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Water Pollution in the Rivers of Northern Central Mongolia Caused by Human Activity

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Abstract: Major ion and heavy mental concentrations in the river water in northern central Mongolia were investigated. Ammonium and manganese concentrations in the Tuurl River exceeded the Maximum Acceptable Concentrations prescribed by the Surface Water Quality Standard of Mongolia. Allowable zinc concentrations were also exceeded at many sampling locations. It is therefore of concern that the quality of drinking water sourced from rivers is affecting people living around Ulaanbaatar.

Keywords: Ammonium, Mongolia, River, Water pollution, Zinc

1. Introduction

Access to safe drinking water is essential for people's health. It is a component of effective health policy and is also a development issue at national, regional and local levels.

Mongolia is considered as a country with relatively poor water resources. The water volume and flow discharge in the basin of Mongolia have decreased owing to numerous reservoirs built for mining, agricultural irrigation, and hydropower generation activities. As a negative consequence of the activity, the ability of the soil to hold water has been reduced and water runs off the soil surface. For the same reason, many streams and lakes have dried up and the water quality has deteriorated.

The exploitation of natural resources has been Mongolia's most important industry and the nation's single most reliable source of revenue since 1992, when the former Soviet Union ceased its raw materials assistance to the livestock industries in Mongolia. The government began exploring natural reserves to sustain the country's economy, and several regions are considered to have potential reserves (Myagmarjav and Davaa, 1999). However, the reserves are mostly close to rivers or river beds, and thus exploitation imposes an immediate threat to the environment. Inadequate technologies used by growing mining companies include the excessive extraction of gold-bearing gravels and sands, poorly designed pumps and wash plants and unsuitable settling ponds. The mining operations and locations, management of tailings and topsoil storage, river diversions, environmental protection plans and reclamations are also unsuitable.

The population of the capital city Ulaanbaatar increases year by year and the quality of drinking water in the city is a problem. This research was conducted to evaluate the change in water quality in northern central Mongolia.

2. Materials and Methods

The sampling sites are shown in **Figure 1**. Water samples were collected from 31 locations on the Orkhon River and its tributaries, the Yeroo, Shariin, Kharaa, Boroo and Tuul Rivers, in Mongolia from March to April 2007. The position of each sampling location was determined using an eTrex Legend portable Global Positioning System (Garmin Ltd., Japan). Water samples for ion measurements were filtered through a 0.45 μm Millipore filter (Millipore Corporation) and collected in polypropylene bottles.

Na^+, NH_4^+, K^+, Mg^{2+}, Ca^{2+}, Cl^- and SO_4^{2-} concentrations were determined using an LCA-10A ion chromatographic analyzer (Shimadzu Corporation, Japan). The accuracy and precision of the analytical methods used here were tested using Anion Mixed Standard Solution IV and Cation Mixed Standard II for ion chromatography (Kanto Chemical Corporation, Japan) and shown to be satisfactory with 2–5% error.

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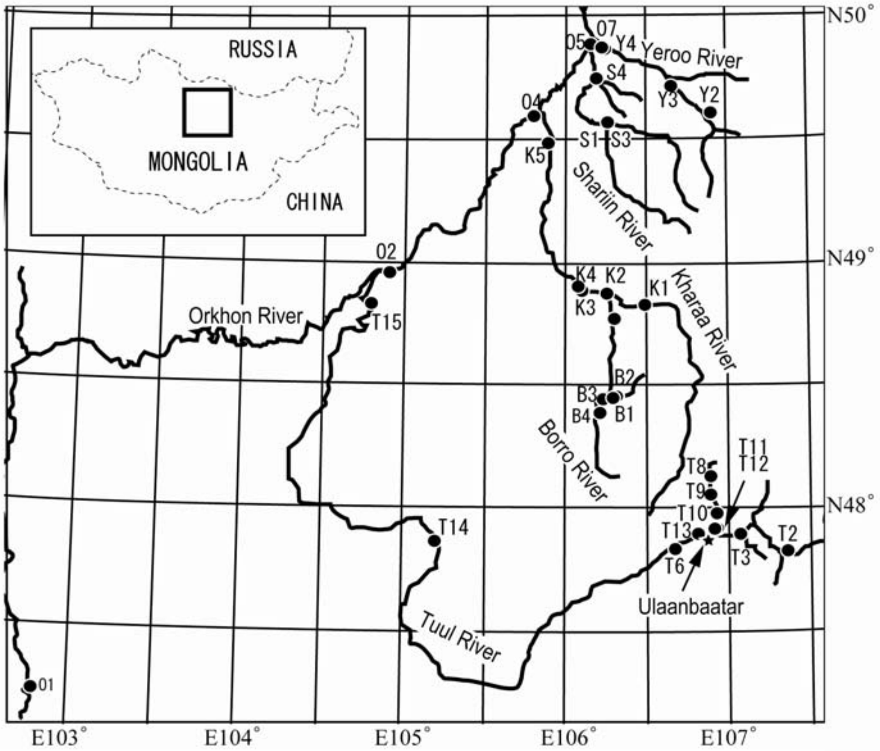

Fig. 1. Location of study areas.

Mn, Cu, Zn, Sr, Cd, Cs and U concentrations in water were determined with a Hewlett Packard inductively coupled plasma mass spectrometer (ICP-MS) using In as an internal standard to compensate for the sensitivity fluctuation. The standard solution was prepared from Spex XSTC-469. The accuracy and precision of the analytical methods used here were tested using Spex XSTC-469 (Spex CertiPrep Inc.) and shown to be satisfactory with 1–5% error.

3. Results and Discussion

The ion concentrations for the sampling locations are given in **Table 1**.

Of the 12 rivers including the small streams sampled, the Tuul River passing through Ulaanbaatar showed a noticeably distributed and high concentration of ammonium, especially at the T6 observation point downstream, owing to the urbanization and growth of industrial activity in the capital. However, at the T8 observation point near the headstream of the Selbe River, a tributary 32 km north of the Tuul River, the ammonium concentration was 58.8 times the Maximum Acceptable Concentration (MAC) prescribed by the Surface Water Quality Standard of Mongolia. It may have resulted from human impact and traditional livestock breeding life-style near to this area.

The T6 observation point had a concentration of manganese 1.66 times the MAC and 4.16 times the World Health Organization guideline level for drinking water (2006). Manganese poisoning has been linked to impaired motor skills and cognitive disorders (WHO, 1973). Bolormaa (2006) demonstrated the manganese concentrations along the Boroo River were higher downstream. However, the concentrations recorded in the present study were not higher than the MAC. The manganese contamination of the Boroo River needs to be investigated in more detail.

Kelderman and Batima (2006) stated that rivers in Mongolia can generally be classified as "clean" or "of acceptable quality" with the exception of the Tuul River, which is classified as "acceptable" to

Table 1. Ion Concentration in River Water.

Location	Name of River	Position Lat.N	Position Long.E	Na^+ mg/L	NH_4^+ mg/L	K^+ mg/L	Mg^{2+} mg/L	Ca^{2+} mg/L	Cl^- mg/L	SO_4^{2-} mg/L	Mn µg/L	Cu µg/L	Zn µg/L	Sr µg/L	Cd µg/L	U µg/L
K1	Kharaa	48° 50'04.3"	106° 29'68.4"	10.62	<0.00	1.31	14.69	51.02	4.88	17.67	1.76	4.65	20.92	21.37	0.03	0.63
K2	Kharaa	48° 52'08.4"	106° 15'61.8"	17.40	<0.00	2.10	19.21	64.16	9.16	29.20	1.85	2.21	13.77	26.44	0.02	4.42
K3	Kharaa	48° 50'26.7"	106° 05'89.6"	16.46	<0.00	2.05	14.04	47.63	11.11	32.87	2.56	4.73	19.39	28.30	0.01	7.24
K4	Kharaa	48° 53'57.4"	106° 04'89.8"	39.74	<0.00	4.09	22.12	45.03	22.11	73.40	1.95	8.87	28.65	33.22	0.06	17.41
K5	Kharaa	49° 29'31.1"	105° 53'69.4"	17.97	<0.00	2.00	12.22	38.61	12.98	42.70	1.92	4.59	14.25	25.90	0.02	5.67
B1	Boroo	48° 27'93.2"	106° 16'15.8"	37.73	<0.00	2.78	30.62	67.38	29.78	81.95	11.82	5.73	22.19	45.51	0.02	22.70
B2	Boroo	48° 47'53.0"	106° 17'06.2"	34.58	<0.00	7.25	34.03	94.90	19.79	47.28	5.40	6.14	19.61	37.58	0.02	11.23
B3	Boroo	48° 27'72.1"	106° 12'20.4"	36.73	<0.00	4.21	29.89	87.19	33.75	72.31	2.61	6.18	17.90	62.13	0.04	50.60
B4	Boroo	48° 23'58.3"	106° 12'64.2"	49.06	<0.00	4.59	47.98	92.80	25.59	94.10	4.00	5.35	14.77	44.72	0.01	15.03
S1	Shariin	49° 33'33.3"	106° 15'48.1"	52.91	<0.00	2.74	41.92	80.83	22.50	92.58	2.79	7.95	21.68	45.58	<0.00	0.63
S3	Shariin	49° 33'34.2"	106° 15'47.4"	46.52	<0.00	4.26	38.56	90.71	16.15	78.33	3.78	2.70	18.62	34.60	0.07	3.45
S4	Shariin	49° 45'45.0"	106° 10'02.5"	29.60	<0.00	4.51	21.75	50.50	12.75	56.91	3.02	1.78	9.35	29.39	<0.00	4.73
Y2	Yeroo	49° 36'52.9"	106° 54'47.4"	27.96	<0.00	4.94	42.74	149.33	30.79	144.28	2.80	4.48	23.43	52.79	0.05	4.71
Y3	Yeroo	49° 43'45.5"	106° 39'40.8"	6.55	<0.00	1.81	6.32	25.69	2.84	11.96	2.04	3.80	27.33	7.84	0.05	0.13
Y4	Yeroo	49° 52'78.5"	106° 14'62.0"	11.56	<0.00	1.23	9.80	35.03	2.88	17.71	55.41	1.10	9.15	14.31	0.26	1.90
O1	Orkhon	47° 12'04.3"	102° 47'86.4"	10.53	<0.00	3.17	7.26	32.09	3.60	11.77	1.74	1.22	7.07	15.85	0.05	2.71
O2	Orkhon	48° 57'99.8"	104° 52'61.3"	37.33	<0.00	2.55	25.73	71.88	13.77	76.94	0.85	2.35	7.75	44.98	0.42	5.90
O4	Orkhon	49° 35'21.0"	105° 47'75.1"	24.62	<0.00	1.75	14.07	39.92	12.62	45.44	2.22	1.31	10.15	39.28	0.26	3.33
O5	Orkhon	49° 53'06.9"	106° 08'84.5"	25.21	<0.00	1.90	15.85	50.31	15.06	42.22	3.80	0.19	13.00	23.39	0.01	3.35
O7	Orkhon	49° 52'83.8"	106° 14'66.6"	16.70	3.52	1.61	10.14	33.60	11.43	27.66	1.58	5.21	19.73	52.20	<0.00	12.25
T2	Tuul	47° 49'34.9"	107° 20'12.9"	3.55	3.77	0.62	1.46	12.74	2.03	8.90	1.23	0.74	12.71	67.81	0.04	0.21
T3	Tuul	47° 53'55.0"	107° 03'89.1"	7.28	<0.00	1.44	4.58	29.58	3.13	16.94	11.85	0.85	7.73	120.80	0.05	0.32
T6	Tuul	47° 50'80.4"	106° 40'56.0"	66.92	28.96	7.32	8.28	67.61	119.03	118.94	166.30	3.78	30.22	496.20	0.08	1.85
T8	Tuul	48° 07'70.9"	106° 53'22.3"	5.53	29.49	14.73	6.64	25.59	6.77	20.85	1.04	0.93	38.94	177.10	0.02	0.42
T9	Tuul	48° 03'99.7"	106° 54'17.3"	9.50	0.81	16.66	8.93	35.23	11.71	31.28	18.31	2.99	13.51	213.90	0.07	0.85
T10	Tuul	47° 58'66.1"	106° 55'57.6"	8.34	0.69	7.84	5.47	25.43	13.15	34.32	5.37	2.27	12.69	254.20	0.06	1.28
T11	Tuul	47° 54'50.3"	106° 55'92.2"	19.34	0.99	6.07	13.07	59.29	29.28	71.36	0.82	5.03	9.59	686.30	0.11	6.17
T12	Tuul	47° 54'20.7"	106° 54'05.4"	12.68	3.59	6.26	10.17	47.27	15.32	35.13	45.44	3.83	16.96	328.10	0.11	1.90
T13	Tuul	47° 53'02.9"	106° 48'80.8"	31.76	4.36	7.45	17.00	77.97	35.30	81.40	20.55	4.28	21.38	459.60	0.12	3.62
T14	Tuul	47° 51'76.9"	105° 11'86.6"	13.60	3.98	1.09	8.03	31.00	11.46	16.38	4.89	0.90	9.13	165.50	0.09	1.48
T15	Tuul	48° 49'40.4"	104° 48'52.5"	42.33	3.54	1.73	20.93	67.80	27.99	77.39	5.43	1.33	10.90	339.70	0.11	5.42
MAC in Mongolia				120	0.5	50	40	180	300	100	100	10	10	2000	5	15

"moderately polluted". Khazheeva *et al*. (2002) demonstrated the concentrations of zinc and chromium in the arms of the Selenge River exceeded MAC values. Bolormaa (2006) demonstrated the concentrations of heavy metals of Mn, Fe, Ni, Zn and As along the Boroo River were higher downstream, which can be explained by dilution, precipitation, adsorption to sediments and local anthropogenic input. Our results show the same trends as for the former studies, but our trends are more serious.

4. Conclusions

This study showed that ammonium, zinc, and manganese concentrations in rivers in northern central Mongolia were higher than MAC values prescribed by the Surface Water Quality Standard of Mongolia. Water pollution was more serious than that found in previous studies. It is therefore of concern that the quality of drinking water sourced from rivers is affecting people living around Ulaanbaatar.

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