The abundances of chemical elements in urban soils

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ABSTRACT

For the first time the abundances (the average concentrations) of chemical elements are given for the soils of urban landscapes. The figures were established by authors on the base of average concentrations of chemical elements in the soils of more than 300 cities and settlements in Europe, Asia, Africa, Australia, and America. The major part of data (sampling, analyses and their statistical treatment) was obtained directly by authors as a result of special studies conducted for more than 15 years. The concentrations of elements were defined by the spectral, gravimetric, neutron activation and the X-ray fluorescence methods of analyses. The control of sampling and also inner and outer laboratory controls of analyses were carried out. The ordinary and the control analyses were carried out in the certified and accredited laboratories, including arbitration laboratory. The sufficiently numerous published materials of different researchers were also used.

1. Introduction

One of the most important indicators for characterising the large geochemical systems is the average content of their constituent chemical elements (Geochemistry, 2006). The biggest geochemical system is the Earth's crust. The data on its chemical composition to a depth of 16 km were first published in 1889 by the American scientist F.W. Clarke. On the proposal of the Russian geochemist A.E. Fersman the average contents of chemical elements in this system, as well as in other major geochemical Earth systems (hydrosphere, atmosphere, pedosphere, in the main types of rocks, etc.) are called *the abundances* or "*the Clarkes*" (Perelman, 1975). *Abundances* express the *average concentrations of chemical elements* in geochemical systems, for example, the abundance of lead in the Earth's crust, the abundance of copper in carbonate rocks, and the abundance of manganese in living matter.

In the time of life existence, or at least in the time of the existence of human beings, the abundances of chemical elements within the Earth's crust have not been changed dramatically due to migration and concentration processes except the radioactive elements and their decay products and also noble gases. However, significant changes took place in the distribution of chemical elements. But within the biosphere not only the distribution, but also the abundances of elements have changed during the last centuries (Alekseenko, 2006; Bowen, 1979; Kabata-Pendias, 2010).

The rate of a number of geochemical changes taking place during the last decades in the biosphere has become catastrophically high. Such changes are often connected with human activities (Cicchella et al., 2008a; Motuzova and Karpova, 2013). To study these changes and to make better informed decisions on diminishing their adverse impact on living organisms, and especially on people, it is necessary to estimate the contemporary abundances of chemical elements in geochemical systems susceptible to the highest anthropogenic impact and having a significant effect on the development and existence of living organisms. One of such systems is the soil of urban landscapes (Cicchella et al., 2005; Gerasimova et al., 2003; Motuzova and Bezuglova, 2007; Norra and Stüben, 2003).

At present certain demand arose for a conversion from a qualitative to a quantitative description of geochemical processes in urban soils and for valid (quantitative) impact forecast (Birke and Rauch, 2000; Cicchella et al., 2003, 2008c; Crnković et al., 2006; Doichinova et al., 2006; Imperato et al., 2003; Li et al., 2001; Linde et al., 2001; Lorenz and Kandeler, 2005; Madrid et al., 2006; Morel and De Kimpe, 2000; Norra et al., 2006; Papa et al., 2009; Pouyat et al., 2007; Thuy et al., 2000; Tume et al., 2008 and others).

The prerequisites for this are: 1 — the changes of environmental and geochemical situations have begun to affect the life safety and, as a result, the sustainable development of both particular regions and whole countries (Bityukova and Kasimov, 2012; Cicchella et al., 2008b; Shayler et al., 2009); 2 — many problems have passed from the category of "pure" geochemical to economic and even political (Alekseenko et al., 2002; Bityukova et al., 2011; Pickett et al., 2008); 3 — in such branches

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Table 1
The list of cities and regions taken into account in this work.

No.	City, region, country	The data was obtained	
		Directly by authors	From literature and from certain researchers
Millionaire-cities (with the number of population more than 700,000 people)			
1	Adelaide, Australia	+	
2	Almaty, Kazakhstan	+	+
3	Beijing, China	+	+
4	Belgrade, Serbia		+
5	Berlin, Germany	+	
6	Bishkek, Kyrgyzstan	+	
7	Budapest, Hungary	+	
8	Cairo, Egypt		+
9	Chelyabinsk, Russia	+	+
10	Cologne, Germany		+
11	Da Nang, Vietnam	+	+
12	Donetsk, Ukraine	+	+
13	Hamburg, Germany	+	
14	Hong Kong, China	+	
15	Istanbul, Turkey	+	+
16	Kiev, Ukraine	+	
17	Krasnodar, Russia	+	+
18	Krasnoyarsk, Russia	+	+
19	London, United Kingdom	+	+
20	Lviv, Ukraine		+
21	Madrid, Spain	+	+
22	Minsk, Belarus	+	+
23	Moscow, Russia		+
24	Naples, Italy	+	+
25	Novosibirsk, Russia		+
26	Palermo, Italy	+	
27	Paris, France	+	
28	Perm, Russia	+	
29	Rome, Italy	+	
30	Rostov-on-Don, Russia	+	
31	Saint-Petersburg, Russia	+	+
32	Samara, Russia	+	+
33	Seville, Spain		+
34	Shenzhen, China	+	
35	Stockholm, Sweden	+	+
36	Ulan Bator, Mongolia		+
37	Vienna, Austria	+	
38	Yerevan, Armenia	+	+
Half-millionaire cities (with the number of population 300,000–700,000 people)			
1	Aktobe, Kazakhstan	+	+
2	Arkhangelsk, Russia	+	+
3	Astana, Kazakhstan		+
4	Astrakhan, Russia	+	
5	Barnaul, Russia	+	+
6	Bielefeld, Germany	+	
7	Brest, Belarus		+
8	Cheboksary, Russia	+	
9	Cherepovets, Russia	+	
10	Gold Coast, Australia		+
11	Gomel, Belarus		+
12	Grodno, Belarus		+
13	Helsinki, Finland		+
14	Irkutsk, Russia		+
15	Kaliningrad, Russia		+
16	Karaganda, Kazakhstan	+	
17	Kaunas, Lithuania		+
18	Kemerovo, Russia		+
19	Kostanay, Kazakhstan		+
20	Mariupol, Ukraine		+
21	Mogilev, Belarus		+
22	Novokuznetsk, Russia		+
23	Novorossiysk, Russia		+
24	Orenburg, Russia	+	
25	Oskemen, Kazakhstan	+	
26	Pavlodar, Kazakhstan		+
27	Semey, Kazakhstan	+	
28	Sevastopol, Russia	+	+
29	Shymkent, Kazakhstan	+	
30	Simferopol, Russia	+	
31	Smolensk, Russia	+	+
32	Stavropol, Russia		+

Table 1 (*continued*)

No.	City, region, country	The data was obtained	
		Directly by authors	From literature and from certain researchers
Half-millionaire cities (with the number of population 300,000–700,000 people)			
33	Taraz, Kazakhstan	+	
34	Tomsk, Russia		+
35	Ulan-Ude, Russia		+
36	Varna, Bulgaria	+	
37	Vitebsk, Belarus	+	
38	Vladimir, Russia		+
39	Vladivostok, Russia		+
Cities with a local significance (with the number of population 100,000–300,000 people)			
1	Aktau, Kazakhstan	+	+
2	Amiens, France	+	
3	Artemivsk, Ukraine		+
4	Atyrau, Kazakhstan		+
5	Babruysk, Belarus	+	+
6	Baranovichi, Belarus		+
7	Barysaw, Belarus		+
8	Biysk, Russia		+
9	Cherkasy, Kazakhstan		+
10	Cherkessk, Russia	+	
11	Dresden, Germany		+
12	Exeter, United Kingdom	+	
13	Horlivka, Ukraine		+
14	Kyzylorda, Kazakhstan		+
15	Lecce, Italy	+	
16	Magadan, Russia	+	
17	Mezhdurechensk, Russia		+
18	Noginsk-Elektrostal, Russia		+
19	Oral, Kazakhstan		+
20	Orsha, Belarus	+	
21	Padua, Italy	+	+
22	Petropavl, Kazakhstan		+
23	Petrozavodsk, Russia		+
24	Pinsk, Belarus	+	
25	Plymouth, United Kingdom		+
26	Rubtsovsk, Russia		+
27	Taldykorgan, Kazakhstan		+
28	Temirtau, Kazakhstan		+
29	Veliky Novgorod, Russia		+
30	Verona, Italy	+	
31	Zhytomyr, Ukraine	+	
Regions where small towns were studied (with the number of population less than 100,000 people)			
1	Almaty Province, Kazakhstan	+	
2	Altai Krai, Russia		+
3	Brest Region, Belarus		+
4	Chernihiv Oblast, Ukraine		+
5	East Kazakhstan Province, Kazakhstan		+
6	Gomel Region, Belarus		+
7	Grodno Region, Belarus		+
8	Hainuat Province, Belgium		+
9	Ile-de-France Region, France		+
10	Jewish Autonomous Oblast, Russia		+
11	Karagandy Province, Kazakhstan	+	
12	Kiev Oblast, Ukraine		+
13	Komi Republic, Russia		+
14	Krasnodar Krai, Russia	+	
15	Krasnoyarsk Krai, Russia		+
16	Kuyavian-Pomeranian Voivodeship, Poland		+
17	Leningrad Oblast, Russia	+	
18	Minsk Region, Belarus		+
19	Mogilev Region, Belarus		+
20	Moscow Oblast, Russia		+
21	Murmansk Oblast, Russia		+
22	Novosibirsk Oblast, Russia		+
23	Rostov Oblast, Russia		+
24	Stavropol Krai, Russia	+	
25	Sukhum District, Abkhazia	+	
26	Vitebsk Region, Belarus	+	
27	Volyn Oblast, Ukraine		+
28	Zaporizhia Oblasst, Ukraine	+	