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ScienceDirect

Procedia Chemistry 10 (2014) 454 – 459

Procedia Chemistry

XV International Scientific Conference "Chemistry and Chemical Engineering in XXI century" dedicated to Professor L.P. Kulyov

Mineralogical and Geochemical Characteristics of the Human Body Ash Residue

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Abstract

The article is devoted to the element composition of the human body ash residue of some Russian cities. It presents the element composition of the human body ash residue, the distribution of elements in the ash residue depending on age and sex. The specific elements of different cities, showing the possible influence of the environmental conditions on the element composition of the human body ash residue. The main objective of this paper is to study the element composition of the human body ash residue and determine the regional characteristics. The methods of instrumental neutron activation analysis and inductively coupled plasma mass spectrometry were applied, an electronic microscope being used as a tool. The result of the research is 63 elements identified within in the human body ash residue. The issue is topical as it expands the knowledge of rare and radioactive elements within the human body and contributes to medicine, for example, by identifying the chemical elements to be included in a person's diet.

Peer-review under responsibility of Tomsk Polytechnic University

Keywords: human body ash residue, element composition of human body, ecological impact, rare chemical elements within the human body.

1. Introduction

Although the element composition of rocks, soil, plants is intensively studied by scientists, the element composition of human body is poorly investigated. There is no information about the influence of many rare and radioactive elements on the human health. The list of investigated elements of the human body is confined to a small group of essential or toxic elements. The famous Russian scientist V. I. Vernadskiy wrote in the 30th years of 20th century that the majority of chemical elements would be found within the human body[1]. This forecast turned out to be true and today a lot of scientists believe that the human body comprises all known chemical

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Peer-review under responsibility of Tomsk Polytechnic University
doi:10.1016/j.proche.2014.10.076

elements. Therefore, it is important to get information about accumulation of the elements within the human body and identify their role. We started the research with analyzing accumulation levels of some elements within human body ash residue. The main objective of the paper is to study the element composition of the human body ash residue and determine the regional characteristics.

2. Materials and methods

Ash residue is the crematory material remaining after the human body has been burnt. The cremation technology is the same for all crematories, the temperature of burning is 1200-1400 °C. Ash residue of the human body represents mostly the composition of bones because the bones constitute the greatest part of the human body. Ash residue reflects the composition of organs and tissues as well, though in less amounts. The process of burning leads to loss of some volatile elements, such as Cl, Br, Hg, As, W, etc.

103 samples from different Russian cities were analyzed within the research: St. Petersburg, Novokuznetsk, Novosibirsk, Rostov-on-Don, and Yekaterinburg. All the cities are characterized by high level of industrial development, on the one hand, and environment pollution, on the other.

The methods of instrumental neutron activation analysis (INAA) and inductively coupled plasma mass spectrometry (ICP-ms) were applied, an electronic microscope being used as a tool. As a result, we obtained the data on accumulation of 63 elements in ash residue of the human body. Electronic microscope Hitachi S-3400N with an attachment for microanalysis allowed determining what compounds were made of these elements.

3. Results

There are 63 chemical elements identified by means of INAA and ICP-ms. Some of these elements are accumulated in the narrow range of content, such as some biogenic elements: Ca, Na, Mg, K etc. Little dispersion can be explained by the fact that the human body keeps on supporting homeostasis of macro- and microelements. Other elements are accumulated in a wide range of content (Fig. 1).

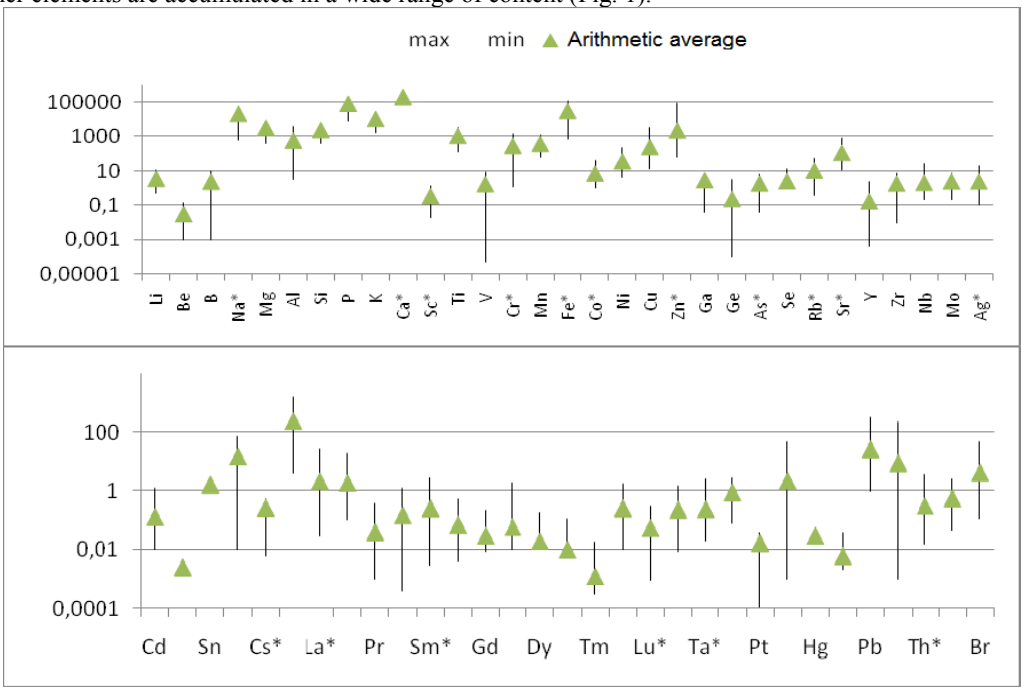


Fig. 1. Accumulation levels of chemical elements in the human body ash residue (mg/kg)

We determined the correlations between elements for the cities of Novosibirsk and Novokuznetsk and obtained some interesting results to specify the ash residue of the human body for Novokuznetsk. The correlation analysis demonstrates that metallurgical industry is the city's priority (Fig. 2). There are Aluminum and Steel plants in Novokuznetsk which actively apply such elements as Fe, Co, Cr, Sc etc.

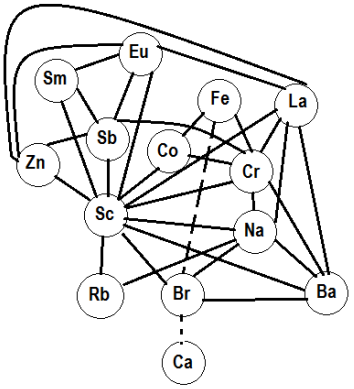


Fig. 2 The correlation diagram of the human body ash residue of Novokuznetsk residents

The next step of the research was to determine the regional characteristics of ash residue of human body for different cities. We pointed out the anomalous values of elements in the ash residue using the rule of Three sigma (3 σ). The values are considered to be anomalous if they are more than the average value plus 3 standard deviations. Thus, we determined the following regional characteristics:

- For Novosibirsk: Co, Ba, Gd, Er, **Au**, Sn;
- For Novokuznetsk: Mg, **Al**, **P**, Ca, Y, Zr, Pr, Nd, Dy, Ho, Er, Tm, **Se;**
- For Rostov-na-Donu: Sc, Cr, Rb, Si, **Zr**, Ag, **La, Ce**, Pr, Nd, Eu, Gd, Dy, Ho, Er, Hf, **Ta**, Pb, **Th**;
- For St. Petersburg: Li, Na, Mg, **P**, K, **Ti, Mn**, Fe, **Cu**, Ga, Mo, Ag, Ce, Sm, **Tb**, Sb, **W**;
- For Yekaterinburg: Na, Rb, **Sr**, **Br**, Zr, Nb, Cd, Ba, Hf.

The elements are given in bold if their concentration in the city is more than ten or hundred times as much as that in the other cities.

Some of the results are predictable and explicable. For example, high concentration of gold in Novosibirsk ash residue can be the result of gold refinery in the city. Aluminium and selenium in the human body ash residue in Novokuznetsk is the consequence of the metallurgical complex including selenium emissions caused by the smelting industry. High concentrations of copper and manganese were found in the ash residue of St. Petersburg as well as in the rivers of the city[2]. High concentration of these elements was noticed in the rivers of other cities as well, however, the concentrations in ash residue of these cities are normal. Strontium and bromine are accumulated in high concentration in human body ash residue of Yekaterinburg residents. This can be caused by the petrochemical plant operations. The significant concentrations of bromine in soil were detected by scientists in other cities with petrochemical industry as well[3].

Unfortunately, concentrations of many other elements are unexpected and difficult to explain. For example, human body ash residue of Rostov-na-Donu residents is characterized by high concentrations of rare and radioactive elements. It has been experimentally proved that the level of radon in buildings is high and the specific activity is more than 200 Bq per m^3. However, radioactive elements in the soil and air were not found, thus, the source of these elements in ash residue is still undetermined.

The last step of the research was to examine human body ash residue by means of electronic microscope. It let us determine the basic elements of the human body ash residue and prove the high concentrations of some elements.

It is a well-known fact that the mineral basis of the human body is hydroxyapatite ($Ca_5(PO_4)_3(OH)$), because this mineral makes up about 50-70% of the bones[4]. Therefore, the basis of the human body ash residue should be such elements as calcium, phosphorus, oxygen and hydrogen. The results of the electronic microscope research proved this fact. The matrix (basis) of the human body ash residue is oxygen, calcium, carbon, phosphorus, as well as the other elements, which also constitute the matrix, but are represented in smaller amounts: sodium, potassium, magnesium (see Table 1).

Table 1. The chemical composition of matrix of human body ash residue

The element	Arithmetic average with error (%)
C	13.6±9.06
O	40.27±2.81
Ca	26.79±7.08
P	10.29±2.31
Na	4.41±0.84
K	1.89±0.65
Mg	1.34±0.54
Total	98.59

The next aim was to find the particles which could prove high concentrations of the elements. For example, gold particles were identified in Novosibirsk residents ash residue and titanium particles were found in the samples from St. Petersburg.

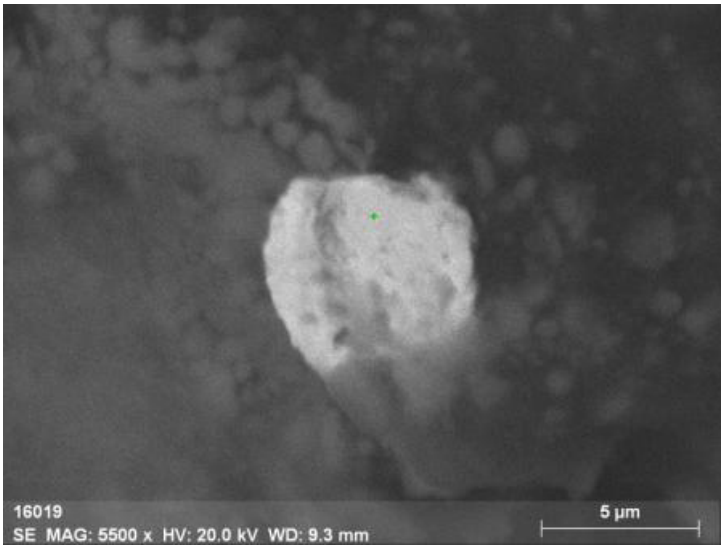
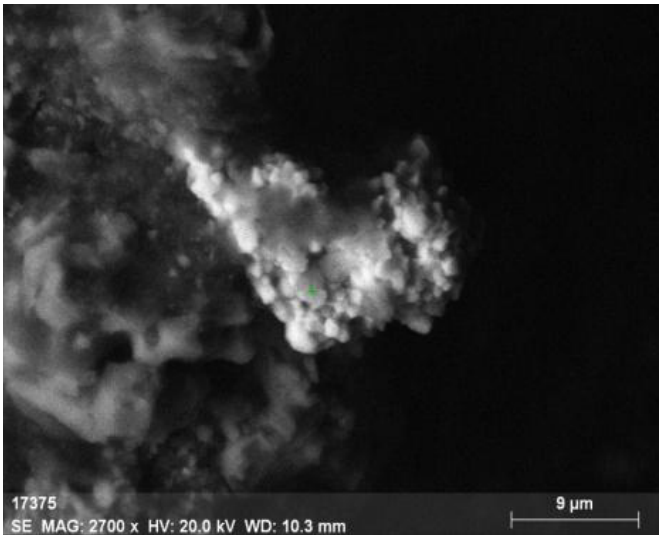


Fig. 3 The gold particle in ash residue of human body of a Novosibirsk resident

Then, we determined other particles in human body ash: a lot of iron oxides, intermetallic compounds (Zn, Pb, Fe, Ni, Co, etc), barite's grains, halite, lanthanum, cerium and thorium particles.

a



b

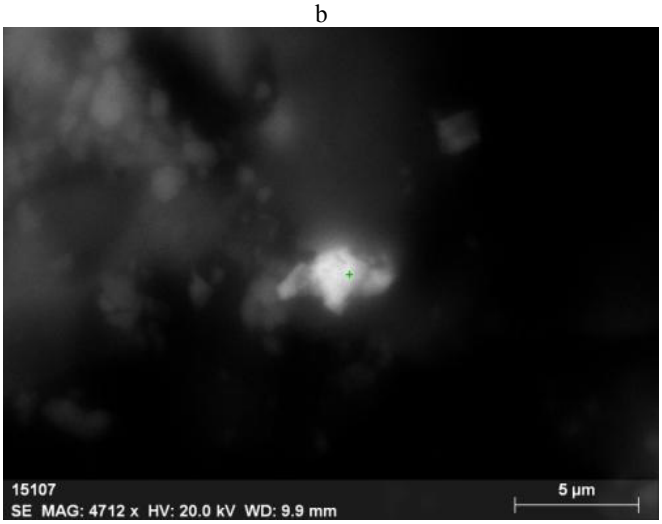


Fig. 4 a) Barite grain b) Lanthanum-cerium particle in ash residue of human body

4. Conclusion

Ash residue of human body can be a good indicator of element composition of human body as well as indicator of geochemical conditions. However, it is necessary to increase the number of samples, and find more information about geochemical conditions of research territory.

The results of the research are quite controversial due to some unexpected outcomes. To explain these data and eliminate the error, we need to have more information about industry of the cities.

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