BOROO RIVER'S CONTAMINATION STUDY REPORT

Javzan Ch., Renchinbud B., Jansagsodnom M., Geography & Geoecology institute

Chapter one: Hydro chemical studies

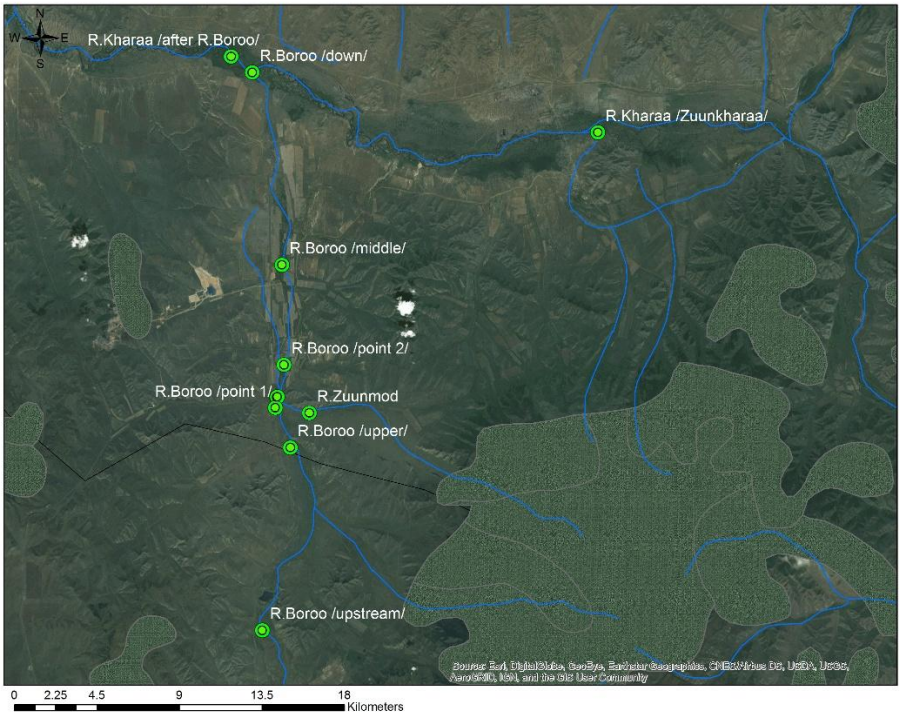
Three research workers' from the Institute of Geography and Geo Ecology, MAS participated for the Boroo River's contamination study for ten days in 12.Aug.2016 along with Russian Mongolian joint comprehensive expedition's Ecological toxicity research study.

1.1.Study area

The general chemical content analyzed in 9 water sample points of Boroo river where 2 sediment samples' taken from Kharaa river and analyzed at the Laboratory of Water Analysis, Institute of Geography and Geo Ecology and the mercuric studies on the sediment sample analyzed at the central laboratory of Geology.

Table 1. Points of water samples

№	River names	Coordinates
1	Boroo River , middle point downward of the bridge /near Khamar way/	$48^0 46' 17.3''$ $106^0 16' 58.1''$
2	Boroo River, end of the river	$48^0 51' 58.5''$ $106^0 15' 47.1''$
3	Boroo River, upward of the bridge	$48^0 43' 20.5''$ $106^0 16' 59.3''$
4	Boroo River, part with mercuric /second branch downward the wreck /	$48^0 42' 23.7''$ $106^0 16' 38.3''$
5	Boroo River, part with mercuric / downward of the branch /	$48^0 42' 24.4''$ $106^0 16' 40.2''$
6	Boroo River, part with mercuric /downward pool/ 1^b	$48^0 42' 04.9''$ $106^0 16' 34.0''$
7	River of Zuun Mod	$48^0 41' 54.9''$ $106^0 18' 05.0''$
8	Boroo River, upward from the joining of Zuun mod River	$48^0 40' 54.3''$ $106^0 17' 12.2''$
9	Boroo River, head water /Near Bornuur/	$48^0 35' 31.9''$ $106^0 15' 49.7''$
10	Kharaa River, upward from the Zuunkharaa bridge	$48^0 50' 01.1''$ $106^0 31' 09.8''$
11	Kharaa River, downward of the joining Boroo River	$48^0 52' 27.4''$ $106^0 14' 51.7''$



Pic 1. Points of water samples

1.2. Study materials and methods

During the field studies we analyzed simple inconstant characters such as physical characters, pH, temperature, electricity, alkalinity, and turbidity. The basic studies were analysed at the laboratory according to the standard methods using modern techniques and methods.

Photo1. Field study

Characters analysed during the field studies:

1. *Temperature* – thermometer, Hach Multiparameter equipment
2. *pH*–pH meter
3. *Electricity* – EC meter
4. *Total dissolved minerals*– TDS meter
5. *Turbidity* – Turbidity meter.

Laboratory analysis methods

The basic analyses completed at the laboratory according to the standard methods using modern techniques and methods as soon as samples delivered to the laboratory. Including:

- *Hardness, Ca; Mg; CO_3; HCO_3; Cl; ПИЧ* – using volume /titer/ methods
- *Sulphate ions*-using weighing method and spectrometer
- *NH_4^+, NO_2^-, NO_3^-, SO_4^{2-} F^-, Fe* - T-60.UV-Vis Spectrophotometer
- *Mercuric of the sediment* with EPA-7473 method.

Table 2. Standard methods for water analysis

№	Parameters		Standard methods
1	Temperature	T°C	MNS ISO 10523:2001
2	pH	pH	MNS ISO 10523:2001
3	Electricity	EC	MNS ISO 4810:99
4	Total dissolved minerals	TDS	
5	Ammonium	NH_4^+	БС 02:2005
6	Nitrite	NO_2^-	MNS ISO .6777:2001
7	Nitrate	NO_3^-	MNS ISO7890-3:2001
8	Calcium	Ca^{2+}	MNS ISO 2572:1999
9	Magnesium	Mg^{2+}	MNS 4346:1991
10	Chloride	Cl^-	MNS ISO 9297:2005
11	Sulphate	SO_4^{2-}	MNS ISO 9280:2001
12	Iron (II)	Fe^{2+}	MNS ISO 4430:2005
13	Iron (III)	Fe^{3+}	MNS ISO 4430:2005
14	Carbonate, hydro carbonate	CO_3^{2-},HCO_3^-	MNS 4425-97
15	Permanganate oxidization	ПИЧ	MNS ISO 4818:1999
16	*Mercuric of sediment with* EPA-7473 method		

Photo 2. Spectrophotometer DR 2800

Photo 3. Local water pH meter

The water quality evaluated as following.

Classification of Water chemical composition. Natural water chemical composition classification divided by anion and cationic balance as following. Including:

The dominancy of the anion identified by separating first and second dominant ions, the first dominant is above 50 mg-eq/%, and the next ions from above 10 mg-eq/% involved in the ingredients are the second dominants. When the difference is below 10 mg-eq/% it is stated as the mixed group.

- **HCO_3** /hydro carbonate type water. This type includes rivers, streamlet, lakes and underground water with low minerals
- **SO_4** /Sulphate type water. This type includes all neutral waters that contain both the hydro carbonate and chloride type water.
- **Cl** /chloride type water includs sea, ocean and underground water containing high amount of minerals and salts. /

For cations it is similar to previous divided by dominants into 4 groups such as calcium, magnesium, natrium and mixed. Anion and cation divided into following types with mg-eq/l unit. Herein:

-*1-type:* $HCO_3^- > Ca^{2+} + Mg^{2+}$
- *2-type:* $HCO_3^- < Ca^{2+} + Mg^{2+} < HCO_3^- + SO_4^{2-}$
- *3- type*: $HCO_3^- + SO_4^{2-} < Ca^{2+} + Mg^{+2+}$
- *4- type*: $HCO_3^- = 0$

Type 1 water is a fresh and soft where the type 3 water is hard. Type 4 is very rare; sometimes it occurred in a springs with special content and ore mining.

Table 3. Natural water mineralization and hardness categories

№	Mineralization degree	Mineralization, gr/l	Hardness degree	Hardness, mg-eq/l
1	Very fresh	< 0.20	Very soft	<1.50
2	Fresh	0.21-0.50	soft	1.51-3.00
3	Slightly fresh	0.51-1.00	softly	3.01-5.00
4	Low salty	1.01-3.00	hardly	5.01-7.00
5	salty	3.01-7.00	hard	7.01-9.00
6	Very salty	>7.01	Very hard	>9.01

Process of the water quality analysis results:

"Water quality parameter" MNS 4586-98 standard and "sanitary category guideline of Surface water" compared with the results.

1.3 Research result

Boroo River originated from 1300-1850 meter high mountains such as Nalag, Artsat, Khukh Shand, Ar tolgoi and watering from 1838 sq.km, flowing from the south to north and reach into Kharaa River. The total length of the river is 118.5 km and the end of the river, on the east side located the Ikh Dashir valley and the main gold mining company is about 5-7 km from the river. Boroo River and their affluent rivers streams categorized into strong flow, and fresh watered mountain river. The sediment of the Boroo River is sandy and loamy. Boroo River is mostly affected with gold mining, especially with

metallic mercury. Rivers' such as Shivert, Shavart, Buuruljuut, Sujigt, Arangat, Bayangol (C^{Ca}_{I}, mineralization 69.8 mg/l, hardness 0.70 mg-eq/l), Zuunmod (C^{Ca}_{I}, mineralization 73.5 mg/l, hardness 0.75 mg-eq/l) affluent to Boroo river.

In august 2009 during our research study the Boroo river's water was high in turbidity, brown coloured, hydrocarbonate, calcium type, 1 anions balance was $HCO_3^->SO_4^{2-}>Cl-$, Cation balance was $Ca^{2+}>Na^+ + K^+>Mg^{2+}$. At the monitoring point; the upper point of the river the water was warm (temperature 20.8^0C), fresh (mineralization 419 mg/l), softly (hardness 3.80 mg-eq/l), with weak alkalinity (pH 8.32), and low contamination (permanganate oxidation rate 5.6 mgO/l, ammonium ion 0.074 mgN/l, nitrite ion 0.033 mgN/l, nitrate ion 0. 51 mgN/l). The water contamination increase is related with herder household with livestock who camp along the river during the warm weather.

Photo 4. Upper point in Boroo River Photo 5. Pool using mercury for gold mining

There was an old diversion using mercury for gold mining in the Boroo River (before the Zuunmod river reaches) thus, we took from this area in order to monitor if there any difference. This area has no willows and many households were camping.

In the middle point chosen in the Boroo river above this point from the right side Zuunmod river reaches and the water was fresh, more softly, thus the Boroo river water quality slightly changes. The water of chosen point in the middle, and the water near the MB-4 has similar water quality and composition, mineralization 329.6-358.4 mg/l, hardness 3.55 mg-eq/l , it means the basic parameters and contamination are decreased compared to the upper point. Therefore, cation balance changed and magnesium ion placed the second position $Ca2^+>Mg^{2+}>Na^+ + K^+$.

Photo 6. Middle point of Boroo River

Photo 7. Lower point of Boroo river

The quality and composition of water in the lower part and in the middle point of Boroo river is similar, and the water quality has no significant difference in river lengthwise. We have identified lead, soft white iron, copper, zinc and detected none of the elements. Chinese people used mercury for gold mining in the upper point which we have selected thus, it's proven that for the past years local people cleaned the. The samples from the chosen 5 points, analyzed at the central laboratory of Geology, they were all similar Hg<0.005 mg/l, As<0.05 mg/l.

During the research study in 2009 in Boroo river bank area a gold mining company "Khamar zam" located and from the pool water with more clay flowed into the river from the lower point. We studied this water and also the water reached in the river, freshness (mineralization 239.9-280.0 mg/l), softly (hardness 2.80-2.85 mg-eq/l), weak alkalinity to alkalinity (pH 8.32-9.02), permanganate oxidation rate 5.76-7.28 мmgO/l, ammonium ion 0.045-0.06 mg/l, nitrite ion 0.025-0.030 mg/l, nitrate ion no presented but arsenic was 0.31-0.33 mg/l it means there is more contamination in this area.

Photo 8-9. "Khamar zam" company's pool of waste water

We made water quality analysis of Boroo river under the implemented projects in 2012-2014. Some results are shown below.

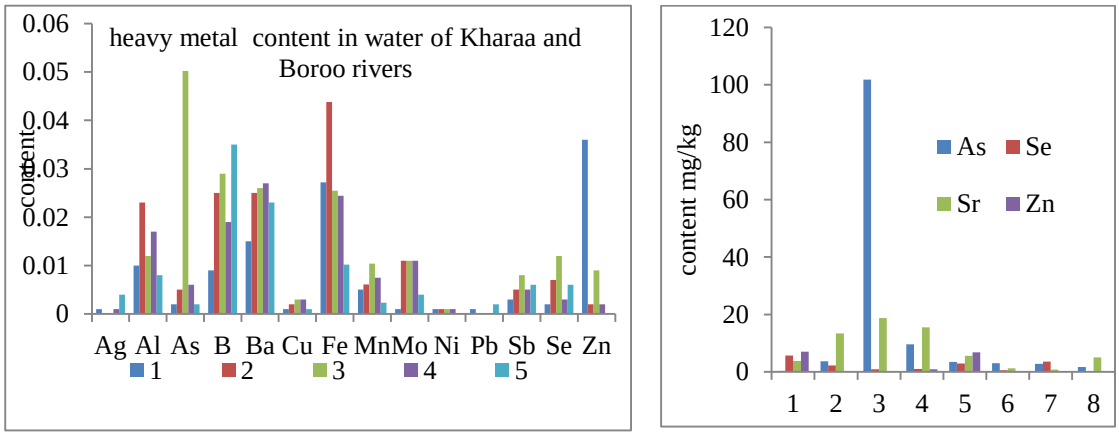


Figure 2. Microelement contents in water of Kharaa and Boroo Rivers

Sample points:
1.Kharaa river, Mandal soum
2. Boroo River, gold mining part
3. pool using Hg for gold mining
4. old wreck used for gold mining
5. Kharaa river, end part

Sample points
1. *Kharaa river*, downward Mandal soum 2. *Boroo river*, upper part of the gold mining part 3.pool using *Hg-for gold mining* 4. Gold mining second part *Wreck* 5.*Boroo river*, before reaching *Kharaa river* 6. *Kharaa river*, upper part of Bayangol soum 7.*Zagdal River*, before reaching *Kharaa river* 8. *Kharaa river*, before reaching Orkhon river

During the research work in august 2016 the operation of “Khamar zam” company was stopped and the local people used the area for the hay field. The results of the last few years analysis of Boroo river was similar, but the minerals in Kharaa river was low in this year.

Table 4. Boroo river’s water analysis result mg/l

Name	Mineral	hardness mg-eq/dm^3	OX	EC /TDS	TURB / NTU	NH_4^+ mg/ Nl	NO_2 /NO_3	Index	Basic elements					
									CO_3^- /HCO_3^-	Cl^-	SO_4^{2}	Na^++ K^+	Ca^{2+}	Mg^{2+}
MNS 4586:1998			10		-	0.64	0.065 /39.9		-	300	100			
ГУЦЗАН pure	300	5.32	5		20	0.06	0.016 / 13.3			150	100		90	30
Headwater of the river /S.Point-8/	386.2	3.90	8.48	504 /252	23.2	0.08	0.0/0.0	C^{Ca}_I	6/256.2	21.3	8.0	29.0	46.1	19.5
Upper part of the river /S.P-6/	373.4	3.80	8.48	482 /236	11.12	0.00	0.0/0.0	C^{Ca}_I	0/262.3	14.2	8.0	24.5	46.1	18.2
Pool /S.P-1Б/	371.6	4.00	7.84	457 /235	10.21	0.00	0.0/0.0	C^{Ca}_I	6/250.1	17.8	8.0	22.2	48.1	19.5
II branch /S.P-1A/	378.8	4.00	8.48	478 /237	10.60	0.00	0.0/0.0	C^{Ca}_I	6/244.0	17.8	18.0	24.7	50.1	18.2
Downward branch	373.6	3.90	8.96	467 /237	9.66	0.00	0.0/0.0	C^{Ca}_I	3/247.1	17.8	15.0	24.4	48.1	18.2
Zuunmod river	141.6	1.50	7.68	162 /80	11.32	0.00	0.0/0.0	C^{Ca}_I	0/97.6	3.6	5.0	7.0	26.1	2.4
Downward bridge /S.P-2	329.7	3.60	8.64	460 /230	19.11	0.00	0.0/0.0	C^{Ca}_I	0/222.7	17.8	10.0	17.4	46.1	15.8
Middle part/S.P-3	326.3	3.50	9.12	392 /196	31.40	0.08	0.0/0.0	C^{Ca}_I	0/219.6	17.8	9.8	18.4	46.1	14.6
End part/S.P-4	326.6	3.50	8.80	443 /223	15.73	0.16	0.0/0.0	C^{Ca}_I	0/219.6	17.8	10.0	18.3	46.1	14.6
Хараа гол, ЗХ-аас дээш	134.9	1.30	7.20	158 /80	6.85	0.08	0.0/0.0	C^{Ca}_I	0/85.4	8.9	6.0	10.8	20.0	3.6
Kharaa river, downward ЗХ-	184.9	1.90	6.08	214 /107	5.11	0.00	0.0/0.0	C^{Ca}_I	0/122.0	8.9	8.0	11.9	28.1	6.1

The contents of the basic elements are shown in the figure below.

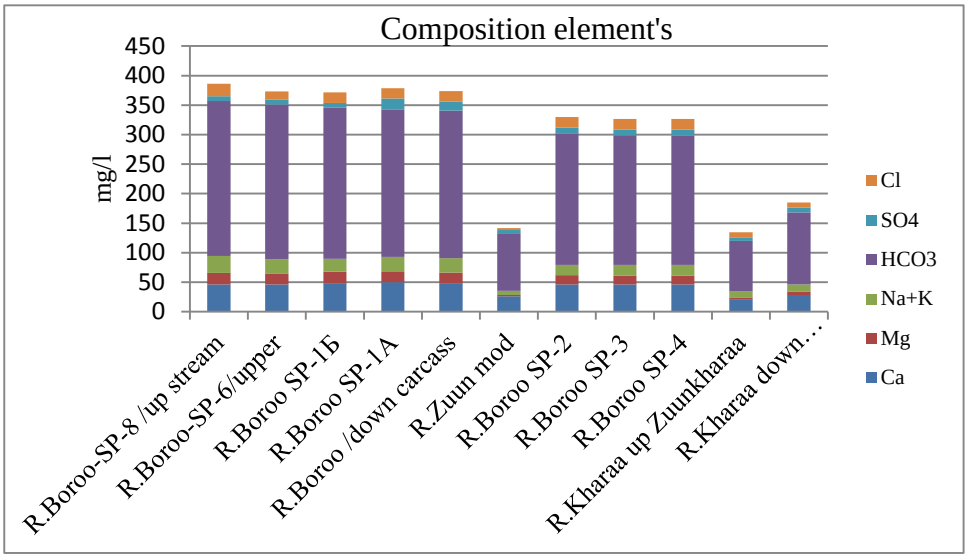


Figure 3. Spatial change of the Boroo River's water quality

From the research study the mineral was about 370-386 mg/l at the upper part of the Boroo river and after joining the Zuunmod River with fresh water (mineralization 142 mg/l) Boroo River's mineral content is slightly decreasing.

Our research work indicated less mercury amount in Boroo river water, but the sediment amount shown in table 5.

Table 5. Boroo River's sediment mercury's content mg/kg

	Headwater of the river /S.P-6/	Zuunmod river	II Branch /S.P-1A/	Middle part /S.P-3	Downstream part /S.P-4
Hg	<0.05	<0.05	12.68	1.47	0.14

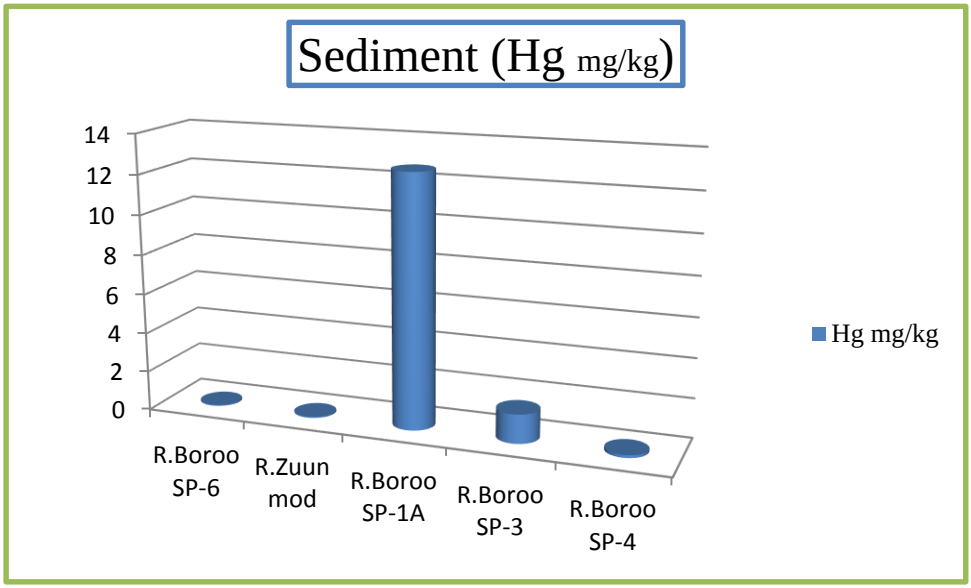


Figure 4. Amount of the mercury in the sediment, Boroo River

From the study result it is mostly high amount of mercury about Hg-12,68 mg/kg in the sediment of the old used pool in gold mining. It means the river is still affected by mercury. In our country the standard of the maximum limit of elements in sediments of

the river is not available. The contamination is above the maximum limit (Hg-10 mg/kg) of the heavy metals available in soil.

Therefore arsenic is commonly occurred in this area. The result of our study the arsenic in the black brown soil of Ikh Dashir valley is 3.3 times higher than the standard available in Mongolia. /figure 5/.

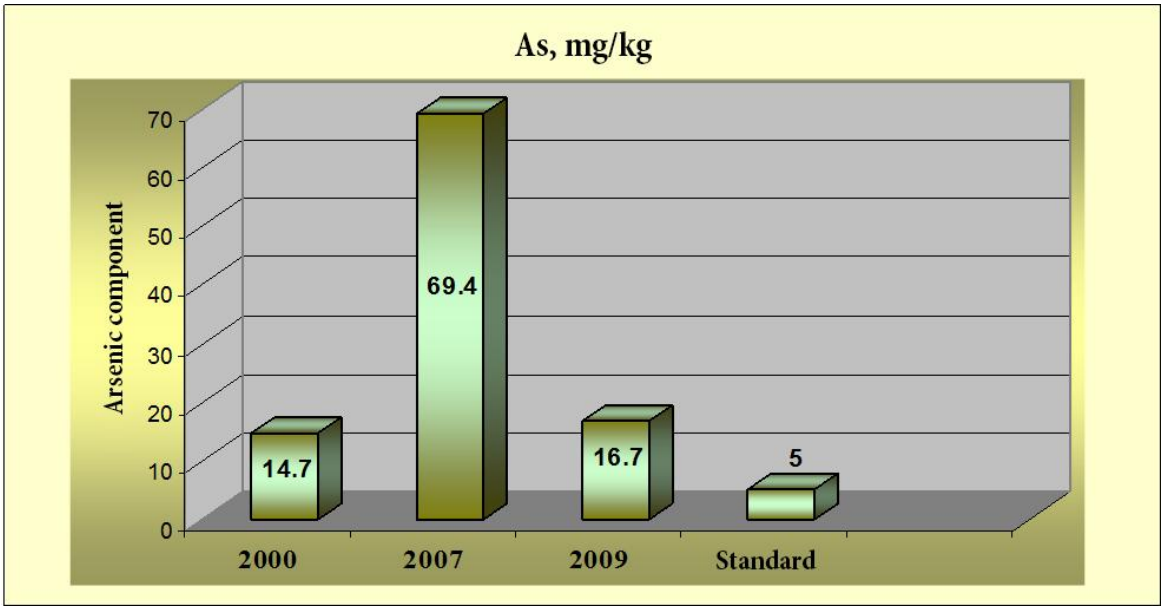
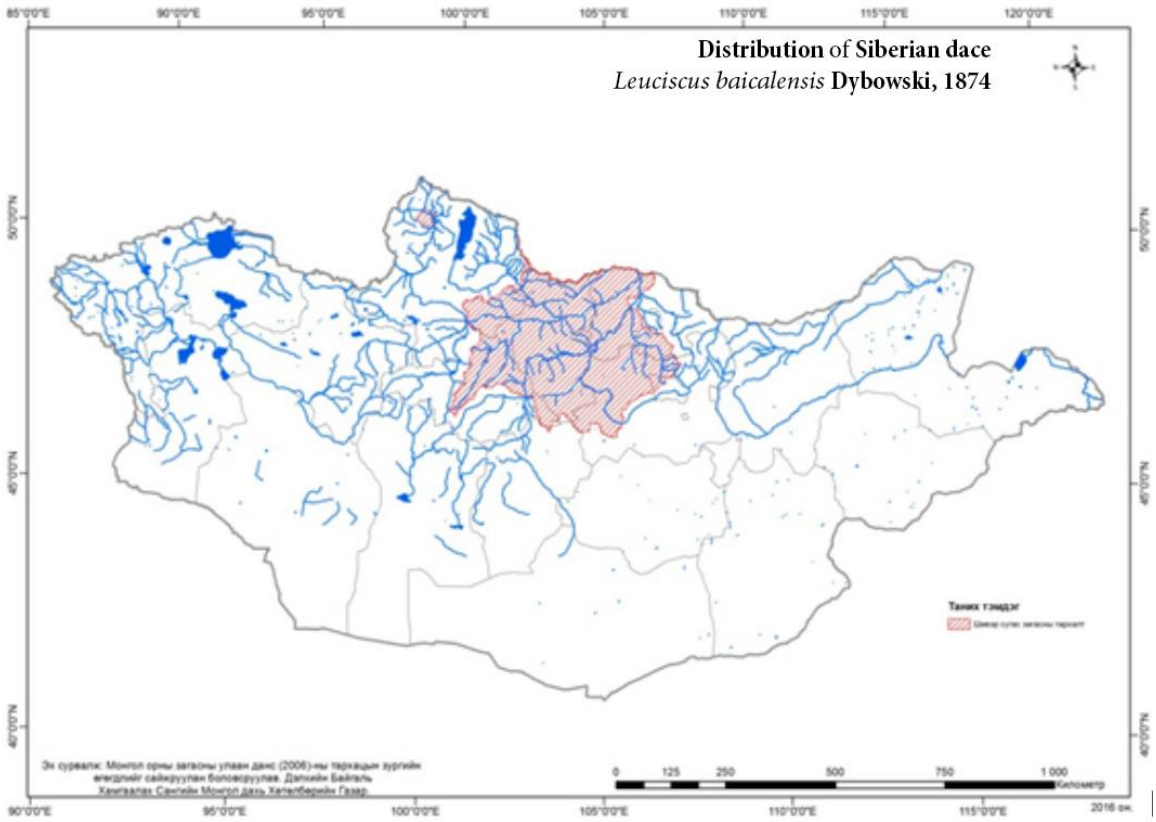


Figure 5. The average amounts of the Arsenic in soil

Generally to determining the migration, transportation, and cumulation of the heavy metals occurred in the nature is incomplete without considering the supply factors of each element's motion and just evaluate it with their amounts in each area.

Chapter two.

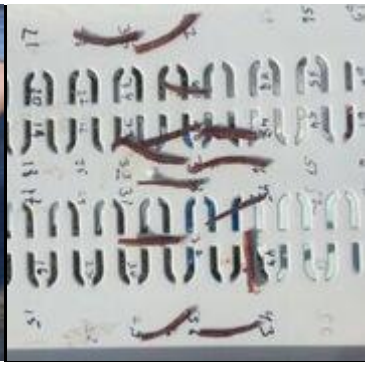
CHAPTER 2. FISH SURVEYS



2.1 Materials and Methods

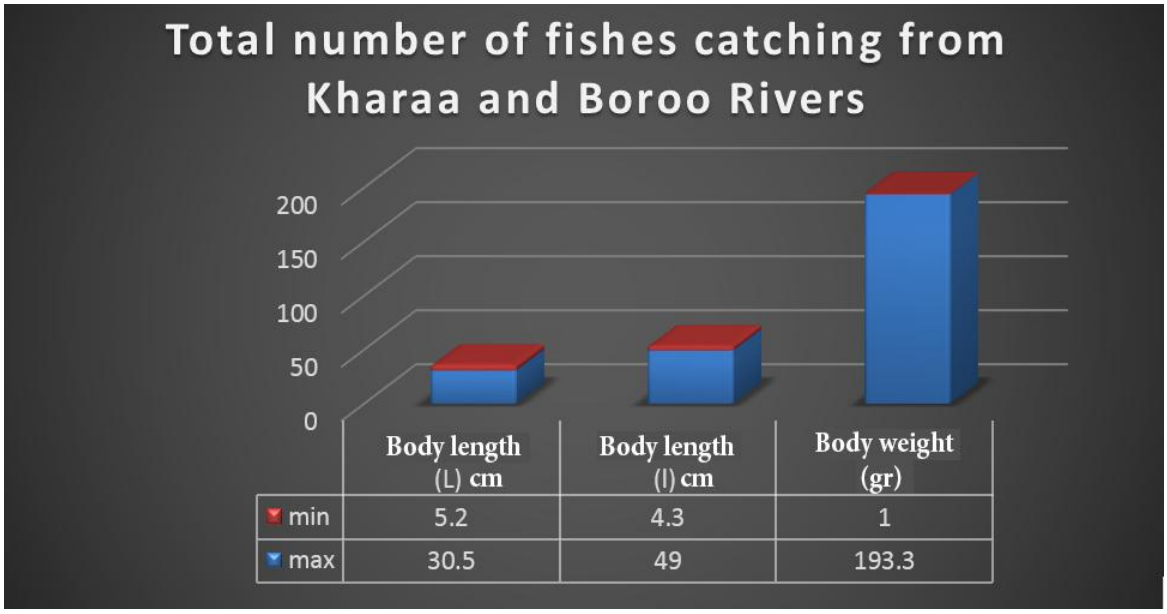
We catch fishes using fishing rods, 12,30,40,50 mm gillnets and nets 2 m long, made the bio analysis and dried the samples from muscles and bones to determine the fish species and the heavy metals. Also sample of macro invertebrates are dried for studies.

2.2 Study results



If there is a great number of mercury in fishes, it will stop the growth, decrease weight and restricts movements of fishes and the lethal dose is 0.5 mg/kg. The researchers in the Hydrobiological section of the Russian Mongolian biological expedition in Boroo river, 2010, determined the high amount of mercury in Siberian dace.

Figure 5. Fish weight and length



The total number of fishes we used in our studies were 108; the species from Boroo river were Siberian dace (*Leuciscus baicalensis*), European perch (*Perca fluviatilis*), Eurasian minnow (*Phoxinus phoxinus*), Siberian Stone Loach (*Barbatula toni*), and from Kharaa river there were sharp-snouted lenok (*Brachymystax lenok*) , Siberian dace (*Leuciscus baicalensis*), northern pike (*Exos lucius*). The maximum length was 30,5 cm, the minimum length was 5,2 cm and the biggest was 193,3 gr and the minimum was 1 gr.

We used samples from muscle and bones from all 108 fishes from Kharaa and Boroo Rivers.

REFERENCES

1. Алексеенко В.А, 2000. Экологическая геохимия: Учебник. – М.: Логос,
2. Геоэкологийн хүрээлэнгийн судалгааны материал, шинжилгээний дүнгүүд, 2009
3. Дорж Д, 2006. “Хүрээлэн буй орчны хими” Улаанбаатар
4. Жавзан Ч, 2011. “Орхон голын сав газрын гидрохими” Улаанбаатар
5. Монгол улсын стандарт “Усан орчны чанарын үзүүлэлт” MNS 4586-98.
6. Оценка экологического состояния земельных ресурсов в зонах влияния промышленных предприятий (на примере Тульской области) под редакцией
7. Добровольского Г.В., Шобы С.А., 1999. - М.: -Изд-во Моск.ун-та
8. Добровольского Г.В., Шобы С.А., 1999. - М.: -Изд-во Моск.ун-та
9. Комов В.Т., Пронин Н.М., Мэндсайхан Б., Горяева А.Н., “Содержание ртути в мышцах рыб реки Сэлэнга и озер ее бассейна (Россия)”.

10. Комов В.Т., Пронин Н.М., Мэндсайхан Б., Горяева А.Н., “Содержание ртути в мышцах рыб реки Сэлэнга и озер ее бассейна (Россия)”.
11. Геоэкологийн хүрээлэн, ‘‘Орхон гол түүний томоохон цутгалуудын ус, усан орчны экологи’’ суурь судалгааны сэдэвт ажлын тайлан’’ Улаанбаатар.: 2011