for whole blood — 4.7 mg/dl. [20]. Biological role of chromium is studied very poorly. Is not known, does any organ fulfill specific function of the accumulation and release of «metabolically reactive» chromium. According to the definition «metabolically reactive» chrome of blood is the fraction, the concentration of which is growing rapidly in response to elevated levels of glucose and insulin. It is believed that this additional release of chromium is reacted with an increased amount of insulin secreted in response to glucose, and enhances the action of the hormone on insulin receptors of cells which are sensitive to insulin. At the same time, taking into consideration the structure of the atom of chromium, its close position in the periodic table of elements to such element as manganese (its biological activity is examined more) it gives reason to believe that chromium is not indifferent and plays some certain role in the life of manganese as it is known that chromium relates to metals with mixed valence, particularly active in complexation. Watching high levels of chromium in the blood of the control group and examined the underground workers we can assume that there is biochemical process which is closely linked with the place of residence, i.e. biogeochemical province is forming and chromium from environmental objects comes into the chain soil-water-plant — a man.

Manganese with optimum dose affects the absorption of copper in the body; it can form complexes with copper and make it unavailable to the organism. That may lead to a decrease of concentration in the blood that we observe in the studied groups. A study of the control group and the workers, in particular drivers of scraper hoist revealed reduction of zinc in the blood within the lower limit of norm of set values (100 to 680 mg/dl).

Thus, the studied workers have marked changes of microelement spectrum of blood. It is manifested in the accumulation of chromium in the blood, which can be a factor of «risk» in violation of the health of workers. The accumulation of chromium among the studied individuals is apparently associated with living in the conditions of technogenic biogeochemical province.

Extensive epidemiological studies are conducted around the world to assess the impact of adverse environmental factors on the health of population. One of the criteria of these researches was to determine the levels of metals in biological substrates of the population. In Kazakhstan, work on the study of metal contamination of environmental objects is held for a long time and it usually deals with inspection of industries related to working conditions in the workplace. Work on survey of child population was not carried out. Thus, the problem of determining the concentrations of metals in biological material among children and non-professional population in Kazakhstan is radically new.

Therefore, we analyzed the number of research papers studying the content of metals in biological environments of children living in areas with varying degrees of environmental well-being.

The content of lead in the soil generally ranges from 0.1 to 20 mg / kg. Lead negatively affects the biological activity in the soil, inhibits the activity of the enzymes decreasing the emission of carbon dioxide and the number of microorganisms. Lead accumulates in the earth's crust not only due to its melting out of mantle, but also as a result of radioactive decay of isotopes of uranium (^{238}U, ^{235}U) and thorium (^{232}Th). The weathering of rocks makes the cations of lead release, most of them are absorbed by highly dispersed clay particles and hydroxides of iron, and less goes into the ground water. As part of the sediment, as well as in the form of organic compounds, simple and complex ions the lead is removed with river flow and deposited mainly in the deltas and narrow coastal strip of the shelf. A small amount of lead that enters the ocean precipitates through biofiltration of sea water by the organisms of plankton. Thus, the ocean is the global accumulator of soluble forms of lead.

On land the lead is absorbed by plants. During the fires a considerable mass of element enters the atmosphere (in the form of smoke). In addition, lead is contained in the highly-dispersive mineral dust. «Lifetime» of lead-containing aerosols is about 7 days.

Annual production of lead significantly exceeds the removal of soluble forms and annual vegetation capture of this element. Technogenic scattering of lead, in contrast to the scattering of gaseous substances, does not cover large areas. It is mainly concentrated along highways, which is connected with the use of tetraethyl lead as antidetonator of motor gasoline.

There are many mineral deposits, rich in lead, and the metal is easily released from the minerals. In total there are more than one hundred lead minerals. The main of them are — galena (lead glance) PbS and products of its chemical transformations — anglesite (lead spar) $PbSO_4$ and cerussite («white lead ore») $PbCO_3$. Less common are: pyromorphite («green lead ore») $PbCl_2 \cdot 3Pb_3(PO_4)_2$, mimetite $PbCl_2 \cdot 3Pb_3(AsO_4)_2$, crocoite («red lead ore») $PbCrO_4$, wulfenite («yellow lead ore») $PbMoO_4$, stolzite $PbWO_4$. The lead ores often also have other metals — copper, zinc, cadmium, silver, gold, bismuth and etc. The soil, plants and water deposited by lead ores enriched with this element (up to 1 % Pb).

The enrichment of lead ores consists of such steps as dry grinding, wet grinding, screening, enrichment on concentration tables and flotation. Methods of grinding depend on the ore characteristics. Before pulverizing ore gravity separation is carried out. It gives raw concentrate of galena which is suitable for further enrichment and separation from minerals of zinc by flotation method. (Flotation method was originally developed just for this.) The finely pulverized ore is poured with water, and the mixture is stirred with compressed air in the tank with adding to it a small amount of certain chemicals and pine oil (turpentine). Galena foam is formed on the surface and waste rock settles to the bottom. Foam is discharged from the tank and dried.

Lead and other metals, if they are present, are converted to the oxides forming sulfur dioxide. To suppress the growth of the accretion of iron oxide (on the walls of the mine) and to form slag we add flux — usually dust-like high silica rock (instead of it we can add powdered limestone or dolomite). The most advanced technology of direct smelting in flash roasting furnace is the process of oxygenic weighted electrothermal smelting of lead and zinc concentrates (OWETS LZC), developed in the Soviet Union. The largest furnace of such type in the West works since 1987 in Porto Vesma on the island of Sardinia. Initially, the process of OWETS LZC was developed as the technology to smelt a mixture of bulk concentrates of various ores in a cyclone. A typical furnace of such kind can melt 120–130 thousands of tones of concentrate a year with loading about 600 tons per day and produce 80–90 thousand of tons of crude lead per year containing up to 97 % of lead.

A significant increase in the content of Pb in the environment is associated with the coal burning, the use of tetraethyl lead in motor fuel, as well as waste water of ore-dressing, some metallurgical and chemical industries. The groundwater lead concentrations rarely reach several tens of mg/l. The acidic waters of ore it is tens to hundreds of mg/l, only chloride thermal water sometimes reaches a few mg/l. Pb is highly toxic, it is accumulated in the bones, liver, and kidneys. MPC of lead for drinking water is 0.03 mg/l.

Lead is mainly used in the manufacture of car batteries and addictive agents of tetraethyl of lead for gasoline (in recent years the use of toxic lead additives is reduced due to the restrictions on the use of ethylated gasoline). About a quarter of produced lead is spent on the needs of building, communication, electrical, technical and electronic industry, manufacture of armament, dyes (white lead paint, red lead and others), lead glass and crystal and ceramic glaze. In addition, lead is used in the ceramic industry to produce typographic fonts, in antifriction alloys as ballast loads or weights; tubes and containers for radioactive materials are made of it. Lead is the basic material for protection against ionizing radiation. Most part of the lead is reused (exception is glass and ceramic products, chemicals and pigments). Therefore, the need for lead can be covered to a large extent due to the processing of scrap metal.

Lead enters the body via the gastrointestinal tract or the respiratory system, and then it is carried by the blood throughout the body. And inhaling lead dust is much more dangerous than the presence of it in food. The city air lead levels on average are from 0.15 up to 0.5 mcg/m^3. Areas with ore processing enterprises the concentration is higher [21].

Lead is a toxic metal. It refers to conditionally essential elements. It is a part of a highly specialized group of elements that «works» not with all species of organisms. Lead is a biogenic element.

Lead is accumulated in the bones, partially replacing calcium in phosphate $Ca_3(PO_4)_2$. When it penetrates soft tissues — muscles, liver, kidneys, brain, lymph nodes, lead causes disease called plumbism. Like many other heavy metals, lead (in form of ions) blocks the activity of certain enzymes. It has been found that their activity is reduced for 100 times with increased concentration of lead in blood for 10 times — from 10 up to 100 micrograms per 100 ml of blood. It causes anemia; hematopoietic system, kidneys and brain are damaged; intelligence is reduced. Sign of chronic poisoning is gray border on the gums, a disorder of the nervous system. Lead is especially dangerous for children, because it causes a delay in development. At the same time, tens of millions of children worldwide under the age of 6 have lead poisoning; the main reason is when the paint containing lead gets into the mouth. Antidote can be calcium salt of ethylene diamine tetracidic acid. Inside the poisoned body calcium is substituted by ions of lead, which are held in this salt very durable and are displayed in this form.

Lead can be easily ingested by drinking water, if it was in contact with the metal: in the presence of carbon dioxide the soluble hydrocarbonate $Pb(HCO_3)_2$ is slowly transferred in solution.

Excessive concentrations of metals can cause serious changes in the metabolism and disruption of metabolic processes, thereby reducing non-specific resistance of the organism, leads to disruption of allergic and physical status, and, consequently, to a violation of the functions of various organs and systems. Under the influence of metal hematopoietic process is damaged, which in its turn leads to an increase of immune deficient state in the body.

Under the action of toxic metals in varying degrees, cardiovascular, excretory, digestive, endocrine, immune and hematopoietic systems suffer. However, with all the polymorphism of toxic effects each metal is characterized by the greatest defeat of one of the above mentioned systems.

Lead in contact with the human body interacts with the sulfhydryl groups of proteins and blocks various enzyme systems. Lead is toxic for the central and peripheral nervous system, it is capable of accumulation in the body, especially in bone tissue. Correlation method established the relationship between levels of lead and cadmium in the hair of students and their intellectual development. Lead exposure leads to the defeat of the renal tubules, accompanied by proteinuria and glucosuria. In the future, this leads to a deficiency of vitamin D and parathyroid hormone, to a violation of calcium metabolism in the body and causes the subsequent systemic lesion of bone tissue — osteoporosis and osteomalacia. There is evidence that an imbalance of lead in the body can predict tumor cell growth.

It was revealed that the concentration of lead and copper varies in a narrow range of from 2.6 to 5,2 mcg/g and from 10.1 to 14, 1 mcg/g respectively. Zinc has the following limit of variability — 91.7 up to 147 mcg/g. In the available literature there are data on content of lead, copper and cadmium in the hair of children living in ecologically-poor areas.

It is educed by us the concentration of lead in the hair of children in Karaganda is almost equal to the concentration of lead in the hair of children in Saint-Petersburg, which are part of the risk group of the city. The content of zinc and copper in the hair of Karaganda children living in the industrial area is increased for 1.5 and 1.6 times respectively, in comparison with a relatively clean area of the city. The question of the natural content of lead and other metals in biological material is a subject of dispute at the present time. It is considered that considers the physiological norm of lead in the hair of children of preschool ge as 9.8 mcg/g. The literature cited as a physiological norm of lead and other amount — 2 mcg/g. World organization IAEA offers the amount equal to 9.17 mcg/g. WHO recommends the allowable concentration of lead in the hair up to 8 mcg/g. It's hard to say what number is more accurate and whether it is justified.

According to the results of work contained in the summary report of the international group of experts (WHO), the most informative bio-substrate at lead action is blood.

According to the literature, the natural content of lead in blood of children must be a concentration within the 10–20 mcg/dl. According to American doctors, the content of lead in children's blood should not exceed 30 mcg/dl; according to Russian researchers the average content of lead in children's blood for cities with low levels of lead in the environment is close to the 10 mcg/dl. In a city with high levels of lead in the environment, this level may be exceeded by almost half and is 18,9 mcg/dl. The content of manganese in the blood is quite different, and allowed up to 4 mcg/dl. But the number of 0.05 to 0.8 mcg/dl is considered as a natural concentration in blood. The manganese content in the blood of Karaganda children is within the physiological values. If we take into account the proposed reference limits of zinc and copper in the blood of children established by the countries of the European Community then the content of zinc in the blood of the investigated children is higher by almost 2.5 times, and the concentration of copper in the blood is reduced by 2 times.

Elimination is the final step of metal toxicokinetics in the body and carries specific information on possible factors affecting toxicokinetic processes in the body, regardless of the level and routes of metal penetration. The excretion with the urine can serve as a good diagnostic test of their effects on the body. The established increase of urinary excretion of zinc and copper for 4 times, and lead for 3.6 times.

In spite of the fact that on an environment and health of population plenty of works is devoted the study of influence of heavy metals, however, many information of protivorechivye and require further more careful study.

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Ауыр металдардың қоршаған ортаға және халықтың денсаулығына әсері

Мақалада қоршаған ортаға және адам ағзасына ауыр металдардың әсері туралы әдебиеттерге шолу жүргізілді. Ауыр металдар өндіріс қалалардың қоршаған ортасының негізгі ластаушылары болып табылады. Ауыр металдардың қосындылары жоғарғы биохимиялық белсенділігімен, яғни қоршаған ортада және тірі ағзаларда жинақталуымен сипатталады. Биологиялық реакциялардың катализатор ретінде микроэлементтердің маңызды рөлі және адам ағзасына ауыр металдардың әсері анықталды. Қоршаған ортаға ауыр металдардың түсу жолдарының негізгі көзі — өндіріс өнеркәсіптер және көліктердің шығарындылары. Қоршаған ортада ауыр металдардың жоғарғы концентрациялары ағзаның бейімделу реакциясының төмендеуіне және аурулардың дамуына әкеледі.

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Влияние тяжелых металлов на окружающую среду и здоровье населения

Дан литературный анализ влияния тяжелых металлов на окружающую среду и организм человека. Тяжелые металлы являются основными загрязнителями окружающей среды промышленных городов. Соединения тяжелых металлов обладают высокой биохимической активностью, способностью накапливаться в окружающей среде и живых организмах. Выявлены важная роль микроэлементов как катализаторов многих биологических реакций и патогенное влияние тяжелых металлов на организм человека. Основными источниками поступления тяжелых металлов в окружающую среду являются выбросы промышленных предприятий и выхлопы автомобильного транспорта. Высокие концентрации тяжелых металлов в окружающую среду могут привести к снижению приспособительных реакций организма и развитию болезненных состояний.

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