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The content of radioactive (uranium, thorium) and rare earth elements in the hair of residents of some territories of Kazakhstan

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Abstract

The present article provides data on the content of radioactive and rare earth elements in the hair of residents of Northern (Akmola and North Kazakhstan regions) and South Kazakhstan (Kyzylorda and Turkestan regions), obtained by inductively coupled plasma mass spectrometry (ICP-MS). As a result of the study, the arithmetic mean and the vibration limit of the elements were determined. Comparative data on the average content of radioactive and rare-earth elements in North and South Kazakhstan were carried out. A cluster analysis of the association of elements was also carried out in the study.

Keywords: Hair; radioactive elements; rare earth elements; biosubstrate

1. Introduction

The Republic of Kazakhstan is the world's largest supplier of uranium along with countries such as Australia and Canada. Numerous uranium deposits are concentrated in six uranium ore provinces: Shu-Sarysu province 60.2%; North Kazakhstan 17.3%; Syrdarya 15.2%; Iliyskaya 4.7%; Caspian 1.8%; Pribalkhash 0.8% (Kazatomprom, 2020).

Uranium deposits in Kazakhstan are characterized by a high content of rare metals, gold and rare earth elements (Aimbetova, 2012; Toksanbaev et al., 2019; Karpov et al., 2016). It

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is also possible to use uranium tailing dumps and solutions of underground leaching of uranium ores as a potential source of rare earth elements (Kazakhstan, 2011).

The unique properties of rare earth elements allow them to be widely used in industry, agriculture and medicine (Gwenzi et al., 2018). Active mining and use leads to the concentration of rare earth elements in the environment and their inclusion in biogeochemical processes. Rare earth elements are becoming very important for living organisms, since they are actively concentrated in them (Baranovskaya et al., 2015).

The study of the relationship between rare earth and radioactive elements in living systems is an important aspect in identifying the features of their accumulation in territories with natural and man-made anomalies.

To ensure quality control of the environment, it is convenient to use a human biosubstrate (hair, nails, blood, etc.), which is easy to sample. According to many scientists, this biosubstrate is hair (Baranovskaya, 2003; Pozebon, 2017). In this context, the aim of the study is to determine the level of the content of rare earth and radioactive elements in the hair of the inhabitants of North and South Kazakhstan.

2. Materials and methods of analysis

The residents of North Kazakhstan (Akmola and North Kazakhstan regions) and South Kazakhstan (Kyzylorda and Turkestan regions), who had no pathologies and chronic diseases, were selected for the study and 43 hair samples were taken. Hair was taken from residents according to the standard method (International Atomic Energy Agency, 1980). The method of inductively coupled plasma mass spectrometry (ICP-MS) was used to determine the chemical elements. Sample preparation was carried out at the Department of Geoecology and Geochemistry of the Tomsk Polytechnic University, Russia.

All the results obtained were processed using the Excel and STATISTICA 10 software package.

3. Results and their discussion

The average content and range of fluctuations of chemical elements in the hair of residents of the studied areas are presented in Table 1.

Table 1. Estimated levels of the content of rare earth metals in the hair of the studied population, mg / kg

Elements	South Kazakhstan		North Kazakhstan	
	lim	*Mean±Std Err*	*lim*	*Mean±Std Err*
La	0,002-0,025	0,01±0,003	0,0005-0,1	0,01±0,004
Ce	0,001-0,025	0,01±0,003	0,002-0,2	0,03±0,006
Pr	0,0008-0,025	0,01±0,003	0,0001-0,03	0,003±0,001
Nd	0,0002-0,0075	0,0035±0,001	0,0008-0,1	0,01±0,004
Sm	0,0012-0,025	0,01±0,004	0,0002-0,05	0,01±0,003
Eu	0,0003-0,15	0,02±0,01	0,0001-0,04	0,01±0,003
Gd	0,0002-0,025	0,01±0,003	0,0002-0,04	0,009±0,002
Tb	0,0075-0,025	0,02±0,003	0,00007-0,05	0,02±0,003
Dy	0,0003-0,0075	0,003±0,001	0,0001-0,04	0,007±0,002
Ho	0,0075-0,025	0,02±0,003	0,00006-0,05	0,01±0,003
Er	0,0006-0,025	0,009±0,003	0,0001-0,04	0,01±0,003
Tm	0,0075-0,025	0,02±0,003	0,00005-0,05	0,02±0,003
Yb	0,002-0,025	0,02±0,003	0,0001-0,05	0,01±0,003
Lu	0,00006-0,0075	0,003±0,001	0,00006-0,05	0,02±0,003
Th	0,002-0,025	0,02±0,003	0,004-0,05	0,04±0,001
U	0,07-0,5	0,2±0,04	0,04-1,12	0,3±0,05

Notes: lim – fluctuation limits, Mean±StdErr – arithmetic mean and its error.

By the value of the average content, chemical elements are arranged as follows in descending order:

South Kazakhstan: U> Eu> Tb> Ho> Tm> Yb>Th> La> Ce>Pr>Gd> Sm>Er> Nd> Dy> Lu;

North Kazakhstan: U> Th> Ce> Tb> Tm> Lu> La> Nd> Sm> Eu> Ho> Er> Yb> Gd> Dy> Pr;

As can be seen from Figure 1, in both territories, the concentration of radioactive elements in the hair is noticeable, which is associated with the mining of uranium in the studied areas.

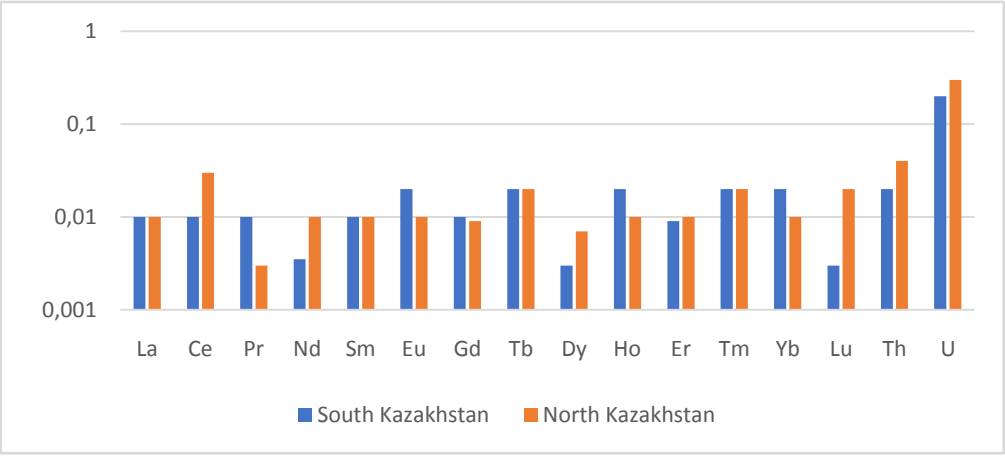

Fig. 1. The average content of rare earth and radioactive elements in the hair of residents of North and South Kazakhstan

Analysis of the average content of rare earth and radioactive elements in the hair of residents of two regions (Fig. 1) made it possible to establish that such elements as Eu, Ho and Yb accumulate to a greater extent in South Kazakhstan. While the inhabitants of Northern Kazakhstan have accumulated the following elements: Ce, Nd, Dy, Lu, Th, U. It is also clearly seen that both regions of Kazakhstan are characterized by a high content of uranium. A possible reason for the high accumulation of uranium on the territory of North and South Kazakhstan may be the uranium deposits and mining enterprises located there.

Cluster analysis of the association of elements on the territory of South Kazakhstan (Fig. 2) showed two large clusters: in the first cluster, the associations Th-Yb-Tm-Ho-Tb-Sm-Pr-Gd-Ce-La are distinguished, with a significant correlation; in the second cluster, the most significant connections are U-Dy-Lu-Nd.

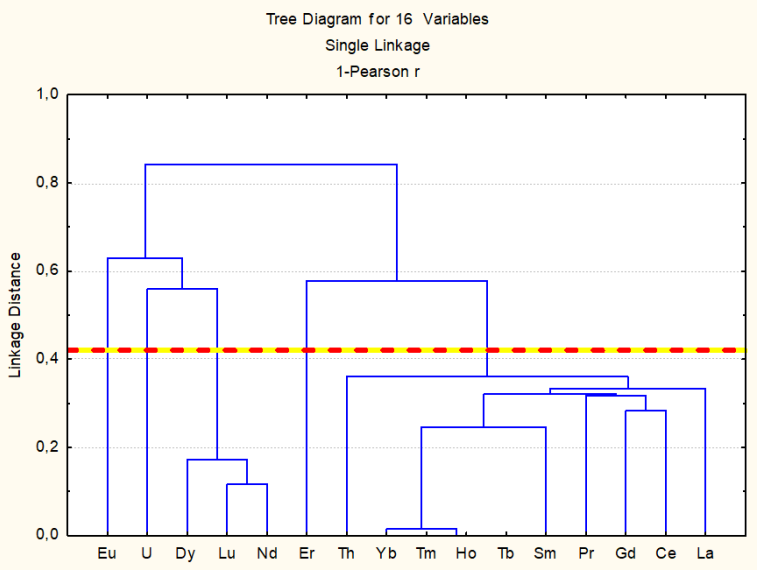

Fig. 2. Dendrogram of the correlation matrix of the geochemical spectrum of uranium, thorium and rare earth elements in the hair of the population of South Kazakhstan (1 - r 0,05 = 0,42; n = 10)

The cluster analysis of the association of elements of the inhabitants of Northern Kazakhstan (Fig. 3) showed four large clusters. The first cluster unites Lu-Ho, the second cluster unites Er-Eu, in the third cluster the most significant bonds have Th-Yb-Tb-Tm-Sm and in the fourth cluster the Dy-Gd-U-Nd-Pr-Ce-La associations are distinguished, with a significant correlation.

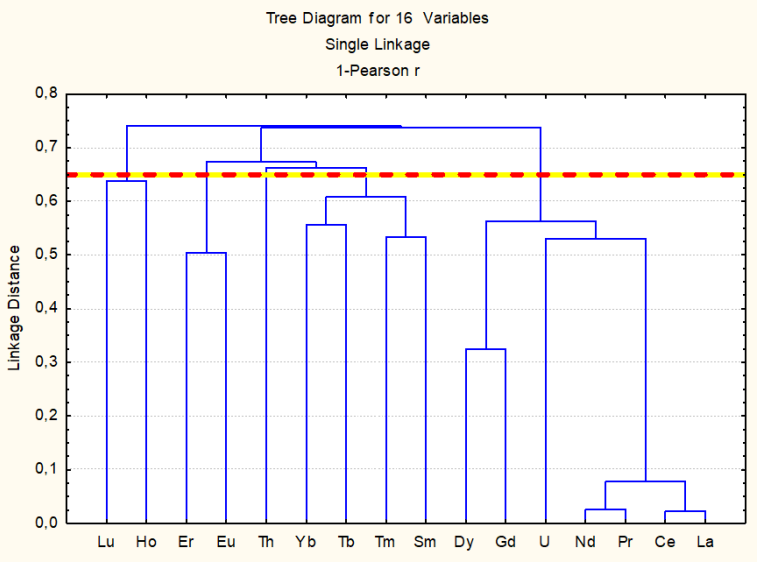

Fig. 3. Dendrogram of the correlation matrix of the geochemical spectrum of uranium, thorium and rare earth elements in the hair of the population of Northern Kazakhstan (1 - $r_{0,05}$ = 0,65; n = 33)

On the territory of South Kazakhstan, cluster analysis showed that radioactive elements correlate to a greater extent with medium and heavy rare earth elements. At the same time, in the territory of Northern Kazakhstan, uranium has a high correlation with light rare earth elements.

The results obtained indicate that radioactive elements (uranium and thorium) have a definite relationship with rare earth elements. This fact can be considered as an indicator of the geochemical situation, which will make it possible to differentiate the studied territories, although additional studies are needed to accurately explain the nature of such behavior of elements.

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