Ni, Cr, Cd, Co, and Pb in the Rock–Soil–Plant System in Forest-Steppe of Transbaikalia

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Abstract

Content of toxic heavy metals (Ni, Cr, Cd, Co, Pb) in the rock–soil–plant system in forest steppe of Transbaikalia has been studied. It was found that it does not exceed percent abundance values and MPC of soils and plants.

INTRODUCTION

It is common knowledge that biogeochemical factors have a pronounced effect on the vitality and functional reserves of an organism of human beings [1]. Relationship between the initiation of various illnesses and chemical heterogeneity of biosphere [2] has been proved. To take an illustration, certain heavy metals (HM) and their compounds (nickel, cadmium, chrome, cobalt, lead, beryllium, arsenic, and mercury) may become a factor responsible for the initiation of tumours in an organism of human beings [3].

The purpose of this work is to determine HM (Ni, Cr, Cd, Co, Pb) content of the rock–soil–plant system in forest steppes of Transbaikalia and to compare the acquired data with the levels of the relevant MPCs.

EXPERIMENTAL

Parent rock (PR), upper organogenic layer of soil, organic part of soil, aboveground and root masses of grassy vegetation were chosen as subjects of the research. Samples were taken in forest steppe of Transbaikalia on grey forest soils.

Total HM content in samples of organogenic layer of soil was determined with the method [4], and that in samples of aboveground and underground mass of plants, by the procedure described in [5]. After incineration, ash of plants was dissolved in 10 mL of 10 % HCl solution and the HM content was determined [4].

Extraction of organic part of soils was performed by the method that was described in the work [6]. Weighted samples of soils that were free from plant remains were subject to repeated treatment with a mixture of 0.5 M NaOH and 0.01 M EDTA solutions to reach the discoloration of the solution above the samples of organogenic layer of soil after their centrifugation.

HM content was determined in an atomic absorption spectrophotometer with a Solaar M6 atomic absorption spectrophotometer (the USA) at the Baikal Institute of Natural Management, SB RAS (the relative error of measurement of ±(5–20) %).

RESULTS AND DISCUSSION

The lead load of PR ranges from 7.8 to 12.3 mg/kg (the average value of 10.0 mg/kg), and it varies in the upper organogenic layer within the limits of 13.1–22.9 mg/kg of soil (the average value of 19.2 mg/kg of soil at $n = 3$). These data are lower than percent abundance values of Pb in the lithosphere. Lead accumulates in organic part of soil in amounts of 2.1–5.6 mg/kg (the average content of 4.2 mg/kg), and in root mass of grasses, 2.9 mg/kg. The

TABLE 1

Content of heavy metals in Transbaikalia ecosystem, mg/kg

Samples	Cd	Co	Ni	Pb	Cr
Parent rock [7]	n/d	n/d	25.7	33.7	50.2
Parent rock [8]	n/d	10.7	5.8	5.8	65
Parent rock* (n = 3)	0	5.3	62.6	10.0	59.1
Average terrestrial abundance of the lithosphere	n/d	23	56	12	93
Grey wood soil [7]	n/d	5.5	26.8	33.9	54.3
Grey wood soil [8]	n/d	9.7	6.5	8.6	81.2
Grey wood soil (n = 3)	0.4	4.6	16.6	19.2	69.5
MPC in soils	3.0		85.0	30.0	100.0
Organic part of grey wood soil	0.1	0.03	13.6	4.2	7.0
Vegetation (aerial material)	0	0.06	7.3	0.8	14.7
Vegetation (underground mass)	0.05	3.5	8.9	2.9	82.1
MPC in plants	0.3			3.0	

Note. n/d – not determined.

* Proluvial-dealluvial gravelly, loamy deposits; eluvial-dealluvial deposits of granite-diorites; alluvial deposits of sandy pebbles.

lead load in aboveground part of plants comprises as little as 0.8 mg/kg (Table 1), consequently, the roots serve as a barrier. It should be remarked that under natural conditions of forest-steppe of Transbaikalia, the content of lead that is highly toxic for biota is essentially less by comparison to its MPC both in soil, and in plants.

On evidence of [7, 8], nickel content of rock comprises 5.8–25.7 mg/kg, and that of the upper organogenic layer of soil is 6.5–26.8 mg/kg. According to the data we received, nickel content of PR is considerably higher, 39.3–85.8 mg/kg (the average of 62.6 mg/kg), and it comprises 14.2–18.2 mg/kg in organogenic layer (the average of 16.6 mg/kg). Nickel is present in the organic part of soil at a rate of 11.6–14.8 mg/kg (the average of 13.6 mg/kg) (see Table 1). The difference of literary data from the data we received is caused by the distinction in PR. According to our data, the content of nickel in proluvial-dealluvial gravelly, loamy deposits comprises 41.8 mg/kg, that in PR of eluvial-dealluvial granite-diorites comprises 39.3 mg/kg, and that in alluvial deposits comprises 85.8 mg/kg. The authors of work [7] give nickel data in light loose sandstones where the content of nickel is less. Transformation of nickel from organogenic layer into a vegetative organism is insignificant. Accordingly, the rate of its accumulation in roots comprises up to 8.9 mg/kg, and that in aboveground part comprises 7.3 mg/kg. Consequently, in spite of its significant content in rock, nickel is not accumulated in plants.

On evidence of [7, 8], chrome content of rock comprises 50–65 mg/kg, and that of the organogenic layer of soil comprises 54–81 mg/kg. Results acquired by us are comparable to literary data. Accordingly, chrome content of PR comprises 48.9–69.2 mg/kg (the average of 59.1 mg/kg), that of organogenic layer comprises 68.0–70.5 mg/kg (the average of 69.5 mg/kg at n = 3), and chrome has been detected in organic part of soil to the extent of as little as 6.0–7.7 mg/kg (the average of 7.0 mg/kg). Chrome content of aboveground part of motley grass comprises 14.7 mg/kg, and that of roots comprises 82.1 mg/kg.

Cobalt is present in PR of grey forest soils in amounts of 10.7 mg/kg [8]. Its content in organogenic layer of grey forest soils comprises 5.5 [7] and 9.7 mg/kg [8] that is comparable with our data, 4.0–5.4 mg/kg (the average of 4.6 mg/kg). In the bedrock of these soils, cobalt accumulates within the limits of 4.6–6.0 mg/kg (the average of 5.3 mg/kg). Its insignificant quantity has been detected in organic part of soil – 0.03 mg/kg, and its respective content in roots

of grasses and aerial material of plants comprises 3.5 and 0.03 mg/kg.

We did not detected cadmium in rocks of Transbaikalia. Its small quantity was recorded in upper layer of soil and in organic part of soil (0.4 and 0.1 mg/kg, respectively). Cadmium content of roots of motley grass comprises 0.05 mg/kg, and this metal was not detected in aboveground part of motley grass. It appears that cadmium as a result of aerogenic pollution of plants is quickly removed from plant remains together with the destructed tissues and it accumulates in dead organic matter on the soil surface [9]. Thus cadmium available in organic part of soil is due to biogenous accumulation.

CONCLUSION

The results arrived at testify that HMs such as lead, chrome, nickel, cobalt, and cadmium are present in grey forest soils of Transbaikalia in quantities that are safe for life, far from the average terrestrial abundance of the lithosphere, from MPC of soils and plants. It should be remarked that data on average content of these elements in the objects under investigation that are spatially separated from each other (Bichura and Pribaikalia forest-steppes, the territory of Tunkinskiy National Park where grey forest soils are most frequent) are comparable.

The following regularity is evidenced for the studied objects in terms of their content of heavy metals: parent rock > upper soil layer > organic part of soil > root mass of plants > aboveground part of motley grass.

A positive correlation has been discovered between HM content of PR and organic part of soils ($r = 0.97$), as well as between the content of elements in organic part of soils and the aboveground, underground mass of plants ($r = 0.96$ and 0.97, respectively).

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