

SUMMARY REPORT

on the scientific and research work

*“Study on Selenga Delta water quality issues” under the contract
RFQ_EMO_2012-009 “Study on Selenga Delta water quality issues”*

At its inflow to Lake Baikal the Selenga river represents the largest freshwater delta in the world occupying a territory of 680 sq km. To a great extent it determines the purity of Lake Baikal waters due to intensive self-purification and sedimentation processes taking place in it. The Selenga delta, one of the largest freshwater deltas in the world was included into the Ramsar List of Wetlands of International Importance (Wetlands) in 1994. The delta is a unique natural entity where organic and biogenic continental off-flow transforms both qualitatively and quantitatively due to intensive biotic turnover (of productional-destructive processes), various physical and chemical factors including substance exchange in the water-ground system. It serves as a natural biological filter protecting the lake from the impact of polluted river waters arriving from the catchment area. In its lower reaches the Selenga river splits into numerous branches forming a vast delta with the total area of 1120 sq km [Bogoyavlenskii, 1974]. The most intensive splitting of the main channel is observed downstream from the Murzino settlement where the lower delta begins occupying the area of about 600 sq km, most of which (85 %) is intermittently flooded. The transforming and purifying role of the Selenga delta is at its maximum during the spring-summer period and is minimal in winter. The main accumulators of chemical substances in water passages are submerged aquatic vegetation, phytoplankton, phytobenthos and bacterial plankton, the development of which is limited by the duration of the warm season. In the last decade climate changes in Lake Baikal basin are accompanied with the reduction of aqueous run-off leading to the decrease of the self-purification ability of the river, increase of pollutants' concentration, intensification of bacterial plankton and phytoplankton development. These derangements are most distinctively seen in the periods of extremely low water content. For instance, in July 2003 discharge of water of the river Selenga equaled just 52 % of the monthly norm. As a result, the ion sink of the river dropped to 0.34 million tons despite the elevated mineralization indexes at July average values of 0.48-0.51 million tons. In average in the period from 1996 to 2005 the ion sink of the Selenga was 20 % below the norm due to low water content. In the most low flow year 2002 it was 32 % below the norm [Sinyukovich et al, 2010]. Under these conditions the development of phytoplankton reached values characteristic of hyper-eutrophic

water bodies [Sorokovikova et al, 2009]. Based on the long-term studies conducted by the research teams from the Baikal Institute of Nature Management and the Limnological Institute of the Siberian Branch of the Russian Academy of Sciences in the period from 2001 to present the most representational water sampling stations in the lower reaches of the Selenga and the delta branches were selected (Fig. 1).

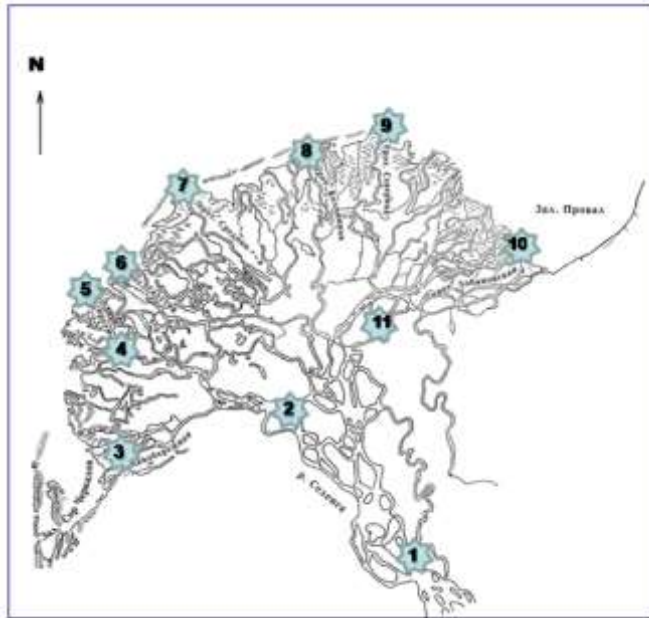


Fig. 1. Schematic map of water sampling

Measurements of the water discharge rates and sample collection for the analysis of various chemical components (dissolved gases, pH, principle ions, biogenic elements, heavy metals, organic compounds) were carried out at selected stations. Simultaneously, samples were taken for the determination of numerosity, biomass and species diversity of bacterial and phytoplankton at the same stations. For the evaluation of water quality and a possibility to select additional sampling stations monthly studies along the Kharauz, the main branch of the delta were carried out from its confluence with the delta to its inflow to Lake Baikal.

The hydrological characteristics

For the fulfillment of hydrological objectives measurements of water discharge rates were carried out on the main branches of the delta in the beginning of their cutoff from the main river channel. Despite some peculiarities of the river off-flow distribution between the branches depending on the water content level it is generally plausible to say that until recently the bulk of the river off-flow (50-55 % in summer and up to 90 % in winter) still goes through the left part of the delta. The most profluent stream in the right part of the delta is the Lobanovskaya branch

(about 30 % of off-flow during the summer period and about 10 % in winter). The least inundated was the central sector of the delta (the Kolpinnaya and Srednyaya branches) through which about 3 % of the river off-flow went. From the middle of winter to springtime these branches usually freeze through and there is practically no off-flow here. Taking into account earlier scientific works and based on the results of the conducted research it is plausible to state that beginning from 1973 the changes in the distribution of the Selenga river off-flow in its delta had a directed character manifested in the reduction of the "transit" role of the southern arm of the delta in general and the main river channel in particular. After 1993 these phenomena considerably weakened. Possibly, this fact is explained by the low water content of the Selenga in the following years, during which no rare floods were registered. Relatively small water rises, including that in July 2012, contributed to insignificant variations of the general distribution pattern of the Selenga's off-flow in its delta, at least for the discharge rate not exceeding 1400-1500 cubic meters/sec. In general, their role in the off-flow transit over the last 15-20 years even grew a little (by 3-4 %) mostly at the expense of the Levoberezhnaya branch. The most significant redistribution of the off-flow took part in the northern part of the delta where the Dologan branch is nowadays the most profluent stream. Its share in the total off-flow of the river Selenga grew up in the period after 1993. At the same time the off-flow through the Galutai, Srednyaya and Kolpinnaya branches grew up. Simultaneously, the off-flow through the Lobanovskaya branch decreased threefold.

The sanitary and microbiological characteristics

Over the observation period in 2012 the level of total coliforming bacteria exceeded the permissible norms set by the sanitation and epidemiological control for drinking water because the standard level presupposes absence of total coliforming bacteria in 100 ml of water. In autumn the total coliforming bacteria levels decreased (1-168 CFU/1 ml) (CFU- colony forming unit) but their presence in water was permanent. Over the recent years [Sorokovikova et al., 1995, 2005] the number of coliforming bacteria has been steadily growing up in the examined area. This is connected with the intensive agricultural activity and intake of industrial and residential waste waters along the entire length of the river. Maximum values exceeded even the norms for public water supply (not more than 1000 CFU/100 ml) as well as norms for recreational water use (not more than 500 CFU/100 ml) [Water. Sanitary Regulations and Standards, 2004]. Presence of the Enterococcus bacterium genus is an additional microbial contamination index. If their number is over 50 in 100 ml of water an excremental contamination intake and a potential epidemiological danger are presupposed. The number of bacteria of

the Enterococcus genus changed within 12-56 CFU/100 ml in summer and 8-50 CFU/100 ml in autumn. In summer the maximum values were detected in the Kharauz branch waters, in autumn they were detected in the Srednyaya branch.

The hydrochemical characteristics

The conducted studies showed that regardless of a season water temperature is 1-1.5° C lower at the mouth of the delta (the Murzino settlement) than in the branches of the central part and the estuary. Besides, the temperature varies approximately by 0.5-1.0° C in large and small branches of the delta. In July, during the increase of water content the water temperature in all branches was the same 20.3° C. In autumn the temperature varied within 7.3-8.8° C range. Gas conditions and pH media in the branches were favorable for the life sustenance of aquatic organisms. Oxygen concentrations did not drop lower than 7.3 mg/l and pH value varied within 7.88-8.90 range. The electric conductivity index in the water of the delta branches varied from 118 to 178 mS/m. Its maximum values were observed in October, while minimal values were registered in mid-July. Concentrations of principle ions HCO_3^- , SO_4^{2-} , Cl^- , Ca^{2+} , Mg^{2+} , Na^+ и K^+ in the water of the delta branches varied within 65-96.4, 6.9-10.2, 0.6-1.2, 15.1-19.9, 2.9-5.1, 3.7-6.2, K^+ - 1.1-1.5 mg/l. The water of the branches as well as of the river Selenga is related to hydrocarbonate class, calcium group (Fig. 1). According to the seasons of the year and the length of branches the relative composition of ions remains constant. Slight variations of the relative water composition in large and small branches may be connected with the specifics of water exchange in them.

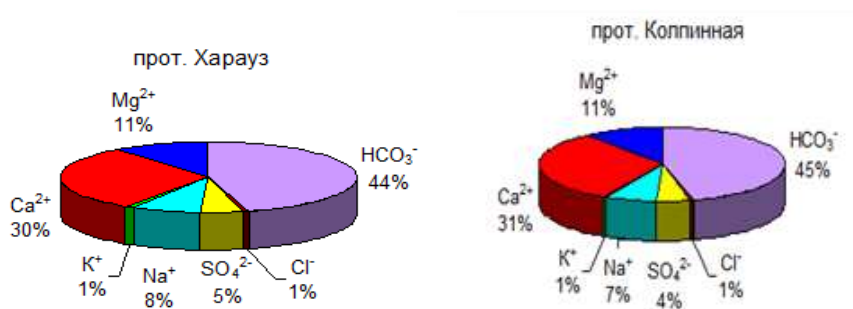


Fig. 1 Relative ion composition in the water of the Selenga delta's branches, 2012 % equivalent.

Concentrations of biogenic elements in the water varied within a wide range, and the maximum values of mineral nitrogen sum (0.50 mg N/l), total and inorganic phosphorus (139 and 24 $\mu\text{g P/l}$) reached rather high values corresponding to those in the excessively trophic water bodies. Water quality in the branches mainly fell into the categories of "rather clean" and "moderately contaminated" according to the content of biogenic elements and organic

substances. Total iron in the examined water samples varied within the interval 63-88 µg/l. Zinc concentrations varied from 0 to 0.2 µg/l. Cadmium concentrations varied from 0.2 to 0.3 µg/l and were within the allowable concentrations and did not exceed the MPC for fishery water bodies. The elevated concentration of iron is characteristic of almost all water sampling stations. Manganese concentration in the examined waters varied within 3-27 µg/l. Specifically high concentrations of manganese were found in the branches of the central part of the delta, Severnaya, Srednyaya and Kolpinnaya. It should be noted that the increased contents of iron and manganese are characteristic of wetland areas due to vegetation decomposition. An elevated content of copper was noted in the Kharauz branch (2 µg/l). Zinc concentrations varied from 0 to 0.2 µg/l, cadmium – from 0.2 to 0.3 µg/l and were within the allowable concentrations and did not exceed the MPC for fishery water bodies. Changes of water content conditions of the river exercised considerable influence. Heavy metals' concentration in the surface water significantly decreased due to a diluting effect, contents of iron and manganese dropped five to tenfold, copper twofold to threefold, zinc from 8 to 12 times in comparison with 2003. On the background of low values of heavy metals contents in the surface waters of the branches of the Selenga a reduction of their concentrations in benthic deposits in the summer-autumn period of 2012 was observed. For the first time the composition the lipidic components (various fatty acids, aldehyds and sterols) in the benthic sediments of the Selenga's branches was determined by the GS-MS (Gas Chromatography-Mass Spectrometry) method. Over 100 compounds were found. Among them specific lipidic markers enabling to identify various groups of microorganisms were determined. Also a screening of the microbial community was carried out using the method of Mass Spectrometry of microbial markers. On the basis of assay content of lipidic markers the microbial composition of benthic sediments was determined. The analysis of lipidic components of the samples demonstrated that some of them may be related to quite certain geni and even species of microorganisms. Representatives of *Firmicutes*, *Proteobacteria*, *Actinobacteria* u *Cyanobacteria* gens play the leading role in the formation of the qualitative composition of the community. In 2012 in the main channel and delta branches 112 species of plankton algae were found. Among them there were 16 blue-green (Cyanobacteriae) algae, 3 Dinophysis, 2 Cryptophytic, 8 Chrysophyceae, 22 diatomic algae, 3 Euglenophyta, and 56 green algae. Very poor development of blue-green algae is a characteristic feature of the Selenga's phytoplankton. It is caused by a significant turbidity of water that contains a mass of SPM of mostly mineral origin and a high river flow rate. In July 2012 a high flood was observed that had an effect on the composition and quantitative indexes of phytoplankton. In the water of the main river channel a

large number of mineral SPM was detected. Water transparency was very low and did not exceed 15 cm. This led to a reduction of the quantity of parvicellular centric diatomic algae in comparison with the dry years [Popovskaya, Tashlykova, 2008]. The development of phytoplankton during the elevated water content in the Selenga corresponded to an oligotrophic type of water bodies. The biomass did not exceed 1 g/cubic m. The saprobity index in the main channel and delta branches varied from 1.6 to 2.4, which corresponded to the 3rd class of purity (moderately contaminated). The elevated content of microorganisms, including pathogenic microbial flora is indicative of a low water quality and a necessity to limit its use for recreational purposes.

Bibliography

1. Bogoyavlenskii, B. A. Urochishcha del'ty r. Selengi / B. A. Bogoyavlenskii // Produktivnost' Baikala i antropogennye izmeneiya ego prirody. – 1974. – s. 5-16. [Bogoyavlenskii, B.A. The Stows of the Selenga Delta. In *The productivity of Lake Baikal and the man-made changes of its nature*. – 1974. – pp. 5-16].
2. Sinyukovich, V. N. Izmenenie klimata i khimicheskii stok reki Selengi / V. N. Sinyukovich et al. // DAN. – 2010. - # 6. – s. 817-821. [Sinyukovich, V.N. The climate changes and the chemical off-flow of the river Selenga. In *DAN*. – 2010. - # 6. – pp. 817-821].
3. Sorokovikova, L. M. Prostranstvenno-vremennaya izmenchivost' sodержaniya biogennykh i organicheskikh veshchestv i fitoplanktona v vode r. Selengi i protokakh ee del'ty / L. M. Sorokovikova et al. // Geografiya i prirodnye resursy. Geografiya i prirodnye resursy. – 2009. – # 4. – s. 465-474. [Sorokovikova, L.M. The space-time variability of the biogenic and organic substances' content and phytoplankton in the water of the river Selenga and its delta's branches. In *Geography and Natural Resources*. – 2009. – # 4. – pp. 465-474].
4. Sorokovikova, L. M. Ekologicheskie osobennosti r. Selengi v usloviyakh navodneniya / L.M. Sorokovikova et al // Geografiya i prirodnye resursy. – 1995. - # 4. – s. 64-71. [Sorokovikova, L.M. The ecological specifics of the Selenga river in the conditions of flooding. In *Geography and Natural Resources*. – 1995. - # 4. – pp. 64-71.].
5. Sorokovikova, L. M. Kachestvo vod v del'te r. Selengi / L.M. Sorokovikova, A.K. Tulokhonov et al. // Geografiya i prirodnye resursy. – 2005. - #1. – s. 73-80. [Sorokovikova L.M. et al. Water Quality in the Selenga Delta. In *Geography and Natural Resources*. – 2005. - #1. – pp. 73-80.]

6. SanPiN 2.1.5.980-00. Gigienicheskie trebovaniya k okhrane poverkhnostnykh vod // M.: Minzdrav Rossii. – 2000. [SanPiN 2.1.5.980-00. Hygienic requirements to the protection of surface waters. Moscow: Ministry of Health of the Russian Federation. – 2000].

7. Sorokovikova, L. M. Khimicheskii sostav vody i fitoplanktona vodnykh ob'ektov del'ty r. Selengi v polednyi period / L.M. Sorokovikova et al. // Vod. resursy. – 2006. – Vol. 33. - # 3. – s. 349-356. [Sorokovikova L.M. The chemical water and phytoplankton composition of the water bodies of the Selenga delta in the under-ice period. In *Water Resources*. – 2006. – Vol. 33. - # 3. – pp. 349-356].