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# An Annotated Report

on the scientific research work on a theme:
"The Study of Issues Connected with the Habitat and Health of the Benthic Zone in the Selenga River Delta"

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The drainage area of the UNESCO World Natural Heritage Site Lake Baikal is an enormous transboundary ecosystem owing to the Selenga, its largest tributary. Forty-six per cent of its total area is located in Mongolia. The river's catchment area equals 447.060 sq km out of which 148.060 sq km (33 %) are in Russia, while 67 % are in Mongolia. The river basin makes up over 80 % of the drainage area of Lake Baikal. This fact makes Mongolia important for the ecological health of the lake in the long run. The confluence of the Selenga and Lake Baikal forms the world's largest fresh water delta occupying an area of 680 sq km. To a great extent the delta determines purity of Lake Baikal's waters due to intensive processes of self-purification and sedimentation taking place in it. The main threats for the Selenga river basin and the drainage area of Lake Baikal in general are climate changes, development of industry and elevation of the pollutants' volumes, destruction of wildlife habitats and shrinking of biodiversity, invasions of alien species and their naturalization.

Despite significant knowledge accumulated over more than a hundred years of study of various components of the Selenga's and Lake Baikal's ecosystems, it is still insufficient for the analysis of processes currently taking place in them under the conditions of significant climate changes and increasing man-induced impact. All this predetermines the acute necessity of work to examine issues connected with the habitat and health of the benthic zone in the Selenga river delta.

Collection of field research data in the benthic zone of the Selenga was carried out on a monthly basis from 16 July to 26 October 2012 at 5 stations (Fig. 1) distributed relatively evenly along the main channel and adjacent branches (see Tab.)

Table

| Station name | Geographical coordinates of stations |
|---|---|
| # 1: Gusevskaya branch | N: 52 11. 817'; E: 106 29. 732' |
| # 2: Shustikha branch | N: 52 08. 000'; E: 106 33. 944' |
| # 3: Delta front (Lake Baikal) | N: 52 17. 508'; E: 106 16. 318' |
| # 4: Lower reach of the Selenga | N: 52 16. 986'; E: 106 16. 781' |
| # 5: Peretaska branch | N: 52 13. 046'; E: 106 23. 694' |

The choice of the branches of the southern delta group as objects of monitoring was primarily determined by their most significant input into the total volume of the river flow (up to 65 % in summer and up to 95 % in wintertime), and secondly, by their location in the most populated and acquired part of the delta. Remote sensors monitoring the water and air temperature were installed in the chosen locations and they recorded data throughout the entire study period. Hydrobiological and ichthyological samples were selected in accordance with the standard practice methods.

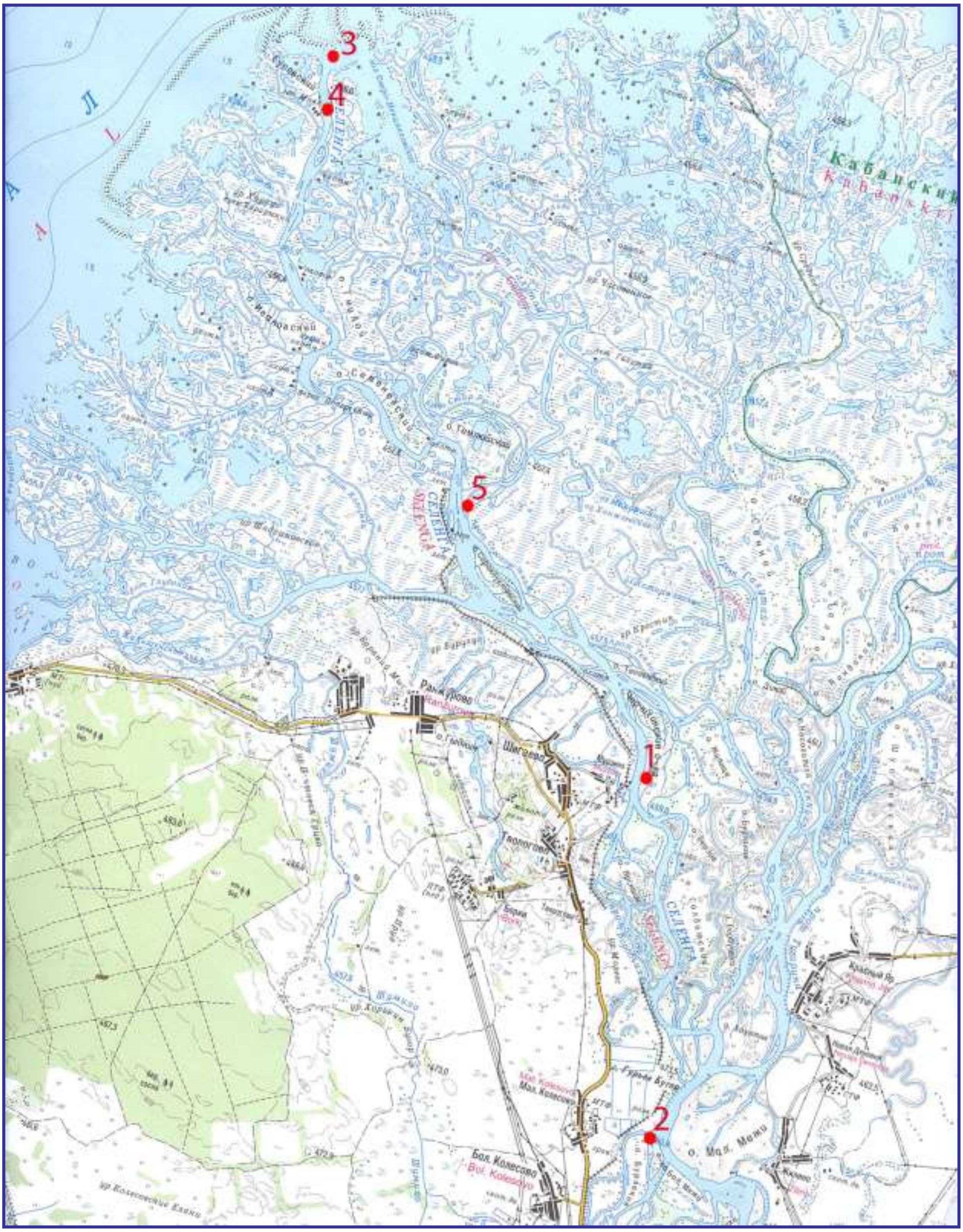


Fig. 1. Sampling map in Selenga delta area.

Project research was carried out in a year extreme according to a number of abiotic factors. A maximum water level over the past 14 years was observed in the delta front of the river. The maximum level values were registered in July. In this period the water level could rise by 30-40 cm. It was followed by an even decrease that equaled about a meter by early September. Consequently, other abiotic parameters sharply changed with the water level rise.

The water temperature changed from 7.3 to 21.4˚ C over the observation period. Lower values were observed in autumn. At the entry to the delta (Murzino settlement) the water temperature was by 1 – 1.5˚ C lower than in the central section of the branches and near the exit regardless of the season. In this way, the water temperature in July changed from 19.4 to 22.4˚ C. Low temperature (19.4˚ C) was observed at the entry to the delta. Further on and as the river flow rate slowed down it gradually increased, equaling 20.4-20.6˚ C in the central part and 21.4˚ C in the Kharauz branch estuary.

Dissolved oxygen concentration changed from 7.4 to 11.4 mg/l or from 86 to 107 % oxygen saturation. The elevated oxygen content was registered in the autumn period. This is caused by an increase of solubility when the water temperature cooled down. The highest oxygen content was detected in some areas of the delta rich in aquatic vegetation, where it reached 16.7 mg/l (196 % of saturation).

The pH value of water changed from 7.22 to 8.33. Dynamics of pH depends on many factors, such as intake of low acidity precipitation from the catchment area, elevated content of organic substances and absorption of carbon dioxide by phytoplankton and so on. In July 2012 the pH value of water was notably lower than in October. This was connected with the surplus of water in July due to heavy rains, organic substances intake from the catchment area and higher concentrations of carbon dioxide against the background of a low level of phytoplankton development.

The river flow rate decreased from August to October at all stations. A high river flow rate was registered in the lower reaches of the river at station # 4 (0.6 meters per second in August and 0.32 meters per second in October) and in the narrow Gusevskaya branch (Fig. 2) (0.52 mps in August and 0.44 mps in October). At station # 2 the river flow rates were minimal: 0.34 mps in August and in October the water there was quiescent.

Fig. 2. Gusevskaya branch (station 1). General view of the duct and sampling point (marked by arrow).

Significant changes of the level and rate of river flow (Fig. 3) in a number of cases resulted in a change of flow direction in the branches, changes of the ground texture and river bed type. To a certain degree this influenced the structure and productivity of the zoobenthos and feeding of fish and their food relations. In order to precisely identify various ground types a color atlas was prepared.

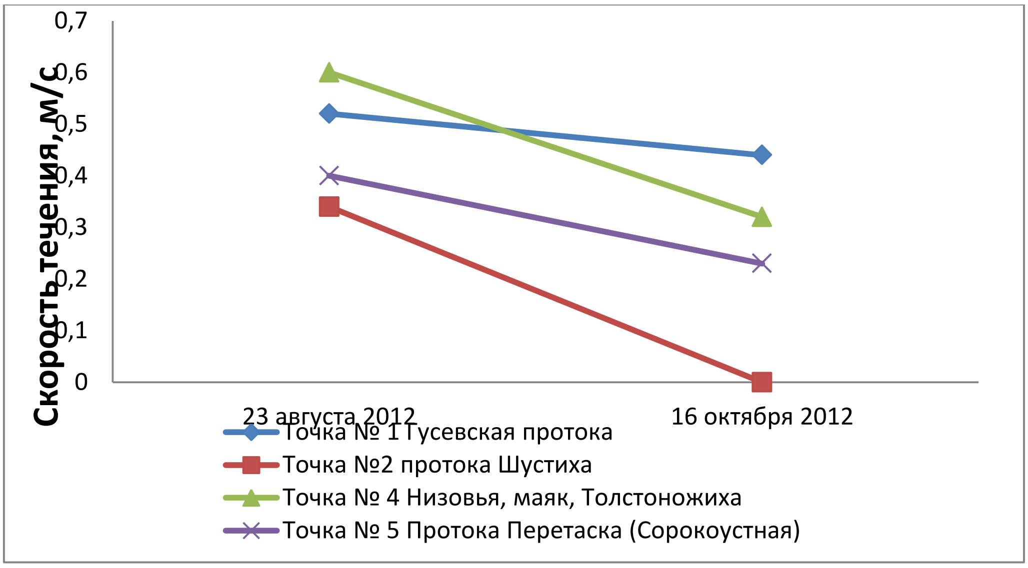


Fig. 3. Changes in river flow on 4 standard observation stations (Aug 2012-Oct 2012)

Studies of meio- and macroalgae of the Selenga river delta allowed compiling a list of meio- and macroalgae of the Selenga delta consisting of 22 species belonging to 4 branches. Eight species from this list are new for the algal flora of the river and four are still not identified as species (in scientific literature only 10 species are known). In the course of the research project a herbarium of charophytes was gathered (consisting of over 50 leaves) as well as about 20 fixed algal samples.

All discovered macroalgae reached mass reproduction and became coenosis producers. Later, when the level decreased and they died out, they formed coastal benthic detritus deposits (CBDD). First signs of emergence of natural CBDD were registered as the water level was decreasing in August.

We obtained preliminary data about percentage composition of benthic algae found in those CBDD. For this purpose three sites were laid on 25 August 2012 in one of the places with mass accumulation of CBDD (a rather typical in this sense piece of river bank, the Zavernyaikha branch, coordinates of sampling point 52°10´271´´ N 106° 30´ 424´´ E) located at a distance of 50-100 m from each other. The total area of each site was 400 sq cm. The mass of pressed macroalgae accumulations (green weight): $m^1$ = 39,84 g; $m^2$ = 57,40 г; $m^3$ = 47,48 g. Average green weight per one site was 48.24 g/400 sq cm or 1206 g per 1 sq m. The approximate percentage composition of summer formed CBDD was as follows: 60-70% *Oedogonium* sp. ster. и 30-40% *Cladophora fracta*.

The composition of CBDD formed in autumn was studied on the basis of aforementioned quantitative samples. It turned out that in September these CBDDs by 100 % consisted of *Cladophora fracta* with a minor admixture of *Oedogonium* sp. Ster threads.

Such mass vegetation of green algae of *Cladophora* genus most probably testifies to a significant eutrophication of the Selenga. Unfortunately due to absence of similar data we are unable to provide any comparisons of quantitative characteristics of CBDD of the lower reaches of the Selenga. It should only be noted that in comparison with Lake Baikal, the Selenga CBDD found by us in the summer-autumn period of 2012 differed both in abundance and composition of the algae and in the manner of their production (Timoshkin et al, 2012 a; b). Unlike CBDD of Baikal formed in classical manner (wrack or dead animals washed ashore), the main reason of forming the Selenga CBDD is lowering of the water level in the river. Studies of microorganisms in intersticial water from a lunule dug on the river bank under the CBDD established that the number of amylolytic (starch-splitting), proteolytic (protein-splitting) and saprophyte microorganisms (CFU/ml) by several times exceeded those found at the standard stations. The number of amylolytic microorganisms was 1060 CFU/ml, proteolytic microorganisms 6040 CFU/ml and saprophytes 8100 CFU/ml.

The distinctness of composition and dynamics of the Selenga delta's grounds determine the structure of benthic population. In general, oligochaetes dominated numerically in the entire examined area over the whole four months and only in October chironomides prevailed. The latter play a significant role during the summer months as well. The oligochaetes also played the dominant role in the biomass. In July they formed more than a half of total biomass and approximately a quarter in the period from August to October.

During the study period average indexes of numerosity and biomass in the examined area fluctuated within the following limits: numerosity 3770-8332 specimen/sq m, biomass 2.90-22.25 g/sq m and considerably exceeded the data registered in summer 1972 in the lower reaches of the Selenga including the delta area (Syroezhkina, 1972). In August the numerosity and biomass significantly increased and then in October the biomass fell by more than four times, while the numerosity was only slightly changing. A sharp decrease of quantitative indexes in September may, perhaps, be explained by the appearance (exposition) of pebble spots and gravel practically devoid of silt and detritus.

The zoobenthos has easy-to-see differences. At the upper part of the delta (station # 2, the Shustikha branch) the zoobenthos is most diverse. Average indexes of numerosity and biomass fluctuate within the following limits: 810-8408 specimen/sq m and 0.87-2.53 g/sq m. The zoobenthos at this site has a complex structure (virtually all known group of invertebrates in the river can be found there), but group correlation was notably unstable.

Next station (# 1) is located down the stream in approximately 15 km from the previous one in one of the transverse river branches with lower river flow rates in comparison with the main channel. The zoobenthos at this station was not diverse. The oligochaetes numerically dominated in July and October (51-41 %) and chironomides (45-36 %), oligochetes dominated in August (67 %) while chironomides – in September (72 %). The biomass is formed in the following way: in July, August and September by chironomides (47, 39 and 47 % respectively) and oligochetes (44, 27, 25 % respectively). In October it is formed by shell (45 %) and Amphipoda (44 %). The numbers of last two groups were small in October (2 and 13 % respectively).

At station # 5 in the Peretaska branch the zoobenthos significantly changed in different months. Average indexes of numerosity and biomass fluctuated within a broad range 933-11320 specimen/sq m and 0.64-11.74 g/sq m. In July oligochetes (49 %) and chironomides (39 %) dominated numerically. In August oligochetes formed the basis of numerosity (81 %), while Amphipoda (64 %) did in September, and chironomides (53 %), Amphipoda (21 %) and oligochetes (15 %) in October.

A totally different group ratio was observed at this station in biomass. In July, at its low value (0.81 g/sq m), oligochetes (37 %) and chironomides (18 %) dominated. In August the total biomass grew to 7.56 g/ sq m and consisted of oligochetes (32 %), shells (27 %), chironomides (19 %) and other dipterans (22 %). In September the lowest biomass was observed (0.64 g/sq m), a half of which was formed by chironomides (57 %), Amphipoda (20 %) and shells (17 %). As at site 2, at this station the benthos is characterized by significant changeability over time.

In the estuary of the main channel (station # 4) the zoobenthos structure was more stable and the quantitative indexes grew from July to October (480-6133 specimen/ sq m and 0.59-12.73 g/sq m) owing it to an increase in the numbers of oligochetes and Amphipoda.

At station # 3 located approximately 0.5 km into the lake from the Emergency Ministry's ranging mark the numerosity of zoobenthos was determined by oligochetes. At the same time the biomass was composed of shells, oligochetes, amphipoda and large dragonflies. In general, the highest biomass indexes were registered at this site: 8.81 g/ sq m in July, 40.86 g/ sq m in August, 22.41 g/sq m in September with the numerosity 11300 specimen/sq m, 27053 specimen/sq m and 8420 specimen/sq m respectively.

Flooding and sharp water level increases in the river considerably affect the ground composition and, consequently, the structure of benthic communities. An analysis of zoobenthos dynamics of the examined site showed a considerable changeability of its qualitative and quantitative composition. Average indexes of numerosity and biomass ranged significantly over the examined area.

In all research months the macrozoobenthos consisted of oligochetes, chironomides, shells amphipoda, dayflies, stone flies, dragonflies, caddis flies, beetles, bugs, ticks, biting midges and other dipterans. In the group composition of the zoobenthos oligochetes dominated almost everywhere. At certain stations chironomides, Amphipoda and shells played a significant role. At the certain sites of the main channel of the Selenga delta Empididae, Ceratopogonidae, Limoniidae dipteran larvae played an important role in the formation of the zoobenthos. In the period of our study the Amphipoda were encountered in the entire examination area except in July, when they were registered only in the river estuary (end of delta) and in Lake Baikal near the river estuary. In August and October at two stations (the Gusevskaya branch, a lake opposite to the Selenga estuary) two specimen of large clam (swan mussel) were found. Their weight reaches 8 grams.

The composition and quantitative indexes of macrozoobenthos point at the considerable eutrophication of the examined site.

During the study period the following fish species were noted in the fish fauna composition: pike, Amur carp, nerfling, dace, bream, roach, Siberian spiny loach, Amur catfish, river perch, Amur sleeper. In October, besides the aforementioned fish species other species were found in the catch: eelpout, Baikal omul and white Baikal grayling making transit migrations through the delta at this season. Ten of the mentioned species are native species. Amur carp, bream, Amur catfish and Amur sleeper are introduced species that got into the ecosystem either through acclimatization or as invasive species (Amur sleeper).

Despite a relatively high species diversity of benthos-feeding fish in the lower reaches of the river Selenga only three of them, namely, dace, roach and river perch can be related to structure-forming dominant species in all three examined sections of the delta. In its turn, the Amur sleeper was the most frequently met and mass species in isolated and semi-isolated lakes and dead stream branches of the delta.

The results of the conducted analysis of dominant fish species of the Selenga delta from the catches at three ranging marks in its upper, middle and lower parts are indicative of an important role of vegetational components in their food ration, i.e. mostly filamentous algae in all seasons of the study.

Filamentous algae represent a practically unlimited food resource for cyprinid fish (besides roach and dace also nerfling, bream and carp). In their turn, by feeding on filamentous algae the cyprinid fish in a certain way contribute to cleansing the water from excessive algae.

A lower significance of the zoobenthos organisms in the feeding of the main fish species during the study period in 2012 compared to the results of the previous years (in scientific literature) may be caused by an impact of an anomalous flooding that lasted practically throughout the summer. High levels and high river flow rates resulted in intensified and lengthy changes of channel branches, overwashing of the grounds and changing of their structure. Undoubtedly, this had an effect on the zoobenthos organisms and led to a change of structure of their communities and lowering of the quantitative indexes, which, in its turn, reflected on their consumption by fish.

The conducted analysis of feeding selectivity of the dominant fish species in relation to the zoobenthos organisms is indicative of the fact that in summer months (July, August) the fish consumed the benthos organisms in considerably lower proportions that the latter are represented in benthic population or did not feed on them at all. This testifies to an insignificant degree of fish impact on them in this period.

In autumn (September, October) as the water level and river flow rates decrease a stabilization of benthic grounds takes place. In its turn, this leads to a recovery of zoobenthos communities' structures and a growth of its quantitative indexes. At the same time, due to a number of reasons, a considerable diminishment of the development of filamentous algae and their availability to fish occurs. This explains an elevated significance of zoobenthos in their food ration.

Thereby in the upper parts of the delta the main impact is laid on the shells. Their index of electivity E reaches +1. In the middle and lower reaches in addition to shells (E=+0.8–0.95) Amphipoda are quite intensively eliminated (E=+0.2–0.25).

It is hardly worth while mentioning any impact of such introduced species as the Amur carp, bream and the Amur catfish because their numbers here nowadays is low. The analysis of small articles about the feeding of these species is indicative of the fact that Amur carp and bream have feeding patterns similar to those of roach and dace. In this way, during the intensive summer fattening season they can use practically unlimited vegetational resources of the delta water bodies. The Amur catfish is a predatory fish and it practically does not affect the zoobenthic organisms.

The Amur sleeper is a different story. It first infiltrated into Lake Baikal basin in 1969 and quickly inhabited all favorable habitats. In the Selenga delta its numbers peaked in the mid- to late 1990s. In the past years a considerable reduction of its numbers took place because it was included into the food ration of practically all predatory fish and piscivorous birds. Unfortunately, at the peak of its numerosity no detailed estimations of its impact on the zoobenthos were carried out. Nowadays the numbers of Amur sleeper stabilized again. Its habitat in the delta is mostly confined to semi-isolated and isolated shallow water bodies where most of Amur sleepers are localized. Practically all age groups of this species render visible influence on the zoobenthos organisms. Young age groups consume chironomides' larvae (E=+0.95–1.0) and small caddis flies (E=+0.75–0.85). Old age groups, besides this, prefer shells (E up to +1). Notably, by autumn in isolated water bodies the Amur sleeper eats out practically all benthic organisms, even large dragonfly larvae. In such situations larger Amur sleeper species start feeding on smaller species. The most effective method of controlling the number of the Amur sleeper is the biological one based on maintaining of a high numerosity of predatory fish, such as pike, river perch, catfish and piscivorous birds.

An evaluation of the degree of pollution by hard domestic waste of the delta banks was carried out throughout the entire period of research. The hard domestic waste mostly consisted of glass bottles (24 %), tinware (tin cans, etc. 19 %). The most frequently encountered hard domestic waste were various plastic things: bottles (7 %), food packages, corks, plastic bags, disposable plastic dishes, clothes, footwear, toys, plastic package boxes (46 %). The average number of waste per square unit on the island part of the delta (2.17 kg/100 sq m) turned out to be higher than on the mainland (1.33/100 sq m).

## Conclusion

Project research was carried out in a year extreme according to a number of abiotic factors. In this connection the results about quantitative and qualitative characteristics of the zoobenthos and living environment of aquatic organisms may considerably vary from “typical” years of small and average water content of the river.

First data about the quantitative and qualitative indexes of the Selenga delta’s zoobenthos (dredge samples) in the summer-autumn period were obtained. The first atlas of the benthos zone’s grounds at the examined stations was compiled (its major part is presented in the report). It may serve as a basis for further study of benthic fauna and flora of the Selenga. First data on the composition, quantitative characteristics and formation mechanism of CBDD and hard domestic waste on the banks of the main channel of the river was obtained. The presented information on CBDD and HDW may be a background for carrying out of scientific work and monitoring of the Selenga delta in the future. Feeding of the main benthos-feeding fish of the delta was studied in detail and their impact on the zoobenthos organisms was evaluated. It was established that in the period of summer intensive fattening the fish mostly consume the practically unlimited vegetational resources and only in the autumn they mostly turn to feeding on the zoobenthic organisms. However, their impact on the zoobenthos is not serious due to the end of the intensive fattening period.

The taxonomical composition and quantitative characteristics of the CBDD in August-September 2012 are the evidence of high trophicity of the river Selenga. It is known that the species of the *Cladophora* и *Oedogonium* species are indicators of high water body trophicity.

As the conducted studies showed, the coastal area of the delta is heavily polluted by hard domestic wastes.

We strongly recommend carrying out of further monitoring works to evaluate the health of the benthic zone of the Selenga delta.