International Journal of BioMedicine 4(3) (2014) 179-181

INTERNATIONAL JOURNAL OF BIOMEDICINE

PUBLIC HEALTH

Imbalance of Macro- and Micronutrients in the Environment and Biosubstrates of Residents Living in the Diamond Mining Region of Yakutia

Natalia V. Borisova, PhD*; S.V. Markova; Palmira G. Petrova, PhD, ScD

Medical Institute of North-Eastern Federal University named after MK Ammosov Yakutsk, Russian Federation

Abstract

The ecological model of modern medicine has acquired a new quality and has become one of the leading models. In this regard, the establishment of ecological and biogeochemical determinants of health is a real problem. Along with the socio-economic and environmental-demographic challenges of the North development, the health issue takes a crucial place. The Yakutia population has been exposed to a number of adverse natural factors, as well as anthropogenic factors. Because of this, the environmentally induced morbidity is significantly increased, which leads to pathology of the major functional systems.

***Keywords**: health; ecology; macro- and micronutrients.*

State of the Problem

Human adaptation to climatic factors is characterized by a tension in the regulatory mechanisms and manifested, in particular, in the changes in the structure of biological rhythms of the different functional systems. The regular and recurring changes in environmental conditions (seasonal fluctuations in light, temperature and humidity, the geomagnetic field, and others) are responsible for the body's ability for "preventative response." At high latitudes, the seasonal changes in the environment have a significant impact on the dynamics of physiological and biochemical processes. The seasonal changes in the environmental conditions modulate the functional status, the level of physical performance, and the state of adaptive capacity [1-4].

Currently, the negative anthropogenic impact factors, including excessive intake of heavy metals, deficit of essential chemical elements and adverse climate-geographic living conditions of large parts of Russia, contribute to reducing health at the individual and population levels, and in some regions to increase the depopulation processes. Changes in intake of macro-and micronutrients and their imbalance in the diet directly affect the activities of the body and can affect its resistance and, consequently, the ability to adapt [1,5].

The Republic of Sakha (Yakutia) is the largest subject of the Russian Federation; Yakutiaa occupies 3.1 million km^2 or nearly one-fifth of Russia. The distance between the extreme points from north to south is about 2,000km and from west to east up to 2300km. Yakutia is located in three time zones ahead of Moscow time by 6, 7, and 8 hours [6-8].

Permafrost formed during the ice age is spread throughout Yakutia. The size of permafrost rocks reaches 300–400m and more than 1500m in some places of Vilyuy River. About 40% of the territory lies above the Arctic Circle. Limiting factors for the human body in the extreme conditions of Yakutia are both climatic and man-made [9].

The climate of Yakutia is sharply continental. Yakutia is the only region in the world where the amplitude of the air temperature oscillations exceeds 100°C. The average annual temperature varies from -16 °C to +10°C. The period with temperature below zero lasts 6–7.5 months (October–April). The average temperature in January in the southwestern area is -26 °C, in the northeast, 38°C, and in the east along Vilyui River up to -40 °C. Minimum temperatures up to -55–65°C are common here. In the territory of Yakutia, in Oymyakon, the Northern Pole of Cold is located, where a temperature -71.2°C has been recorded. Summer temperature is strongly dependent on topography and altitude. The average July temperature in the north is +12°C and +20°C in the south. With the arrival of

***Corresponding author:** Natalia V. Borisova, PhD. Medical Institute of North-Eastern Federal University named after MK Ammosov Yakutsk, Russian Federation.
E-mail: mira_44@mail.ru*

warm air masses from the territories of Mongolia and China, the temperature rises to +35-38 °C, and the temperature falls to frost with the invasion of the arctic air masses. Significant variations in temperature during the month as well as during the day are also characteristic for Yakutia [5, 10].

In winter, the low altitude of the sun determines the shortest day of the entire territory of Yakutia; above the Arctic Circle, polar night comes. In summer, due to the relatively high altitude of the sun, transparency and dry air, sunny days are predominant. With the onset of the White Nights, the duration of daylight is 20 hours at the latitude of Yakutsk, and the sun shines all day without going below the horizon in the north.

Yakutia is a unique region of the Russian Federation according to its biogeochemical characteristics. Seasonal thawing of soil is measured from ten centimeters in the north and up to 2–3m in the south. Yakutia soil is characterized by a deficit of calcium, phosphorus, potassium, cobalt, and an excess of strontium, especially in river floodplains. Soils and the *bottomset beds* of the Lena-Vilyui watershed are deficient in copper content, boron and molybdenum; at the same time they are enriched by manganese, iron and cobalt [10, 11].

The bottomset beds, because of their high sorption properties, can be regarded as an integral indicator of anthropogenic impact on the hydrosphere, and their study should occupy an important place in the general system of the water environment observation. Composition of lake and river water generally is characterized by low salinity and low content of fluorine, copper and molybdenum, reduction in the intensity of water migration of zinc, manganese, copper, as well as an increase in migratory activity of tin. Accordingly, in such circumstances, the content of calcium, phosphorus and magnesium is considerably reduced in the local fodder grasses.

The analysis of chemical elements in drinking water from the local reservoirs that residents use in the diamond region showed the presence of high concentrations of Mg, P, Pb, Sn and Zn and low concentrations of Al and Ca. At the same time, a particularly high content of Fe and Mn (66.7% and 44.4% of samples, respectively, exceeded maximum permitted concentration (MPC)) in drinking water, which agrees well with the received data on the prevalence of excessive content of these elements in the hair of the inhabitants of this area. Probably, the drinking water is one of the main sources of these elements in the human body. At the same time, the excess of MPC according to Pb was not noted in any samples, which indicates the existence of other routes of entry into the body for this element.

Quantitative chemical analysis showed no excess of MPC in food. However, the content of most chemical elements in foods from Yakutia was higher than from other regions of Russia. Thus, food is probably not to be regarded as the main sources of toxicants for the human body. It is well known that one of the main routes of entry into the body for toxic chemicals is the way of "hand-mouth." Therefore, the causes of extremely high content of Pb in the body may be associated with personal hygiene and environment.

Our studies indicate the excess of MPC for P, Zn Co, B, Ag, Ti, Pb, and Be (2.6 times) in soils of the Vilyui zone. The concentration of P, Zn, Cu, Co, Cr, V, Ti, B, and Pb in the *bottomset beds* in this region exceeds the regional level that indicates the geochemical anomalies in Vilyui Basin. Thus, in the soil of the Vilyui zone, as well as in drinking water, the MPC for a number of chemical compounds, including heavy metals, is exceeded. Comparative analysis of micro- and microelement composition according to the "soil-water-food-bottomset beds" model indicates the presence of significant anthropogenic impacts on the environment.

To determine the causes of the revealed features for the element status in the exo- and endogenous environment of the Vilyui zone, we analyzed correlations between the elements contained in drinking water, food rations, the bottomset beds and soil samples taken from natural objects and the content of these elements in hair of adults and children (Fig.1).

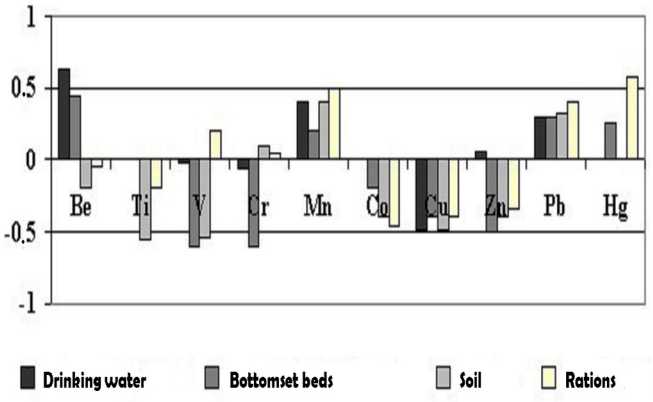

Figure 1. *Correlations between the elements contained in drinking water, food rations, the bottomset beds and soil samples taken from natural objects and the content of these elements in hair of children.*

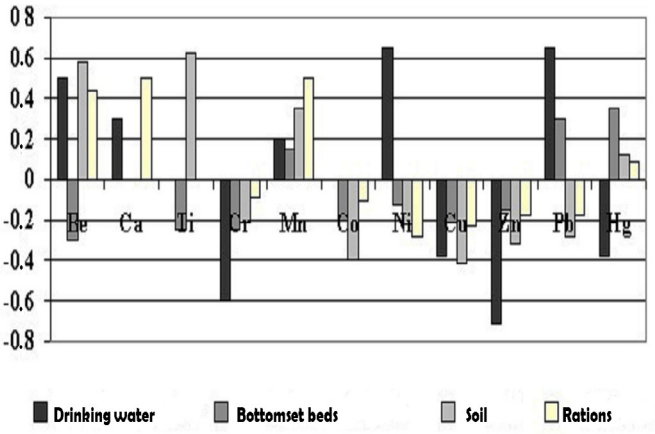

Figure 1. *Correlations between the elements contained in drinking water, food rations, the bottomset beds and soil samples taken from natural objects and the content of these elements in hair of adults.*

The data obtained show (Fig.2) the elevated concentrations of Mn and Pl in hair of adults, which are positively correlated with the content of these elements in drinking water, soil and food, as well as in BB sampled in residences. Low concentrations of the cobalt, zinc and copper in the hair are inversely correlated with the increased levels of these elements in the soil (Zn, Co), in the drinking water (Cu), in the bottomset beds *(Zn)* and diets (Co, Zn, Cu).

We also found a strong direct correlation between the levels of beryllium and potassium in the hair of children and their content in the water, as well as beryllium and vanadium in the soil (Fig.2). Lead and nickel in hair of children had a strong direct correlation with the level of these elements in drinking water, and concentration of titanium correlated with its content in soils and the bottomset beds. Low concentration of copper in the hair of children had an inverse correlation with increased levels of this element in the soil, water and food rations, simultaneously.

Consequently, it is possible to outline some cause-and-effect relationships between the level of micro- and macroelements in the environment and their levels in the hair of the inhabitants of this region. The observed features of the element status in the Vilyui zone is associated with excessive or reduced content of macro- and microelements in drinking water, food and environmental objects. These features may lead to the development of imbalances in the human body and form the specific regional elemental "portrait" of the studied population.

Thus, natural and man-made features of the diamond region predispose residents to the emergence of macro-and micronutrient imbalances. These processes are determined by the chemical composition of soils, moderately mineralized water of river basins and the presence of the anthropogenic troubles relating to the activities of the diamond mining company.

Competing interests

The authors declare that they have no competing interests.

References

1. Agadzhanian NA, Marachev AG, Bobkov GA. Human environmental physiology. M.: KRUK; 1999. [Monograph in Russian].
2. Evteev A, Cardini AL, Morozova I, O'Higgins P. Extreme climate, rather than population history, explains mid-facial morphology of Northern Asians. Am J Phys Anthropol 2014; 153(3):449-62.
3. Ermakova NV. Environmental portrait of a man in the North and questions of ethnic physiology. The X1 International Symposium "Environmental and physiological problems of adaptation". M: Peoples' Friendship University; 2003:183. [Article in Russian].
4. Nilssen O, Brenn T, Høyer G, Lipton R, Boiko J, Tkatchev A. Self-reported seasonal variation in depression at 78 degree north. The Svalbard Study. Int J Circumpolar Health 1999; 58(1):14-2.
5. Agadzhanian NA. Human adaptational physiology and ecology: culture, morality, and spirituality. Fiziol Zh 2011; 57(5):23-5. [Article in Russian].
6. Agadzhanian NA, Petrova PG. People in the North. M.: AGMA; 1996. [Monograph in Russian].
7. Borisova NV, Petrova PG. Ecological-physiological basis in the formation of the functional reserves in the indigenous inhabitants of the Sakha (Yakutia) Republic. Nauka Obraz 2008; 50(2):55-61. [Article in Russian].
8. Nefedov BN. Some ecological and technological risks for the creation of the large hydraulic structures in the north of Siberia. The IX International Symposium on Cold Regions Development. Yakutsk; 2010:42. [Article in Russian].
9. Cepon TJ, Snodgrass JJ, Leonard WR, Tarskaia LA, Klimova TM, Fedorova VI, et al. Circumpolar adaptation, social change, and the development of autoimmune thyroid disorders among the Yakut (Sakha) of Siberia. Am J Hum Biol 2011; 23(5):703-9.
10. Report on the environmental situation in the Republic of Sakha (Yakutia) for 2011. Yakutsk; 2011. (Report in Russian).
11. Petrova PG, Borisova NV. Environment Features and Human Health in the North. IJBM 2014; 4(2):114-116. [Article in Russian].