Chemical codes identification based on periodic dependences of chemical element distribution in biological objects

V I Otmakhov¹, I S Kuskova¹, A V Obukhova¹, E V Petrova¹ and Yu S Sarkisov²

¹National Research Tomsk State University, 36, Lenin Ave., 634050, Tomsk, Russia
²Tomsk State University of Architecture and Building, 2, Solyanaya Sq., 634003, Tomsk, Russia

E-mail: kuskova.i@mail.ru

Abstract. This work for the first time considers the periodic dependences of logarithm of chemical element concentration in human hair, animal hair, crude drugs and other objects of flora and fauna of Siberia on the atomic number in the periodic table. The hypothesis is put forward that the maxima on the constructed curves can serve as the original code reflecting their interrelation with various factors of a genetic and ecological nature. The samples of the animal origin, blood-sucking insects and fish are selected in Siberia (the Tomsk region), whereas the samples of the drug plants are taken in the Krasnoyarsk region. The diversity of the objects at issue and the regions for sampling is conditioned by the breadth of challenges this paper faces. The chemical element concentration in the objects is determined by the detection limit of the method applied (from $1 \cdot 10^{-5}$ to $10^4 \mu g/g$ and more). For convenience, this element concentration is represented as logarithmic charts. It is shown that periodic dependences of the living world of Siberia and Siberian regions are of the same genetic nature. In this research performed in the certified Environmental Monitoring Laboratory of the Tomsk Regional Core Facility Center of National Research Tomsk State University we use the Spectrometer "Grand" with a multichannel analyzer of emission spectra.

1. Introduction

In February 2019, it was 185 years from the date of the birth of the great Russian scientist Dmitry Ivanovich Mendeleev and 150 years since he opened the periodic law. At the age of 35, he classified the chemical elements, which glorified his name for centuries. The periodic law became not only the key to understanding the secrets of the atom, but also opened up fundamentally new opportunities for predicting the properties of materials of various functional purposes.

Based on the proposed classification of chemical elements, it is possible to predict the properties of both individual atoms and more complex technical and biological structures, including living organisms. Periodic dependencies are being increasingly used in various fields of basic and applied sciences. Undoubtedly, the identification of new regularities of chemical element distribution in living organisms is highly relevant, as it allows expanding the ideas about their role in the life of individual biological objects and bio- and eco-systems at local, regional and global levels.

The aim of this work is to define the regularities of the periodic dependences of the chemical element distribution in the objects of plant and animal origins.
2. Materials and methods
Hair of teenagers without health problems were selected to identify the regularities of the chemical element distribution in a human body. Hair 3–4 cm long was cut from back of the head, neck and other parts of the head because this hair section contained the most important information about the human organism for the past several months. In the case of failure to cut the wool from shoulders, a wool fragment was taken to study animals. Scale of fish (crucian, ide, pike perch, pike, bream, perch) from the river Ob was washed, dried to a constant weight and then grinded and sieved. The samples of ticks for research were provided by the Department of Invertebrates of the Biology Institute of National Research Tomsk State University (NI TSU). Ticks were collected from May till August 2019 in different industrial districts of the Tomsk region. For studying plants widely used in official and folk medicine, selected were camomile, salvia officinalis (grass), garden lemon from Blagoveschenskaya village of the Anapa region, Krasnodar Krai (July 2019); eucalyptus leaf from the Adler region, Sochi, Krasnodar Krai (October 2019). All the biological samples were collected in the period of their full activity and flourish. In fact, the concentration of chemical elements is different in different seasons. However, according to our previous research, the average concentration is almost the same. The surface parts of plants were dried in air, grinded and sieved.

At present, there are various ways to detect chemical elements and their distribution in living organisms [1, 2]. A method for determining the elemental composition of biological objects using the atomic emission spectrometry of ash residues is developed at the certified Environmental Monitoring Laboratory (accreditation certificate RA.RU.21BO08 of 16.11.2017) of the Tomsk Regional Core Facility Center NI TSU [3].

The spectrometer "Grand" with a multichannel analyzer of emission spectra in combination with a Rowland polychromator and a generator Vesuvius-3 (Russia) were used to analyze the mass concentration of elements in ashes of plant and animal origins [4-7]. The standard samples composed of the graphite collector micro-elements (set SOG-37) (GSO 8487-2003) with a 60-year validity [8]. The samples were prepared to measure the mass concentrations of elements in the ash samples of plant and animal origins using the atomic-emission analysis combined with arc excitation. The sample weight of 1–5 g was reduced to ash in a muffle furnace at a 400–450 ºC for two hours. A cup of ash residue was cooled to ambient temperature and weighed on an analytical balance. The obtained analyte was then grinded for 20-30 min in an agate mortar with a few drops of ethyl alcohol until a homogeneous powdered mixture was obtained, and then mixed with the graphite powder in the proportion of 1:10 and 1:100, sequentially. The former was used to analyze the impurities and the latter to analyze the main elements [9-15].

3. Results and discussion
For this experiment, we selected a group of 30 elements from the periodic table. The choice was conditioned by the presence of standard samples with definitely known concentrations of the selected elements, which provided reliable results in the specified measurement range. Using the “Grant” spectrometer, the living organisms of plants and animals were analyzed.

The obtained results are presented as dependencies between the logarithm of the element concentration and the charge of the atomic nucleus. These dependences allow us to identify new regularities. According to Figures 1–5, a group of elements forms a frame periodically repeating in all of the objects at issue. This frame on the dependences represents the extreme values of the minima and maxima. There are, however, deviations in the form of the additional extreme values of minima. This is because the habitat of the investigated object. Despite these deviations, it is still possible to identify combinations of the most frequently observed concentration dependencies of the elements on increasing atomic nuclei or the atomic number in the periodic table. Let us call them “life codes”. The extreme values of maxima are even, whereas that of minima are odd. Next, let us write the derived regularities as the code of combinations of the minima and maxima and the respective atomic numbers.

Chemical life code of terrestrial living organisms:
Mg-Si-Ca-Fe-Zn-Sr-Ba/Be-V-Co-W
12-14-20-26-30-38-56/4-23-27-74
Figure 1. The periodic dependence of logarithm of chemical element concentration in drug plants: 1 – garden lemon, 2 – eucalyptus, 3 – salvia, 4 – chamomile.

Figure 2. Periodic dependence of logarithm of chemical element concentration in tick samples: 1–5 – technogenic regions of the city of Tomsk.

Figure 3. Distribution of logarithm of chemical element concentration in animal hair: 1 – horse, 2 – bull, 3 – elk, 4 – stirk.
Figure 4. Periodic dependence of logarithm of chemical element concentration in hair samples of the Tomsk-city residents: 1–9– the number of people participating in the experiment.

Figure 5. Distribution of logarithm of chemical element concentration in fish samples from the River Ob: 1–6 (crucian, ide, pike perch, pike, bream, perch).

These life codes are mainly characteristic to terrestrial living organisms. For aquatic inhabitants (see Figure 5), these codes differ. Thus, the maximum for silicon is substituted by phosphorus. Also, we observe the additional extreme values of minima for Al, Cu, Zr, Ag, Sn associated with the lack in these elements in the habitat of the River Ob. The main frame elements remain with the exception of phosphorus. Thus, the chemical life code for the inhabitants of the freshwater environment can be written as follows:

Chemical "Life Code" of freshwater living organisms:
Mg-P-Ca-Fe-Zn-Sr/Be-V-Co-W
12-15-20-26-30-38-56/4-23-27-74

4. Conclusions
The mechanism of developing the maximum and minimum concentrations of chemical elements is empirically detected for the first time. The detection of the inner mechanisms of their correlation is currently impossible and will be discussed in future works. The derived life codes certainly need further understanding and additional statistical information. However, already at this research stage, the periodic dependences obtained for all the studied living organisms, show that they belong to the same type. In the authors’ opinion, this is in good agreement with the biological law, which states that the genome of all life on Earth has a common nature. The element arrangement in wildlife is therefore in
strict adherence to the element distribution in the periodic table. Without going deeply into the problem of the influence of chemical elements on human health (it is enough to refer to monographs [16–22]), we can conclude that the periodic dependences allow us to detect general trends in the chemical element distribution and to find optimum ways to improve the quality of life.

References
[1] Pupyshev A A and Surikov V T 2006 Mass spectrometry with inductively coupled plasma. Ion formation (Ekaterinburg) 114
[2] MUK 4.1.1482-03 Atomic emission spectroscopy and mass spectrometry with inductively coupled plasma of chemical elements in biological environments and medicines 2003 (Moscow) 56
[3] MU FR.1.31.2013.13831 Atomic emission spectroscopy combined with spectrum excitation of mass concentration of elements in hair samples 2016 (Certificate of measurement technique N 08-47/380.01.00143-2013.2016)
[4] Labusov V A, Garanin V G and Zarubin I A 2017 New spectral complexes based on MAES analyzers Industrial. Diagnostics of Materials 83 1–2 15–20
[5] Otmahov V I and Petrova E V 2012 Optimization of conditions of atomic emission spectral analysis of complex graphite powder samples Industrial. Diagnostics of Materials 78 1–2 82–85
[6] Otmahov V I Methods of creation atomic emission analysis of various objects 2005 Analitika i control 9 3 245–249
[7] Otmahov V I, Petrova E V and Varlamova N V 2008 Development of methods of analysis of oxide materials using atomic emission spectroscopy Industrial. Diagnostics of Materials 74 8 15–17
[8] GSO 8487-2003 Standard graphite collector of micro-impurities. SOG-37 set 2003 (Ekaterinburg)
[9] Otmahov V I, Kataeva N G, Kuskova I S and Petrova E V 2015 Elemental analysis of hair by atomic emission spectroscopy combined with spectrum excitation for disease diagnosis Moscow: Proc. 1st All-Russian Conf. “Chemical Analysis and Medicine”
[10] Otmahov V I, Petrova E V and Shilova I V 2015 Atomic emission spectroscopy combined with spectrum excitation of drug plants Industrial Laboratory. Diagnostics of Materials 81 1 145–148
[11] Otmahov V I, Kuskova I S, Petrova E V et al 2016 Analysis of production of lithium-containing plant extracts of cardiac rhythm simulation action Tomsk State University Journal of Chemistry 2 35–44
[12] Otmahov V I, Obuhova A V, Ondar S A, Petrova E V 2017 Elemental status of person for assessing environmental safety of region Tomsk State University Journal of Chemistry 9 50–59
[13] Kuskova I S 2017 Optimization of elemental analysis of biological objects by methods of spectrum excitation and plasma atomic emission spectrometry Tomsk: Cand. Sci. Dissertation Abstract, Chemistry 24
[14] RMG 61–2010 Accuracy, correctness, precision of quantitative chemical analysis. Assessment methods. State system of ensuring unity of measurements 2013 Moscow: Standarinform 58
[15] Skalnaja M G, Skalnyj A V and Demidov V A 2001 Hair elemental composition vs. gender and age St. Petersburg: Vestnik SPb GMA im. I.I. Mechnikova 4 72–77
[16] Skalnyj A V and Rudakov I A Bio-elements: basic concepts and terms 2005 Orenburg
[17] Zhornjak I V 2009 Ecological and geochemical assessment of Tomsk territory Tomsk: Cand. Sci. Dissertation 205
[18] Nozdrjuhina L R, Grinkevich 1980 Violation of micronutrient metabolism and ways of correction Moscow: Nauka 168
[19] Skalnyj A V, Rudakov I A 2004 Bio-elements in medicine (Moscow: Mir) 272
[20] Skalnyj A V 2004 Chemical elements in physiology and ecology of person (Moscow: Mir) 216
[21] Otmahov V I, Sarkisov Yu S, Pavlova A I, Obukhova A S 2019 Periodic dependences of the distribution of chemical elements in the ash residue of human hair Industrial Laboratory. Diagnostics of materials 85 1-II 73-77