Data Article

Data on the concentration of fractions and the total content of chemical elements in catenae within a small catchment area in the Trans Urals, Russia

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Abstract

Research on migration of chemical elements (ChEs) in soils is important for the understanding of geochemical processes in polluted and undisturbed landscapes. In this article, we report original data on Anthric Chernozems and Anthric Planosols within a small gully's catchment area in the Trans Urals (Russia). Mean total concentrations of 24 ChEs and content of mobile fractions (F1 — exchangeable, F2 — bound within organo-mineral complexes and F3 — bound with Fe and Mn hydroxides) of 61 ChEs including macro elements (Al, Ca, Fe, K, Mg, Mn, Na, P, Ti, Si), heavy metals (Ba, Co, Cr, Cu, Ni, Pb, Rb, Sr, Th, U, V, Zn), trace elements (Ag, As, B, Be, Bi, Br, Cd, Cs, Ge, Hf, Li, Mo, Nb, Pd, Sb, Sc, Se, Sn, Ta, Te, Ti, W, Zr) and rare earth elements (Ce, Er, Eu, Gd, La, Lu, Nd, Pr, Sm, Tb, Tm, Dy, Ho, Y, Yb) are determined from in a total of 60 samples from topsoil and subsoil of Anthric Chernozems and Anthric Planosols. The data obtained also include pH-value, total organic carbon content (TOC), seven particle-size classes (<2, 2—6, 6—20, 20—63, 63—200, 200—630 and 630—2000 μm), electrical conductivity and chemical composition (cations and anions) of water extracts as well as soil mineralogical composition.

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1. Data

The Trans Urals forest-steppe region has one of the highest population densities in Siberia and limited application of micro fertilizers. Geologically, the region is composed of Palaeogenic marine clays, sandstones, opokas and diatomites that are overlain by loess-like loams. Sloping plains of abrasive-erosive and alluvial-lacustrine genesis and Neogene-Quaternary ages with flat or slightly undulating interfluves of 110—140 m a.s.l. are deeply dissected by well-developed valleys of rivers [4].
According to the Köppen-Geiger classification, the area belongs to the snow fully humid type with warm summer conditions (Dfb) [5].

Data were collected within the catchment area (480 000 m²) of a U-shaped gully on the Trans-Urals Elevation of the Ishim Plain (Fig. 1). It was selected by means of analysing the maps of vegetation, soils, parent materials and geochemical migration factors within the Ob river basin area [6]. Within the catchment, Anthric Chernozems were found on interfluvies and slopes and Anthric Planosols—at the bottom of the gully. This site represents a group of soil catenas typical for the central part of Western Siberia [7]. During the fieldwork, 60 soil samples (300–500 g) were collected from 11 soil pits (Figs. 1 and 2, Table 1).

Data included TOC, pH, particle-size distribution, total concentrations of 23 ChEs and content of three mobile fractions of 61 ChEs (Table S1). Electrical conductivity, basicity and concentration of anions and cations were determined in the upper part of plough layers and the main horizons of three soil pits (Fig. 1). Mineralogical composition was analysed in samples from the most typical pits of Anthric Chernozem on the interfluve and Anthric Planosol at the gully bottom (Table 2).

2. Experimental design, materials and methods

Soil samples were taken from 7 pits of Anthric Chernozems and 4 pits of Anthric Planosols (Table 1) and analysed by standard techniques.

At the Faculty of Geography of MSU (Lomonosov Moscow State University), total organic carbon (TOC) in soils, electrical conductivity, basicity (HCO₃⁻/CO₃²⁻) and pH of water extracts were determined by standard techniques [1–3]. The particle-size distribution in soils was analysed using a laser diffraction technique and an ‘Analizeter 22’ equipment (Germany). The particle-size classes were defined as: G1 — clay (particles <2 μm), G2 — fine silt (2–6.3 μm), G3 — medium silt (6.3–20 μm), G4 — coarse silt.
Fig. 2. Photos of soil pits (numbers 1–11). Pit locations are shown in Fig. 1.
Table 1
Morphological properties of Anthric Chernozems and Anthric Planosols.

| Soil     | Horizon | Depth, cm | Colour description          | Mansell | Structure                        |
|----------|---------|-----------|-----------------------------|---------|----------------------------------|
| Chernozems | Ap      | 0–20      | Uniform, dark grey          | 10YR 2/1| Angular blocky with some crumb-like peds |
|          | A       | 20–30(40) | Uniform, dark grey          | 10YR 2/1| Small angular blocky or subangular blocky |
|          | AB      | 30(40)–55(75) | Brown background with numerous dark grey, sharply delineated, vertically oriented stripes of humic material | 10YR 7/4| Angular blocky and prismatic |
|          | Bk      | 55(75)–195| Brown with lighter mottles (CaCO₃ concentrations) | 10YR 6/6| Prism-like peds consisting of small angular block-like peds |
| Planosols | Ck      | 195–220   | Uniform, brown              | 2.5Y 6/6| Structureless                     |
|          | Ap      | 0–20      | Uniform, dark grey          | 10YR 2/1| Angular/subangular blocky with some crumb-like peds |
|          | A       | 20–80(100)| Uniform, dark grey          | 10YR 2/1| Angular/subangular blocky and crumb |
|          | E       | 80(100)–110(130) | Uniform, whitish grey       | 2.5Y 6/3| Laminated                         |
|          | Bt      | 110(130)–200| Uniform, brown             | 10YR (4–5)/6| Prism-like peds consisting of small angular block-like peds |
|          | C       | 200–220   | Uniform, brown              | 2.5Y 6/6| Structureless                     |

Table 2
Mineralogy of Anthric Chernozems and Anthric Planosols.

| Soil     | Horizon | Smectite | Illite | I/Sm | Kaolinite | Chlorite | Plagioclases | PFS | Quartz | Calcite |
|----------|---------|----------|--------|------|-----------|----------|--------------|-----|--------|---------|
| Chernozems | Ap      | 24.2     | 7.1    | 10.7 | 4.2       | 0.3      | 10.4         | 3.9 | 38.6   | 0.6     |
|          | Ck      | 21.7     | 5.8    | 5.7  | 4.7       | 1.1      | 8.8          | 10.6| 40.4   | 1.1     |
| Planosols | Ap      | 24.6     | 6.8    | 16.2 | 4.1       | 0.9      | 7.8          | 5.3 | 34.0   | 0.4     |
|          | E       | 7.5      | 9.1    | 8.0  | 2.7       | 1.4      | 14.7         | 7.9 | 48.0   | 0.6     |
|          | C       | 25.7     | 5.7    | 10.9 | 3.0       | 1.5      | 11.9         | 5.9 | 35.0   | 0.4     |

I/Sm — illite-smectite mixed-layer minerals with predomination of illite interlayers, PFS — potassium feldspars.

(20–63 μm), G5 — fine sand (63–200 μm), G6 — medium sand (200–630 μm) and coarse sand (630–2000 μm). Anions (Cl⁻, SO₄²⁻, NO₃⁻, PO₄³⁻) and cations (Ca²⁺, Mg²⁺, K⁺, Na⁺, NH₄⁺) in water extracts (soil:solution ratio of 1:5) were measured by high performance liquid chromatography using a Styer chromatograph (Aquilon, Russia).

Total content of chemical elements (ChEs) was measured at the IGEM RAS (Institute of Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry of the Russian Academy of Sciences) using an Axios X-Ray fluorescence spectrometer (made by PANalytical, Netherlands) and Russian Soil Standard samples (SSs of ‘Chernozem’ and ‘Albeluvisol’) with accuracy reported in [7].

Mobile fractions F1 – F3 were obtained according to the extraction procedure by [8] with the use of the following reagents: F1 — with NH₄Ac (ammonium acetate buffer) and the soil:solution ratio of 1:5, F2 — with 1% EDTA (ethylendiaminetetraacetic acid) and the soil:solution ratio of 1:5 and F3 — with 1M HNO₃ and the soil:solution ratio of 1:10. Concentrations of the extracted ChEs in the filtrates were determined using an Elan-6100 ICP-MS System (Inductively Coupled Plasma Mass Spectrometer by PerkinElmer Inc., USA) and an Optima-4300 DV ICP-AES System (Inductively Coupled Plasma Atomic Emission Spectrometer by PerkinElmer Inc., USA) at the VIMS (N. M. Fedorovskii All-Russia Institute of Mineral Raw Materials). The procedure [8] is regularly used for analysing mobile fractions of ChEs in soils in Russia. The ChE mobility (ChEm) was calculated as a ratio of its mobile fractions (F1+F2+F3) to its total content, multiplied by 100%.
At the MSU Faculty of Geology, soil mineralogical composition (phyllosilicates and other minerals) was determined using an ULTIMA-IV X-Ray diffractometer (made by Rigaku, Japan) operated at 40 kV, 40 mA, 3–65° 2θ, with Cu radiation and a DTex/Ultra semiconductor detector. Minerals were identified by comparing experimental data with standard X-Ray patterns from the PDF-2 database with the use of the MDI Jade-6.5 software and methodological recommendations by [9–11]. A quantitative mineralogical analysis was carried out using the Rietveld full-pattern fitting method [12] and the BGMN software [13].

Statistical analyses included calculations of percentiles, median, median absolute deviation, mode for topsoils and subsoils of Chernozems and Planosols. Moreover, the normal distribution hypothesis was tested on all parameters analysed (Table S2).

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Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.dib.2019.104224.

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