INTRODUCTION

The Selenga River is the main water source of Lake Baikal. The Selenga River forms a wide winglike delta. Contrary to the middle reaches of the river, the delta is characterized by more pronounced side erosion, meandering, furcation of the riverbed, and dynamic riverbed processes resulting in the development of a wide floodplain with channels and islands.

The development of floodplain soils in the Selenga delta is affected by tectonic processes; the small inclination of the floodplain surface is responsible for the relatively poor drainage and swamping of the area. The climatic conditions (the regimes of the temperature and precipitation and the direction and strength of the winds), the low soil temperatures related to the long-term seasonal freezing, the drainage of the area, and the soil properties. After the flood period, the concentrations of $\text{Ca}^{2+}$, $\text{HCO}_3^-$, $\text{Fe}^{3+}$, and $\text{SO}_4^{2-}$ in the groundwater increase with the rise in the soil temperatures. In the dry periods, the concentrations of $\text{Na}^+$ and $\text{Cl}^-$ ions increase, whereas the concentration of $\text{C}_{\text{total}}$ decreases.

OBJECTS AND METHODS

Field investigations were performed on the low floodplain of the Selenga River delta in 2000–2003. The four test plots were set in the area of the settlement of Stepnoi Dvorets on the left bank of the river.

Test plot 1-01 was set on a well-drained element of the floodplain 1.5 m from a river channel of the third order ($52^\circ11'\ N, 106^\circ21'\ E$) under a forb–sedge association with participation of grasses. A poorly developed alluvial soil on stratified alluvial deposits was described on it (soil pit 1 and borehole 1). The soil profile consisted of the following horizons: Wca–W1–WB–BCg~ (the index W designates a slightly developed organic horizon).

Test plot 2-01 was set on a flat part of the floodplain under a small grass–forb–sedge association 11.5 m to the south from plot 1-01. The soil profile (pit 4 and borehole 4) consisted of the following horizons: Wca–(C~)–G.

Investigations into the genetic features of the floodplain soils of the Selenga River delta are not numerous [7, 18, 20, 21], and data on the groundwater regime in this area are absent.

We studied the regime and chemical composition of the groundwater in several test plots of the floodplain in relation to the soil processes. This information contributes to our knowledge of the soil-forming processes in hydromorphic delta soils and their regional specificity.

SOIL CHEMISTRY

Specific Features of the Chemical Composition of Groundwater in Floodplain Soils of the Selenga River Delta (Lake Baikal Region)

E. Yu. Shakhmatova, E. O. Makushkin, and V. M. Korsunov†

Institute of General and Experimental Biology, Siberian Branch, Russian Academy of Sciences, ul. M. Sakh'yanovoi 6, Ulan-Ude, 670042 Buryat Republic, Russia
E-mail: ekashakhmat@mail.ru
Received April 19, 2007

Abstract—The chemical composition of groundwater has been studied at several test plots in the Selenga River delta. The fresh groundwater containing calcium bicarbonates favors the formation of nonsaline soils in the delta and, hence, contributes to preservation of fresh water in Lake Baikal. The role of groundwater as a source of dissolved organic matter, iron compounds, phosphorus, and other elements is discussed. It is shown that the depth and chemical composition of the groundwater in particular areas depend on the character of the mesotopography, the drainage of the area, and the soil properties. After the flood period, the concentrations of $\text{Ca}^{2+}$, $\text{HCO}_3^-$, $\text{Fe}^{3+}$, and $\text{SO}_4^{2-}$ in the groundwater increase with the rise in the soil temperatures. In the dry periods, the concentrations of $\text{Na}^+$ and $\text{Cl}^-$ ions increase, whereas the concentration of $\text{C}_{\text{total}}$ decreases.

DOI: 10.1134/S1064229309060064
Test plot 3-01 was found in an old oxbow depression filled with alluvial sediments (52°11′30″ N, 106°22′ E) under a sedge–grass–horsetail association on a mucky gley alluvial soil (pit 2 and borehole 2) consisting of the following horizons: H–Hg–BG–[H].

Test plot 4-01 was set in a hollow 200 m to the north of plot 3-01 under a grass–sedge–cotton grass community on a mucky-gley alluvial soil (pit 5 and borehole 5). The soil profile included the following horizons: Hca–Hca/BG–BG–Gox–G.

The soil cover of the test plots was studied with the use of the comparative-geographic and landscape approaches with the use of stationary observations [13, 14]. Samples of the groundwater and river water were taken, and the groundwater level was determined. The soil water was collected with the use of lysimeters [22]. The chemical composition of the water was determined by the colorimetric method with disulfophenol acid (for nitrate ions), the Griess reagent (for nitrite ions), the Nessler reagent (for ammonium ions), sulfosalicylic acid (for iron ions), and a mixed reagent (for phosphate ions). The water-soluble carbon of organic compounds was determined by the Tyurin method. The physicochemical properties were determined by routine methods (the pH, by the potentiometric method; the exchangeable cations, by the trilometric method); the total nitrogen was determined according to Kjeldahl’s procedure; the total humus, according to Tyurin’s method; and the available phosphorus and potassium compounds, according to the Machigin method in the modification of TsINAO [1, 3]. The diagnostics of the alluvial soils and their taxonomic position were given according to the new Russian soil classification system [9].

RESULTS AND DISCUSSION

Some researchers argue that river water with dissolved salts serves as the main source of the groundwater supply [5, 10]. Other researches believe that the effect of the river water on the ground and soil water in floodplain soils is not very strong [16]. It is important that the chemical composition of the groundwater in floodplain soils depends not only on the textural, mineralogical, and chemical properties of the soils but also on the season and depth of the sampling [4, 17].

We have already shown that the water of the Selenga River in its delta has a bicarbonate–calcium chemical composition. The chemical composition and salinity of the river water in the periods without ice are subject to considerable fluctuations. The water salinity is closely related to the hydrometeorological conditions, the river discharge in particular seasons, and the portion of groundwater in the river alimentation. The effect of the groundwater on the development of the plants and soils in the lower reaches of the Selenga River has been shown in our previous work [21].

Within the studied plots in the delta, the highest content of salts in the river water (as judged from the weight of the dry residue after the water evaporation) is observed in the spring and early summer (Table 1); the salt content in the summer decreases with an increase in the river discharge (which is ensured by the soil thawing in the Selenga River basin). The water reaction in the river channel is neutral or slightly alkaline.

The physicochemical properties of the soils on the test plots vary considerably. Thus, in the weakly developed alluvial soils of plots 1 and 4, the humus contents in the upper horizons comprise 4.7 and 1.6%, respectively; the nitrogen contents reach 0.2 and 0.1%, respectively. In the mucky gley soils (plots 2 and 5), the humus content increases to 5.7–6.3%, and the nitrogen content is 0.31–0.38%. The sum of the exchangeable bases in the upper horizon of the weakly developed stratified alluvial soil (pit 1) is 28 meq/100 g of soil; in the mucky gley soil (pit 2), it reaches 47 meq/100 g of soil. The content of available phosphorus in the upper horizon of the weakly developed soil (pit 1) is 9.7 mg/100 g, and the content of available potassium is 8.0 mg/100 g. In the mucky gley soil, the contents of available phosphorus and potassium are lower: 4.3 and 2.2 mg/100 g of soil, respectively. The distribution patterns of these compounds in the soil profiles are bimodal or polymodal, which is related to the presence of buried horizons. The activity of H⁺ ions changes correspondingly, which affects the chemical composition of the groundwater.

According to our data, the groundwater depth in the soils of the test plots varies within 0.5–1.5 m. The depth and salinity of the groundwater depend on the local mesotopography and drainage conditions.

In the weakly developed stratified alluvial soils with a relatively coarse texture near the river channel (pits 1 and 4; boreholes 1 and 4), the groundwater regime is affected by the regime of the river flow. The upper sandy loamy humus horizons are underlain by a stratified sequence of alluvial deposits with alternating sandy and loamy sandy layers. The clay fraction content does not exceed 3%. The regime of the soil flooding differs from year to year. The groundwater is usually present in the lower part of the soil profile. Gley features are unevenly distributed in the soil profile. The soil reaction is slightly acid to highly alkaline (pH 6.5–8.0).

The groundwater at the lowest points of the floodplain further from the river channel (test plots 3-01 and 4-01) is relatively independent of the regime of river floods. The poor drainage conditions and the impact of floodwater and runoff from slopes in the spring result in the excessive soil moistening and shallow groundwater level (pits 2 and 5; boreholes 2 and 5). Mucky gley alluvial soils may have a thin peat horizon and are characterized by strong gleying and the surface accumulation of organic matter and clay particles. The soils are medium or light loamy in the humus-accumulative