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GEOLOGY

The Lithogeochemical Barrier Zone of the Angara River

G. A. Karnaukhova

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Principal processes of reformations in the composition of water, suspension, and bottom sediments proceed in geochemical barrier zones of water bodies [9]. The results of transformation of sedimentary material and chemical elements are most prominent in bottom sediments of lithogeochemical barrier zones (LGBZs) [6]. A great body of materials on reliably investigated general and particular regularities in LGBZ evolution has been published to date [1, 2, 5, 8]. However, one can see a special type of LGBZ related to the regulation of natural river discharge and the creation of water reservoirs, e.g., alternating backwater areas and adjacent upper reaches of reservoirs. Information about such barrier zones is scanty and incomplete [3, 4, 7].

Discharge of the Angara River flow issuing from Lake Baikal is regulated by the cascade of the Irkutsk, Bratsk, and Ust'-Ilim hydroelectric power stations (HPS). Reservoirs of the HPS are characterized by an intermittent cascade system. For example, the Irkutsk and Bratsk reservoirs are separated by a 100-km-long unregulated fragment of the Angara River. An alternating backwater area and the Bratsk Reservoir begin downstream of the unregulated fragment. The alternating backwater area and the Angara headwater region of the Bratsk reservoir include an LGBZ area with the following features: (a) simultaneous influence of two hydrodynamic systems (river and reservoir); (b) intense accumulation of sedimentary materials transported by the river; and (c) maximal accumulation of contaminants. According to our observations, the amount of contaminants delivered annually to the study area by waste waters is as follows: more than 23.3 kt of nitrogen compounds, more than 6 kt of phosphorus compounds, about 4 kt of iron compounds, more than 2 Mt of organic matter, and about 1.9 kt of heavy metals. The annual load of terrigenous materials is as much as 1.398 Mt (Karnaukhova, 2000). Therefore, the objective of this work was to study processes of the accumulation of elements in bottom sediments of the LGBZ of the Angara River.

Institute of the Earth's Crust, Siberian Division, Russian Academy of Sciences, ul. Lermontova 128, Irkutsk, 664033 Russia; e-mail: karnauh@crust.irk.ru

Deposition of materials and formation of different lithological types of bottom sediments proceed in accord with variations in the flow velocity. Each type of sediment occupies a certain bottom area with the hydrodynamic conditions most favorable for its deposition. Geochemical differentiation of material takes place in the course of its transportation across the alternating backwater area. Sedimentation processes promote the withdrawal of chemical elements and compounds from the water flow and accumulation of their considerable masses in bottom sediments of the LGBZ. The elements under discussion can be subdivided into three groups by the value of their retention in the LGBZ of the Angara River.

The first group is characterized by high losses of elements, because this includes weak water migrants (Mo, Pb, and Cr), as well as Fe, P, and OM (Fig. 1A). Only 74% of Cr, more than 50% of OM, and 50% of Mo delivered by the Angara River water are left in the alternating backwater area and bottom sediments. Elements of the first group tend to sediments mainly composed of particles of the silt–pelite fraction. One can see a certain sedimentation relationship of Pb with Fe and P.

The second group comprises Mn, Cu, and Zn, which are good migrants. The amount of loss of elements of this group is within 54.6–69.3%. Copper precipitates from water rather rapidly. Its precipitation is mostly related to deposition of silty particles, indicating the sorption nature of accumulation and the anthropogenic origin of the metal. Most manganese precipitates within

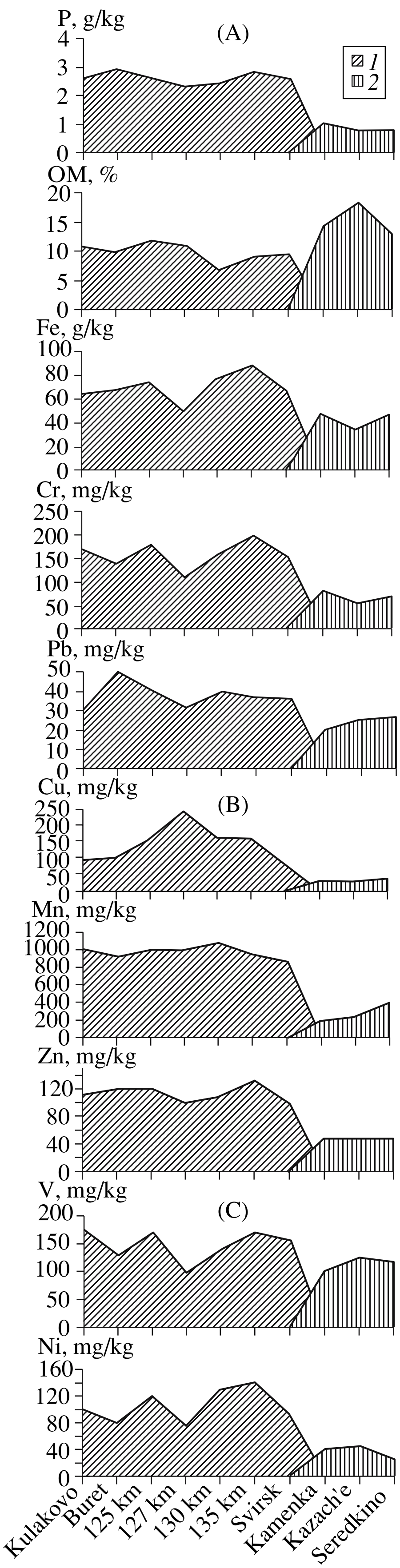

Fig. 1. Distribution of elements of the (A) first, (B) second, and (C) third lithogeochemical barrier zones. (*1*) Alternating backwater area; (*2*) Angara headwater area.

the Angara headwater area and is actively sorbed by mineral and organic particulates. The concentration of Zn in bottom sediments of the alternating backwater area varies but slightly (Fig. 1B). At the same time, Zn shows a direct correlation with the 0.05–0.01 mm fraction. Zn tends to the pelite fraction, and the concentration of this element decreases to 50 mg/kg in sediments of the Angara headwater area.

The loss of elements of the third group (Ni and V) is 23–34.4%. The maximal Ni concentration in sediments (130–150 mg/kg) is recorded in the 10-km-long sector located between 125 and 135 km (Fig. 1C), where maximal concentrations of V, Cu, and Cr are registered.

Thus, it is evident that not only natural, but also artificial reservoirs include LGBZs. Processes of active precipitation of sedimentary material in these zones promote intense differentiation of chemical elements. The results of long-term studies on the Angara River and reservoirs of the Angara cascade give grounds to identify the alternating backwater areas and upper reaches of reservoirs as the LGBZ.

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