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Hydrochemical Characteristics of Selenge River and its Tributaries on the Territory of Mongolia

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Abstract

Hydrochemical research of the Selenge and its main tributary the Orkhon river on the territory of Mongolia has been conducted. Concentrations of the main water ions were measured. Distribution of heavy metals was determined. Dynamics of biogenic elements (NO_3^-, NH_4^+, phosphates) and degree of phenol pollution was determined.

Key words: Baikal, biogenic, heavy metals, ions, phenol, Selenge River

Introduction

During the last 30-40 years Lake Baikal has been influenced by various anthropogenic factors. Industrial and household waste water have changed the chemical composition of Baikal with a deterioration in water quality in the basin territory. According to sustainable development policy, protection of Baikal region is considered one of the priorities of environmental conservation. The main indicator of the condition of Lake Baikal is water characteristics of Selenge tributary (57 % of flow), from which 4 million tons of mineral substances, 0.4 million tons of organic matter, 1 million tons of solid particles and 0.2 million tons of oil products arrive annually (Dugarova, 2002). Two thirds of the Selenge river basin is situated in Mongolia. The length of the Selenge river on the territory of Mongolia is 1043 km.

The Selenge river formed as a result of joining the rivers Ider and Muren and its source is in the Khangai (Mongolian Altai). The main tributaries of the Selenge river in Mongolia are the rivers Tuul, Orkhon and Kharaa with the main industrial districts situated on their banks (Fig. 1). These industrial towns include Erdenet and Govi, a metallurgy plant in Darkhan, carpet and woollen enterprises, meat processing and goldmining plants in Booro and Zaamara. Industrial wastewater pollution is having an adverse effect on the environment destroying natural processes of degradation within biological communities. The river is polluted along its entire length. To assess the current ecological condition in the Mongolian part of the Selenge river basin, it is necessary to implement hydrobiological and hydrochemical monitoring. It requires information not only of chemical composition, but of biogenic components in the processes of accumulation and transformation in water, bottom sediments and river banks.

The main aim of the work is to research hydrochemical characteristics of the Mongolian part of the Selenge river and close water arteries to identify chemical elements (heavy metals, basic ions and biogenic elements) and estimate their influence on Lake Baikal.

Fig. 1. Map of the sample locations

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Methods

Hydrological and hydrochemical research on rivers of the Selenge basin in Central, Selenge, Ovurkhangai regions of Mongolia was conducted. Water from the rivers Tuul, Khogshin Orkhon, Eroo, Selenge was sampled in July-August 2002. Samples were taken once from each site.

Near the water temperature was taken with an electric sensor thermometer "Prima", pH with portative precision pH-meter PRO, redox potential with a redox potential tester ORP and mineralization with a portative tester-conductometer TDS-4. Determination of cations and heavy metals was by atomic-absorption method of spectrophotometry SOLAAR. Relative accuracy is 2-3 %. Anion determination was carried out according to known procedures (Lurye, 1984).

Table 1. Physical and chemical characteristics of Selenge catchment (*maximum and minimum values in bold*)

№	Rivers	Coordinates of sample selection	Temperature, °C	pH	Salinity, g/l	Eh, мV
1	Tuul	N 47° 51' 788'' E 105° 11' 866''	15.7	**6.5**	0.101	+308
2	Khogshin Orkhon	N 47° 08' 891'' E 102° 59' 058''	13	8.1	**0.208**	**+238**
3	Orkhon 1	N 47° 11' 778'' E 102° 47' 454''	15.9	**8.6**	0.083	+253
4	Orkhon 2	Bridge Darkhan-Erdenet	**18.0**	8.1	0.15	+297
5	Orkhon 3	N 50° 11' 754'' E 106° 11' 491''	**12.8**	7.6	0.11	**+480**
6	Selenge 1	N 49° 28' 124'' E 104° 17' 074	13.7	7.9	0.15	+381
7	Selenge 2	N 50° 11' 852'' E 106° 11' 396''	13.2	7.6	0.10	+476
8	Eroo	N 49° 52' 950'' E 106° 16' 285''	15.6	7.8	**0.06**	+400

Biogenic element were determinated was by colorimetry, nitrate nitrogen with disulfophenol acid, ammonium nitrogen with Nessler reagent, phosphates by reduction with ascorbic acid. Identification and quantitative determination of phenol near SukhBaatar city was performed by gas chromatography with electronic capture detection on the gas chromatograph Hewlett-Packard 6890.

Results

Temperature, pH environment activity, general mineralization, reduction-oxidation potential were determined (Table 1). Water temperature was 12.8-18.0 °C. The pH value of water varied from 6.5 (Tuul) to 8.6 (Orkhon 1) and decreased to 7.6 up to the junction with Selenge river.

Main ions: Concentration of the main ions are shown in Table 2. The highest concentration is found on the Mongolian border (645.8mg/l). Hydrocarbonate ion content is 31.7 mg/l in the tributaries Tuul, Eroo, 148.80 mg/l in Orkhon, 100.00 mg/l (average) in Selenge up to 407.5 mg/l on the border of Mongolia. In tributaries of the river Orkhon (Kharaa and Sharin Gol) there is a high concentration of sulfate ions, 24.0 and 21.0 mg/l respectively. Chloride ion concentration varies from 14.2 mg/l (Tuul) to 36.8 mg/l (Orkhon 2). A general tendency for an increase in anion quantity from tributaries to Mongolian border is observed.

Among dominant cations are calcium ions, whose concentration varied from 12.0 to 48.0 mg/l. Magnesium concentration varied from 1.2 (Eroo) to 34.8 mg/l (Selenge) on the border. There does not seem to be a big difference in potassium ion concentration between the sampled sites. Sodium ion content increases sharply downstream from tributaries (3.5 mg/l at Eroo; 4.73 mg/l (average) at Tuul; 10.0 mg/l at Kharaa) up to 109.0 mg/l at Selenge on the Mongolian border. Anions correlation in waters of the rivers in Mongolia is $HCO_3^- > SO_4^{2-} > Cl^-$, cations one – $Ca^{2+} > Na^+ > K^+ > Mg^{2+}$.

Biogenic elements: Ammonium nitrogen content in tributaries of the river Orkhon varied from 0.03 mg/l in Eroo and Kharaa rivers to 0.42 mg/l in the river Sharin Gol. In the waters of Orkhon ammonium nitrogen reached 0.42 mg/l (Orkhon 3) and at the junction with Selenge river was 0.08 mg/l

Table 2. Concentration of main ions in water of Selenge catchment, mg/l (*maximum and minimum values in bold*)

№	Locality of sample selection	CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	K^+	Na^+
3	Orkhon 1	**2.4**	109.8	36.8	2.25	24.0	8.4	1.4	9.0
4	Orkhon 2	4.8	153.7	34.0	6.25	40.0	9.6	1.7	32.0
5	Orkhon 3	-	100.0	26.9	2.85	24.0	7.2	0.9	30.0
9	Orkhon 2 bridge	**4.8**	148.8	**36.8**	5.25	38.0	7.2	1.1	14.0
2	Khogshin Orkhon	-	241.6	25.5	3.5	36.0	**14.4**	**2.4**	43.0
6	Selenge 1	4.8	163.5	18.4	5.25	**48.0**	10.8	1.05	50.0
7	Selenge 2	-	100	24.1	6.75	32.0	12.0	0.6	70.0
10	Selenge (border of Mongolia)	2.4	**407.5**	34.0	**21.0**	36.0	34.8	1.1	**109.0**
8	Eroo1	-	46.4	19.8	1.25	12.0	**1.2**	0.55	3.7
11	Tuul (Ekh Tengeri)	-	31.7	14.2	0.25	**12.0**	1.2	**0.20**	**2.5**
12	Sharin Gol	-	197.6	19.8	21.0	46.0	12.0	1.7	16.0
1	Tuul (Ulanbatar)	-	**31.7**	**18.4**	**0.2**	14.0	2.4	0.3	2.7
13	Kharaa	-	163.4	32.6	24.0	46.0	13.2	1.25	10.0

Table 3. Concentration of biogenic elements in water of Selenge catchment, mg/l (*maximum and minimum values in bold*)

№	Rivers and stations	NO_3^-	NH_4^+	P_2O_5	P
3	Orkhon 1	**7.6**	0.05	0.18	0.078
4	Orkhon 2	4.1	0.05	**0.74**	**0.323**
9	Orkhon 2 (bridge)	1.4	0.03	0.15	0.065
5	Orkhon 3	1.2	**0.42**	0.12	0.052
2	Khogshin Orkhon	1.2	0.05	0.02	0.009
6	Selenge 1	1.64	0.08	0.33	0.144
7	Selenge 2	0.8	0.05	0.13	0.057
10	Selenge (border of Mongolia)	1.24	**0.007**	0.02	0.09
8	Eroo 1	0.92	0.05	0.06	0.026
11	Tuul (Ekh Tengeri)	0.38	0.03	0.03	0.013
12	Sharin Gol	0.58	0.42	0.33	0.144
1	Tuul (Ulanbatar)	0.404	0.03	0.02	0.009
13	Kharaa	0.76	0.03	0.11	0.048
14	Tuul	1.16	0.08	0.26	0.113
15	Eroo 5	**0.18**	0.03	**0.01**	**0.004**

Table 4. Concentration of heavy metals in water of Selenge catchment, mg/l (*maximum and minimum values in bold*)

№	Rivers and stations	Cu	Cr	Ni	Pb	Zn	Cd	Co
4	Orkhon 2	0.0843	0.0057	0	0.0125	0	**0**	**0**
5	Orkhon 3	0.0281	**0.0044**	0.0002	0.0195	**0**	0.0009	0
2	Khogshin Orkhon	0.069	0.0101	**0**	**1.4371**	0.0002	0.0003	0
6	Selenge 1	0.03	0.0574	0.0054	0.0147	0	**0.0091**	0
7	Selenge 2	0.0354	0.0419	0.0128	0.0191	0	0.0016	0.0050
1	Tuul (Ekh Tengeri)	0.0366	**0.2946**	0	0.0099	0	0.0004	0
12	Sharin Gol	**0.0092**	0.0116	0	**0.0038**	0	0	0
1	Tuul (Ulanbatar)	0.0342	0.0591	**0.0157**	0.0148	**0.0992**	0	0.0001
13	Kharaa	0.0330	0.0381	0.0005	0.0205	0	0	0
14	Tuul	**0.1624**	0.0511	0.0041	0.019	0	0	0
15	Eroo 5	0.0599	0.0164	0.0131	0.0232	0	0.0006	**0.0062**

(Selenge 1). Nitrate nitrogen content in water changed in the same succession from tributaries: 0.18 mg/l in Eroo; 0.76 mg/l in Kharaa; 0.38-1.16 mg/l in Tuul to 1.2-1.4 mg/l in Orkhon and 1.64 mg/l at the Selenge river. Nitrite nitrogen was not found. Phosphate concentration was 0.11 mg/l in Kharaa; 0.02-0.26 mg/l in Tuul; 0.01-0.06 mg/l in Eroo; 0.12-0.74 mg/l in Orkhon; 0.13-0.33 mg/l in Selenge. Accumulation of biogenic elements is observed from the tributaries of Orkhon to their joining with Selenge (Table 3).

Heavy metals: Total concentration of heavy

metals are shown in Table 4. Copper content varies from 0.0092 – 1.624 mg/l. In Orkhon head water copper concentration is 0.069 mg/l, that is rather higher than maximum permissible concentration (MPC) (0.001 mg/l). Lead concentration varies from 0.0038-1.437 mg/l, that is higher than lead MPC (0.006 mg/l). Chromium content varies from 0.0044 to 0.2946 mg/l (chromium MPC= 0.001 mg/l). High values of the high metal concentrations on the Orkhon (Tuul, Kharaa, Eroo) should be noted, in Khogshin Orkhon lead is 1.4371 mg/l, chromium in Tuul is 0.2946 mg/l. Distribution of heavy metals downstream of the Orkhon river and comparative characteristics at sampled sites show the decrease of heavy metal concentration downstream of the Orkhon river.

Phenol: The literature shows, that in 1998 phenol concentration of the Selenge river on Mongolian territory was 0.0052 mg/l, in 1999 it was 0.0039, in 2000 it was 0.0047, in 2001 it was 0.0056 mg/l (Dugarova, 2002). According to our data the phenol pollution level in 2002 was 0.00091 mg/l, that is normal MPC (0.001 mg/l).

Discussion

The literature lacks research data on the main ions, biogenic elements and heavy metals for the Selenge basin region. Also microbiological research has not been conducted. The data presented here is the first such data on the complex research of the Selenge river basin ecosystem in Mongolia. We considered the territory from Ulaanbaatar to the station Naushki (boundary railway station). In waters of the Selenge river and its tributaries HCO_3^- and Ca^{2+} dominate (refers to hydrocarbonate class, group of calcium).

Analysis of the total content of chrome, lead and copper in tributaries of the river Selenge, e.g. Orkhon, Tuul, Eroo, Kharaa exceeds MPC. The Selenge river water is polluted by nickel and cadmium. The comparative study of water characteristics in the Selenge river and its tributaries in Mongolia and Russia showed that concentration of ions in Russia is less than in Mongolia. It is explained by the character of river nutrition, which is caused by chemical composition of water in the tributaries flowing into the Selenge river. Waters of the Selenge river tributaries in Mongolia are more mineralized than waters of tributaries situated on Russian territory. As an example for Orkhon river water (Mongolia) it is 200-282.05 mg/l, for water of the Djida river (Russia) it is 157.4 mg/l, the Temnik river (Russia) is 62.4 mg/l (Mongontsetseg, 1979).

There is a difference in content and dynamics of combination of biogenic elements and chrome. As for heavy metals (lead, copper), their content is greater in water from Selenge river in Mongolia. Selenge is also polluted with nickel and cadmium. Chemical composition of water and hydrochemical regime of the Selenge river is formed mainly in Mongolia (Bogdanov, 1973).

To reveal mechanisms and dynamics of chemical components of the Selenge basin ecosystem, more detailed hydrochemical and hydrobiological research is necessary. For more objective estimation of the impact of the Selenge water and its basin on water quality of Lake Baikal, many years of systematic research is necessary.

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References

Bogdanov B.T. 1973.The modern condition of hydro-chemical regime of the river Selenge, main tributary of Lake Baikal. In: *Rotation of substances and energy in the lakes*. (Ed. by G.A.Galasi), pp. 64-72. Irkutsk.

Dugarova I. 2002. The Selenge – borderless the river. *Peaks (Ulan-Ude)*1: 210-224.

Lurye Yu. Yu. 1984. *Analytical chemistry of industrial waste water*. Chemistry, Moscow.

Mongontsetseg A. 1979. Hydro-chemistry of the Selenge river basin (in MPR region). Synopsis of thesis prepared by PhD of chemical science. Irkutsk.

Хураангуй

Монгол орны Сэлэнгэ мөрөн, түүний томоохон цутгал болох Орхон голын гидрохимийн судалгааг хийж, усны гол ионуудын концентрацийг тогтоов. Усанд агуулагдах хүнд металлын тархацын хэмжээг тодорхойж мөн NO_3^-, NH_4^+, фосфат зэрэг биоген элементүүдийн хөдлөл зүй болон усны фенолын бохирдолтын зэргийг тогтоов.

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