Policy Study 2010-02

Integrated Water Management Model on the Selenge River Basin

Development and Evaluation of the IWMM on the SRB (Phase 3)

JangMin Chu, ChangHee Lee, Lunten Janchivdorj,
Bair Oktyabrevich Gomboev, SangYoung Park,
and HyunJoo Mun

- United Nations Environment Programme (UNEP)*
- Korea Environment Institute (KEI)
- K-water Institute (K-water)
- Myongji University (MJU)
- Institute of Geoecology Mongolian Academy of Sciences (IGMAS)
- Baikal Institute of Nature Management, Siberian Branch, Russian Academy of Science (BINM SB RAS)

* This research was initially carried out as UNEP-NISD partnership project.

Research Staff

Korea Environment Institute

JangMin Chu

SangIn Kang

HyunJoo Mun

JeongHo Lee

SooJae Lee

SuJin Yun

EunSun You

MiKyeong Won

Korea Institute of Water and Environment

SangYoung Park

GwangMan Lee

Myongji University

ChangHee Lee

SeungHoon Yu

Enkhtuya Minjuurlunden

Bulat Nadmitov

SungHoon Go

Institute of Geoecology, Mongolian Academy of Science

Lunten Janchivdorj

Jamsran Tsogtbaatar

Damba Odontsetseg

Yadambaatar Baasandorj

Gendvaa Udvaltsetseg

Choijilsuren Javzan

Batdelger Odsuren

Sukhbaatar Chinzorig

Minjuurlunden Enkhtuya
Jenny Frieden (Australia)
Khasbaatar Badarch
Purevsan Bayarmaa
Damdinbazar Unurjargal
Bayansan Tsengelmaa
Byambaa Battuya
Baatarsuren Bayarjargal
Otgonbayar Onon
Dashdondog Gerelt -Od
Boldsaikhan Oyun-Erdene
Sangi Chuluunhuyag (University of Science and Technology)
Tsend Badrakh (Water Authority, Ministry of Nature and Tourism)
Shirnen Baranchuluun (Ministry Of Food, Agriculture and Light Industry)
Lkhanaajav Tsedendamba (National Development Institute)
Bataa Binie (Ministry Of Food, Agriculture and Light Industry)

Baikal Institute of Nature Management, Siberian Branch of the Russian Academy of Sciences

Bair Oktyabrevich Gomboev
Arnold Kirillovich Tulokhonov
Daba Tsyban-Dorzhievich Zhamyanov
Dmitry Markovich Mognonov
Anna Semenovna Mikheeva
Andrey Nikolaevich Beshentsev
Marina Romanovna Sizikh
Viacheslav Victorovich Khakhinov
Erzheni Mikhaylovna Zomonova
Svetlana Dorzhievna Puntsukova
Erdeni Dorzhievich Sanzheev
Valentin Sergeevich Batomunkuev
Vitaly Evdokimovich Rogov

Alexander Valerievich Makarov
Irina Dabaevna Ulzetueva

Sergey Vladimirovich Morozov (Novosibirsk Institute of organic chemistry SB RAS, Novosibirsk)
Larisa Nikolaevna Korsun (Buryat State University, Ulan-Ude)
Valeriy Sergeevich Molotov (Department of water resources of Lake Baikal of the Federal Water Resource Agency)
Olga Platonovna Kolomeets (Department of water resources of Lake Baikal of the Federal Water Resource Agency)
Rinchin Ivanovna Gomboeva (Department of water resources of Lake Baikal of the Federal Water Resource Agency)
Tatiana Batomunkuevna Tsyrenova (Department of water resources of Lake Baikal of the Federal Water Resource Agency)
Elena Vladimirovna Lavrenteva (Institute of General and experimental biology SB RAS)
Bair Badmabazarovich Namsaraev (Institute of General and experimental biology SB RAS)
Leonid Markusovich Korytny (Institute of Geography SB RAS, Irkutsk)

Publisher Tae Joo Park
Published by Korea Environment Institute
290 Jinheungno, Eunpyeong-Gu, Seoul,
Republic of Korea
Tel.(822) 380-7777 Fax.(822) 380-7799
http://www.kei.re.kr
Published and printed in July 2010
ISBN 978-89-8464-449-6

FOREWORD

Water is an important element for economic development and the health of both human and the ecosystem. However, it is rarely distributed and shared equally by countries with international watercourses. In fact, more than 260 river basins in the world are transboundary, covering nearly half the world's total land surface and a significant share of the world's available supply of fresh water. Thus, problems arising in these river basins indicate their global dimension and importance.

With growing populations, increasing pollution, and declining groundwater availability, many countries are becoming more dependent on international watercourses. Especially, many developing countries sharing water resources of international river basins are facing problems in meeting their rapidly growing demands for domestic, irrigation, industrial, power, and other uses. In addition, these problems become even greater in arid and semiarid regions, where water is scarce.

The Selenge River basin, a transboundary water resource which flows from Mongolia into Baikal Lake, the greatest freshwater lake in the world located in Russia, also faces the challenges above. The river plays a significant role in the surrounding ecosystem and environment as well as economic development of the two countries involved. And with global climate change, the region becomes more and more arid, emphasizing the river’s even greater importance. Facing a variety of economic and ecosystem needs and challenges, the Selenge River is unable to meet all of the identified needs. Thus, in order to maximize mutual benefits of a shared watercourse flowing between Mongolia and Russia, it is important to develop an integrated water management model as well as build an effective international cooperation mechanism.

In this aspect, Korea Environment Institute has promoted a partnership joint research project "Integrated Water Management Model of the Selenge River Basin" within the framework of Network of Institutions for Sustainable Development (NISD), along with the Institute of Geoecology Mongolian Academy of Sciences, Baikal Institute of Nature Management Siberian Branch Russian Academy of Sciences, and UNEP Economic and Trade Branch. This report is one of the outcomes of such a collaborative on-going research project. Particularly, it aims to investigate the main socio-economic driving forces and pressures on water resources as well as the natural ecosystem status through an extensive survey, thus prioritizing the major problems of the region.

This report contains the outcome of Phase III to develop Integrated Water Management Model for the Selenge River Basin. During Phase III, our collaborative research team analyzed states of water environment and resources, domestic and transboundary water management system in the Selenge River Basin, and finally suggest international cooperation project for Integrated Water Management Model for the Selenge River Basin. This outcome of Phases III based on Phase I and II research. Phase I focused on collecting data and information about socio-economic studies, water resources studies, and water quality studies. Phase II conducted DPSIR analysis to define main problems of water management including water quality field surveys in hot spots, analyzing socio-economic situation, legal, government and regulation system.

I believe and hope that this report will make an important step toward building integrated water management model on Selenge River Basin by offering the region's researchers and policy makers more systematic knowledge and information on the rising problems. And I also sincerely hope that it will be used in peaceful decision-making for sustainable use of Selenge's water resource in the long run.

I would like to appreciate the research staffs, Dr. Jang Min Chu, Dr. Sang

In Kang, Dr. Hyun Joo Mun, Dr. Jeong Ho Lee, Dr. Soo Jae Lee, Dr. Ki Bok Chang, Dr. Kwang Yim Kim, Su Jin Yun, and Eun Sun You and Mi Kyeong Won for their enormous efforts in conducting this study. My sincere gratitude also goes to other researchers, including Dr. Sangyoung Park and Dr. Gwang Man Lee from Korea Institute of Water and Environment, Professor Chang-Hee Lee, Seunghoon Yu, Enkhtuya Minjuurlunden, Bulat Nadmitov, and Sunghoon Yu from Myongji University, Dr. Janchivdorj, Dr. Odontsetseg, from Institute of Geoecology, Mongolian Academy of Sciences and Dr. Gomboev, and Mr. Zhamyanov from Baikal Institute of Nature Management Siberian Branch Russian Academy of Sciences for their great contribution and collaboration in arranging field surveys as well as developing the study.

July 2010

Tae Joo Park
President
Korea Environment Institute

Gwang-Dueg Park
President
Korea Institute of Water and Environment

Jamsran Tsogtbaatar
Director
Institute of Geoecology, MAS

Arnold K. Tulokhonov
Director
Baikal Institute of Nature Management, SB RAS

Abstract

This project has been launched in order to develop an integrated water management model in the Selenge River Basin (the SRB). This report describes the results of Phase III, and includes: 1) State of Water Environment and Resources, 2) Domestic Integrated Water Management Model, 3) Transboundary Water Management System, and 4) International Cooperation for IWRM.

Three field studies were performed through 2006-2008. In total, 68 sampling stations were identified, with 39 stations in Mongolia and 21 stations in Russia. The results of analysis indicated that pollution sources in the SRB originated from mining areas. The highest SS (Suspended Solid) were at SM10, and SM21; it was measured at the beginning of the agricultural irrigation which the dark stream water was caused by rain and discharge from gold mining sites in Mongolia. Main sources of pollution identified in Mongolia were Zaamar gold placer, upstream along the Orkhon River, the Shar River gold mining, population/settlements, agriculture and WWTPs.

We have been identified eight Hot Spot areas in two countries, Mongolia and Russia-Buryatia. The water quality issues originated problems of mining and urbanization. In order to improve the water quality conditions in the Selenge River Basin, we need to identify the exact locations of the Hot Spots and observe the existing management measures. After that the efficiency of the treatment operations for mitigation of pressure on water quality and improvement of local water quality condition should be checked. The origins of water quality pollutions are different from place to place (mining and urbanized areas). The management options and approaches have to be properly defined and established according to management priorities. To determine the management priorities, we used the mDSS model. The data was pretreated for main issue priorities using expert survey analysis, weighting the issues priorities and normalized numbers of the weighted values, and fitting the data in the mDSS software. In the process of design of mDSS model, the database (DB) was transferred into analysis matrix (AM). Then it was setted by the ideal point method (TOPSIS). By aggregating the group members' preferences in the group decision, the final solution rank was

achieved by the borda rule.

In addition to the mDSS modeling, we performed expert survey. This survey showed that some implemented management measures is not sufficient and effective for mitigation and protection of water bodies within SRB due to rough inobservance of rule in operation/working, outdated and inoperative technical equipments, and some other nonprofessional approaches in environment regulation.

The origins of water quality pollutions are different from place to place. The management options and ordering of its implementation should be properly defined and established. On the last workshop meeting in Mongolia, some recommendations were suggested for implementing management measures, for mining and urbanized areas in both countries. The recommendations are considering institutional, infrastructural and government alternatives. Based on the result of our surveys, we have defined the following: affected reaches within the Selenge River Basin and order priorities for implementation of management measures and its strengthening.

In addition to these expert survey results, feasibility analysis was performed to identify which policy options are possible or impossible in Mongolia and Russia. Most policy alternatives have high administrative feasibility in both Mongolia and Russia. However the Mongolian and Russian experts have tended to assign low numbers to economic feasibility.

For each country, integrated water management on the SRB is a long term goal, but its introduction may not be readily available. Therefore it is recommended to gradually proceed with relevant domestic policies in each country. Therefore in this report, three stages are suggested forwarding the integrated water management on the SRB. Lastly, a sustained management of water-related indicators should be a part of the SRB integrated water management plan.

In transboundary water management, this report introduced the transboundary river theory, issues of transboundary river management, transboundary river cooperation case studies in other regions and countries. The characteristics of the SRB as a transboundary river are identified by analyzing the situation of the SRB. Also, we have conducted expert survey in

Korea, Mongolia and Russia for selecting the policy alternative on transboundary water management system. This report suggested the basic design of transboundary water management system for the SRB. The basic design of transboundary water management system is; first, to step up the level of current cooperation system implementing committee is recommended in order to ensure the systematic and stable implementation of the cooperation projects, going a step further from the current governmental representative meeting. Second, extend the scope of the projects by organizing specialist groups and working groups to facilitate the management system. Third, build a joint monitoring network and information sharing system on water quality and water resources in each country. Fourth, perform a joint EIA on basin development projects, such as developing water resources. Fifth, implementation schemes should be built and fiscal investment should increase at the national levels to guarantee the effectiveness of the management system. Sixth, as regards such issues as level and nature of transboundary water management agreement and the organization in charge of transboundary water management system, and water flow allocation, building a long-term channel for strategic dialogue is recommendable.

As noted before, there is a need for the joint management of the SRB water management indicators currently managed on domestic levels of each country. To address this issue, major monitoring spots in the SRB should be designated, and an integrated water management data from scientific and objective measurement should be accumulated and shared. This will serve as an important basis for mutual consultation and coordination in future development projects of the Selenge River.

Finally, we suggested the Korea-Mongolia-Russia Environmental Cooperation Project on Water Management System for establishing and implementing IWMM on the SRB. The environmental cooperation projects in water resources development area projects include1) studying on the treated waste water reuse project in metropolitan of M/R, 2) Rationalizing the groundwater utilization in M/R, 3) working water resources development project. The environmental cooperation projects in water management area include 1) the non-point source management in M/R, 2) automated water quality/quantity monitoring system, 3) improvement of the water/wastewater management system, 4) environment capacity building projects. This report also suggests transferring technology for industrial waste water treatment in mining areas as a prior cooperation project of SD. Lastly, the implementation scheme for environmental cooperation project between Korea and other countries is suggested.

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Chapter Ⅰ. Introduction

1. Objectives and Research Components

A. Objectives and Core Activities

The overall objective of this project is to provide policymakers and stakeholders with the IWMM on the Selenge River Basin. It will play an important role inoriginating the policy and the management plan for the preservation of Lake Baikal, while also providing the sustainability of the Selenge River Basin. Furthermore, it will settle the disputes and the profit sharing at local, regional, and international levels in Northeast Asia.

The first objective of the project is to investigate the status of the Selenge River Basin and to collect data in order to develop the integrated model, which takes into account the natural environment of the river basin, social and economic changes in the Russia and Mongolia. The second objective is to analyze the water management system of each country and to compare them and between two countries, in order to provide the integrated model for the transboundary water, which overcomes a variety of differences between two countries. The third objective is to elaborate the integrated model in order to afford the policy and the management plan in a proper way, which contributes to the sustainability of the Selenge River Basin andLake Baikal.

To achieve the objectives, the following five interrelated and complementary activities will be undertaken:

- Establishment of the foundation for the working group to collaborate and to manage the overall project;
- Investigation of water usage, water quality, and ecosystem of the river basin and the socio-economic situation in its vicinity;
- Assessment of the existing national water management systems in Mongolia and Russia;
- Assessment of the existing transboundary water management systems between Mongolia and Russia;
- DPSIR analysis or PSR analysis to find water issues and to prioritize

them; and,

- Development of an Integrated Water Management Model for the Selenge River basin and its application.

B. Research Components

This project includes one project management and ten research components (Figure 1-1).

(0) Project Management: Coordinating the overall project and encouraging active cooperation.
(1) Basic Survey: Identifying the intrinsic condition of the river basin, pending problems, and existing water management systems.
(2) Water Quality Study: Examining the determining factors of water quality, such as the water quality of individual water systems, the features and distributions of pollution sources, characteristics of pollutants, and the present condition of the ecosystem.
(3) Hydrological Study: Identifying the hydrological characteristics of the water system, such as the water balance among individual water systems, available water resources, characteristics of the river and its basin, and meteorological conditions.
(4) Socio-Economic Study: Examining the socio-economic factors that affect water management, such as traditional culture, political structure, and the economic system.
(5) Water Resources Study: Examining the determining factors of water usage and supply, such as land use and land cover, existing water usage and supply, water management plans, and future water use predictions.
(6) Study of Water management between Russia and Mongolia: Investigating the major problems of water management, the discrepancies of policies and management systems, and relevant international treaties and agreements.
(7) Analysis of Existing Water Management System: Conducting the DPSIR (Driving force-Pressures-State-Impact-Response) or the PSR (Pressure-State-Response) analysis for water management.

(8) Development of an IWM Model for the Selenge River Basin: Developing an integrated model that takes the natural environment of the river basin, the socio-economic changes in both countries, and their transboundary problems into account.

(9) Evaluation of the IWM Model for the Selenge River Basin: Improving the integrated model for the Selenge River Basin by comparing it with other transboundary river basin models.

(10) Construction of a Cooperation Network: Sharing information and research results, offering education to other developing countries, and expanding networks via international workshops.

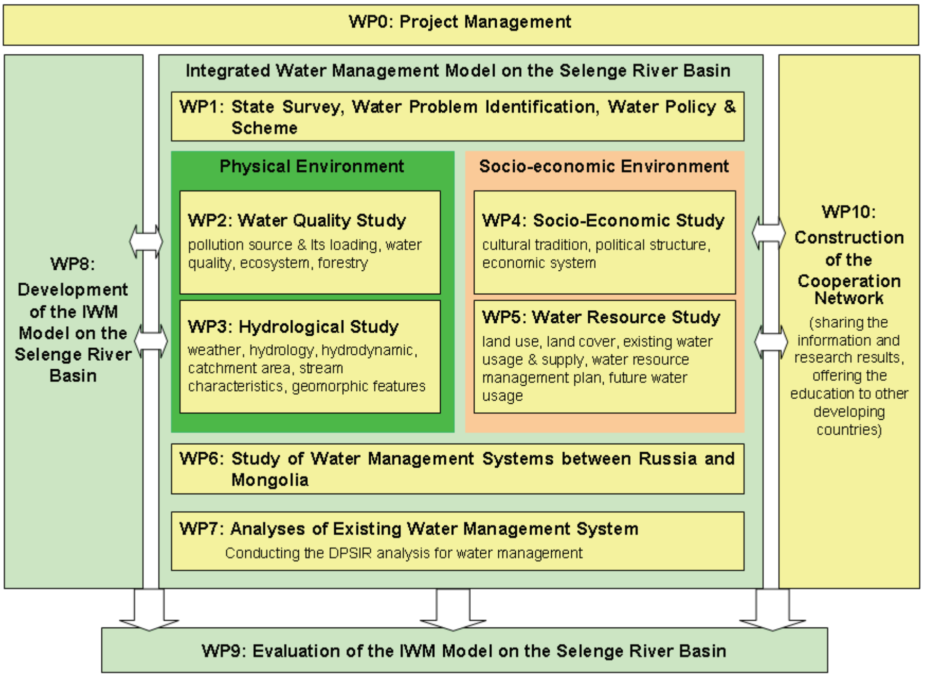


Figure 1-1. Research Components

The research of Phase I was completed through five research components. InPhase II, the research of the project has been focused on the studying and analyzing of water management systems between two countries. Finally in Phase III, the research is focused on the developvement of the IWM Model on the Selenge River Basin (Figure 1-2).

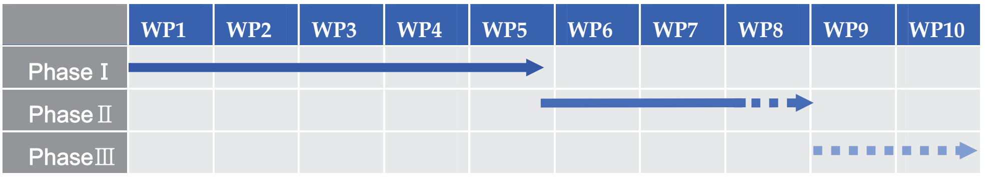


Figure 1-2. Research Schedule

2. Summary of Phase I and II Research

Research for Phase I was performed to collect data and information from existing studies, socio-economic studies, water resourcestudies, and water quality studies.

Mongolia and the Republic of Buryatia have shown similarities in socio-economic and political conditions and have experienced the same economic transition from a planned economy to a market economy. This transition resulted in a dramatic economic decline in both countries, but their measures and consequences were dissimilar.

Mongolia is the second-largest landlocked country, and the least densely populated. It is also regarded as a low-income country, which is significantly influenced by the inflow of foreign funds. It has experienced noteworthy human migration;people have moved to urban areas or other countries because of the lack of employment, education, health care, and public services due to severe poverty and unemployment during economic transition period. However, economic indicators displayed a recovery since 1995 and the rapid growth in the GDP since 1999. Its major economic activities include agriculture, mining, and light industry.

Its mining industry has radically grown in recent years, as foreign concerns have risen with abundant natural resources such as copper, molybdenum, and gold. These mining and light industries have threatened the water quality of the Selenge River and adjacent ground water.

The Republic of Buryatia, which is located north of Mongolia, is part of the Siberian Federal Districts of Russia. It also has been experienced a severe economic decline during the economic transition period and major cities still suffer from severe depopulation and high rates of unemployment, so it is regarded as a low-income republic within the Russian Federation. Its major economic activity has been agriculture and tourism has also risen as one of the key industries since 1995.

In the Selenge River Basin, three major cities of Mongolia – Ulaanbaatar, Darkhan, and Erdenet – are inhavited by approximately 86% of the total population of the Mongolia. Nevertheless water resource is very limited in this basin, as annual precipitation is only 250~400 mm. Moreover, 90% of annual precipitation occurs in the summer, which brings out frequent floods causing lots of damage in the summer and severe shortage of water during the rest of the year. This river provides one of major water supplis in this basin. 10~70% of wastewater is treated and untreated wastewater is returned to the river.

In Mongolia, the 'National Water Master Plan' performed a comprehensive water resource evaluation for both surface water and ground water in 1975, subregional schema SRB, 1986. Most tributaries show considerable water level fluctuation and they have occasionally disappeared. For example, a 20 km stretch of Tuul River dried up for one month in 2002, so it should be filled with treated water from the treatment facilities of Ulaanbaatar. Water demand has also increasedfrom rapid economic growth, so new production wells are still in progress or installation causing ground water level declines.

In the Republic of Buryatia, the flow and quality of surface water has been constantly monitored by the Federal Hydrometeorology and Environmental Monitoring Service since 1967. Its water consumption in 2004 decreased by 1.9 times compared to that in 1982, as opposed to the increase in water demand in Mongolia.

There are diverse pollution sources in the Selenge River Basin, which have threatened public health and the ecosystem as well as the deterioration of quality of the Selenge River and adjacent ground water. This study performed a field study of water quality during field excursions in July 2007. Samples were taken from 28 stations along the Selenge River and its tributaries. Eight water quality parameters were measured on site: temperature, conductivity, pH, DO, electro conductivity, total dissolved solids, suspended solids, and turbidity. Heavy metals such as Chromium (Cr), Iron (Fe), Nickel (Ni), Cobalt

(Co), Copper (Cu), Lead (Pb), Manganese (Mn), Arsenic (As), Cadmium (Cd), and Zinc (Zn) were analyzed in the laboratories of Myongji University, IGMAS and BINM SB RAS. The results of analysis showed the possibility of local pollution with heavy metals especially in the north-west of Mongolia. Some sampling points indicate high turbidity, which might be caused by soil erosion. If sampling points are connected to a waste water treatment plant, its measured alkalinity is lower than others. High electroconductivity was measured in mining areas. It shows that the water quality depends on regional characteristics.

The objective of Phase II was to conduct DPSIR analysis and through the analysis to find out the main problems of water management in the transboundary area. Another objective was to conduct a field trip for Phase II. During Phase II, the environmental status, socio-economic situation of the Selenge River Basin and existing laws, regulations and decrees related to water resource use in Mongolia were considered. By the analysis of regulations and laws on water the main gaps in regulation of water resource management in Mongolia were found. Current water use and water quality problems in Mongolia show that the laws and regulations have not satisfied the requirements of a free market economy.

The use in the Selenge River basin as transboundary territory should be considered in the context both of internal and external regulations of nature management.

The result of phase II is as follows:

- Investigation of Water Quality Status in Mongolia
- Investigation of the laws, regulations, decrees, administrative and infra structure on water management in Mongolia
- DPSIR Analysis on water environment and management system in Mongolia
- Issue identification in water management

3. Purpose and Main Issue of Phase Ⅲ

The objective of Phase III is to develop and evaluate the Integrated Water Management Model in the Selenge River Basin based on the DPSIR analysis results of the water quality and water resources in the Russian Federation, Mongolia, and the whole river basin.

The project tasks of Phase III are as follows:

Phase III will include tasks (1-4 and 8 – 10 work plans) from the work plan.

- Water Quality Measurement and Emission Sources Investigation in big cities, mining and large scale grazing area (WP 1-4)
- Development of Integrated Water Management Model on SRB (WP 8) regarding tasks 8 and 9, an Integrated Water Management Model based on analysis using the DPSIR approach will be developed. Formulating the integrated model will include all intrinsic conditions of Selenge River Basin, Mongolia and the gap between policy and management will be filled through the integrated model of management for water resources. The formulated model will then be evaluated in comparison to other models and linked with Mongolian and Russian laws and regulations on natural management and water resource use. The steps involved include:
  - *A. Developing the model*
    - *- List all problems on water issues*
    - *- Match the problems and regulations*
    - *- Find out the gap between laws and regulations*
    - *- Evaluate the DPSIR components*
    - *- Develop the model*
  - *B. Evaluating the model*
    - *- Compare with other transboundary models*
    - *- Evaluate the model for SRB*
  - *C. Evaluation of Implementation Potential of the developed Model*
    - *- Questionnaire Survey and Interview for relevant officials and experts*
- Water Management Cooperation System on SRB between Mongolia – Russian Federation (WP 9)
  - *A. Analysis on the existing international water management system*
  - *B. Development of the water management needs of Mongolia and Russian Federation*
  - *C. Cooperation system, organization and its role*
- International Cooperation and Priority in Water Management on SRB (WP 9)

A. Development of international cooperation needs for efficient water management on SRB
B. Cooperation Area among Korea-Mongolia-Russian Federation

In terms of work plan task 10, Phase III will work on building an enhanced cooperation network for sharing the information and research results, which are collected and expected from this project. This will include a basic database for water resource management in transboundary territory.

4. History of the Project

The project was launched in 2006, and gained momentum after the conclusion of the MOU in 2007. Two NISD meetings and eleven working group meetings were held before completing Phase III of the project. A number of experts in various fields were invited to six international workshops.

Table 1-1. History of Selenge Project

Title of Meeting	Venue/ Date	Major Tasks
1st NISD meeting	Jeju, Korea / Mar. 2004	- Building the Network of Institute for Sustainable Development (NISD) -Arranging Four Thematic Groups Water, Transportation, National Park, Trade
2nd NISD meeting	Geneva, Switzerland / Sep. 2005	- Presenting the Proposal of Integrated River-Basin Management Model for the Selenge River to NISD
1st Working Group Meeting	Seoul, Korea / Nov. 2005	- Developing the Cooperative System by Participations of IGMAS and BINM SB RAS
2nd Working Group Meeting	Istomino, Russia / / Jun. 2006	- Holding 1st International workshop -Discussing the Contents of MOU between KEI, IGMAS and BINM SB RAS -Sharing the Issues, Knowledge, and Experience regarding the SRB

Title of Meeting	Venue/ Date	Major Tasks
3rd Working Group Meeting	Ulaanbaatar, Mongolia / Nov. 2006	- Specifying the Proposal of 'Integrated Water Management Model on the Selenge River'
4th Working Group Meeting	Seoul, Korea / Jan. 2007	- Holding 2nd International workshop - Discussing the Capacity Building & Network Expansion - Concluding the MOU
5th Working Group Meeting	Ulaanbaatar, Mongolia / Jun. 2007	- Presenting the Preliminary Study of Environmental Information - Discussing the schedule and tasks of Field Study
Field Study 1	Selenge River Basin in Mongolia and Russia / Jul. 2007	-Holding 3rd International Workshop -Performing the Socio-Economic Survey -Executing the Water Quality Measurement -Excursing from Lake Khovsgol to Lake Baikal
6th Working Group Meeting	Ulaanbaatar, Mongolia / Nov. 2007	-Sharing the Data and Information from Field Study between Institutions -Performing the Socio-Economic Survey
7th Working Group Meeting	Jeju, Korea / Feb. 2008	- Finalizing the Final Report of Phase 1 - Discussing the Schedule of Phase 2 - Discussing the schedule and tasks of Field Study
Field Study 2	Selenge River Basin in Mongolia and Russia / June. 2008	- Holding 4th International Workshop - Performing the Socio-Economic Survey - Executing the Water Quality Measurement - Concluding contract of Phase 2
8thWorking Group Meeting	Daejeon, Korea / Nov.2008	- Holding 5th International Workshop -Operating Training Program by Kwater
9th Working Group Meeting	Seoul, Korea / May. 2009	- Finalizing the Final Report of Phase 2 - Discussing the Schedule of Phase 3 - Discussing the schedule and tasks of 3rd Field Study
Field Study 3	Selenge River Basin in M/R July. 2009	- Performing the Socio-Economic Survey - Executing the Water Quality Measurement - Concluding contract of Phase 2

Title of Meeting	Venue/ Date	Major Tasks
10th Working Group Meeting	Seoul, Korea / Nov. 2009	- Sharing the Data and Information from Field Study between Institutions - Discussing the Schedule of Phase 3
11th Working Group Meeting	Ulaanbaatar, Mongolia June. 2010	- Holding 6th International workshop - Performing the Expert survey with M/R expert - Duscussing the cooperation project & Folloswing research

Three field studies were performed troughout 2006-2008. KEI, IGMAS, and BINM SB RAS took two weeks to gain an overview of the Selenge River Basin in 2006. In 2007, they executed an international excursion from Lake Khovsgol to Lake Baikal over a two-week period (Figure 1-3).

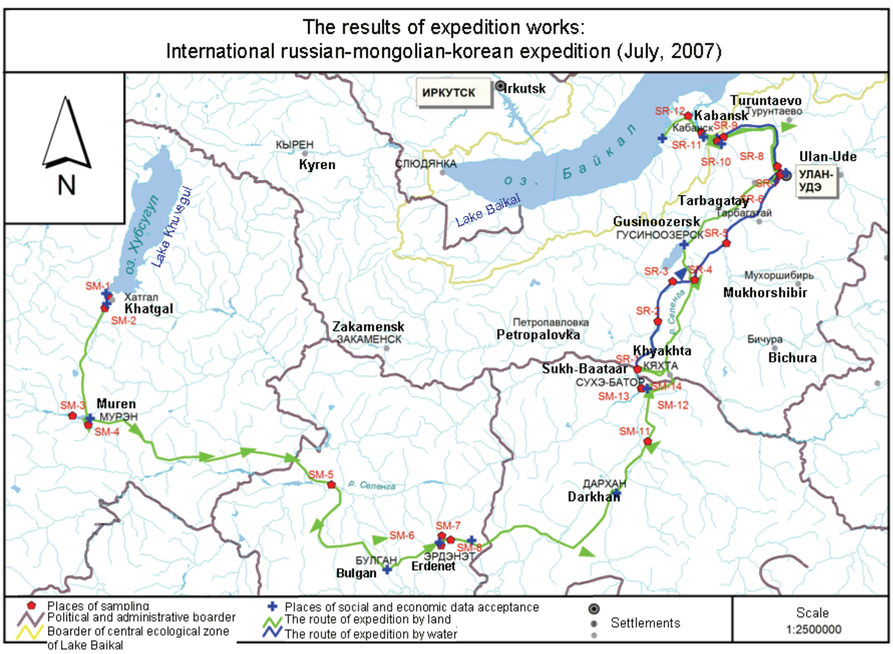


Figure 1-3. Route scheme of International Expedition on Integrated Water Management Model of SRB in 2007

The socio-economic survey and water quality measurements were implemented everytwice of field study in 2007 and in2008, especially in 2008. In the field study temperature, DO, pH, conductivity, turbidity and SS were analyzed by using field filter sets in the Mongolian site.

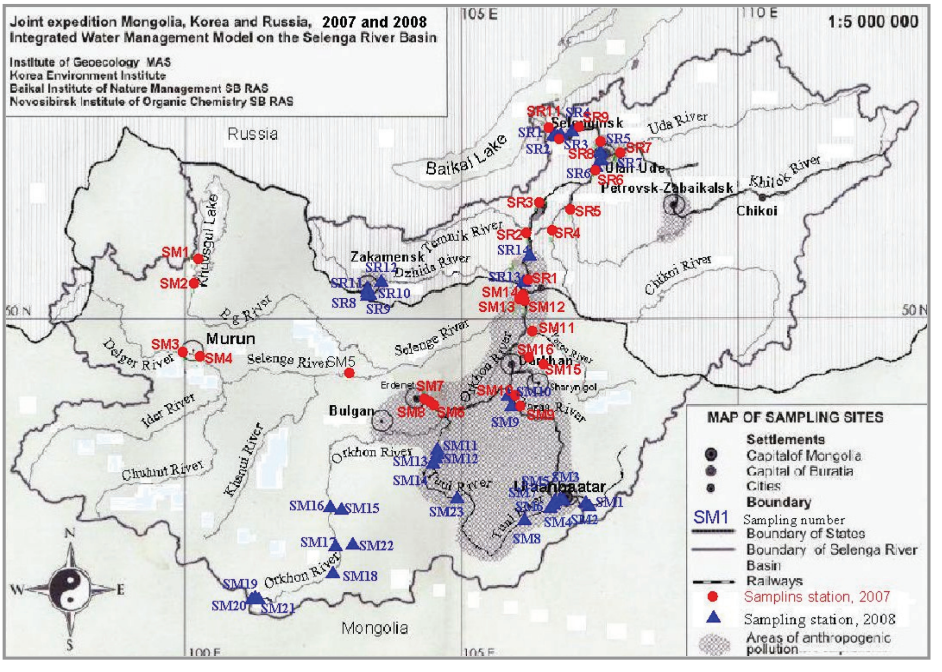


Figure 1-4. Sampling location of International Expedition on Integrated Water Management Model of SRB in 2007-2008

In 2009, 34 samplings were taken; f24 from Mongolia and 11 from Russia. The sampling stations were taken by KEI/IGMAS/BINM research team's discussion for detail studies in Hotspot areas and for getting more understanding of present water quality condition within the Selenge River Basin. Figure 1-5 shows the route of the field trip in 2009.

Figure 1-5. Route scheme of International Expedition on Integrated Water Management Model of SRB in 2009

5. Structure of Report

In this report, the first chapter includes a short, general introduction to objectives and the research components. Chapter II focues on water quality and resource states in the Selenge River Basin including the summary of overall filed trip result and also includes the analyses of hotspot areas for each country. Chapter III describes the design of a domestic integrated water management model from both countries as responses to the mDSS modeling results and expert survey result. Also in Chapter IV, it describes the design of transboundary water management model from both countries as responses tothe expert survey result and case studies.

Chapter V includes the system of Korea-Mongolia-Russia Environmental

Cooperation Projects on Water Management for the Selenge river Basin.

Finally, an overall summary and conclusion are presented in Chapter VI.

Chapter II. State of Water Environment and Resources in SRB

1. Water Environment State of SRB

A. Water Quality Measurements and Analysis

110 water quality measurements sites in the Selenge River basin were selected after several discussions between Korea Environment Institute (KEI), Institute of Geoecology of Mongolian Academy of Sciences (IGMAS) and Baikal Institute Nature Management (BINM) Siberian Branch Russian Academy of Sciences (SBRAS).

The basic field framework initially developed from Environmental Information Survey, which had been jointly conducted by IGMAS and BINM-SBRAS from December 2006 to April 2007. The objectives of the project were to indentify the distribution of pollution sources and to estimate the degree of water pollution. To support the objectives, several conventional water quality parameters (BOD, SS, conductivity, pH) and some heavy metal parameters (Cu, Fe, Zn, Au, and Pb) were measured at the several sites in the Selenge River basin.

The project mentioned above was embedded in this project after year 2007, and the scope and content of the project were reestablished according to the objectives of this study. The previous project had only covered parts of the Selenge River basin, but this study included the whole basin from head water in Mongolia to the Lake Baikal in Russia. In addition, more number of water quality parameters were included silver (Ag), arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), manganese (Mg), zinc (Zn), iron (Fe), cobalt (Co), lead (Pb), and nickel (Ni). Several in-situ water quality parameters such as water temperature, conductivity, pH, electro conductivity, total dissolved solids, dissolved oxygen (DO), turbidity and suspended solids (SS) were also measured.

The field survey, water sampling, water quality measurements and data analysis were conducted by the joint research team composed of Myongji

University, IGMAS, and BINM SB RAS.

a. Site Descriptions

The water quality measurements and analysis were taken from Mongolian and Russian sites (Buryat Republic) in summer time during three years (2007-2009). Further Mongolian stations will be named as SM and Russian as SR.Detailed data of site description is in Appendix A.

Water quality measurements and analysis in 2007

In 2007, sampling sites were selected from 28 areas, with 16 in Mongolia and 12 in Russia. Most of them were located close to waste water treatment plant outlets, Selenge River's tributary and portions of the Khovsgol and Baikal lakes (Figure 2-1). These areas are densely populated and contain industres, anthropogenic activities such as mining, livestock, etc. In order to identify a general picture of water quality the choice of the territories was considered on theeconomic activities.

In 2007, the following samples were taken:
In Mongolian site

- ✓ On the upstream of Egin River (one of the tributary of Selenge River) at Khovsgol Lake (SM1) and its outlet (SM2);
- ✓ On the upstream of Delger River (one of the tributary of Selenge River) at Murun locations (SM3 and SM4);
- ✓ First sampling point on Selenge River at Hutag Ondor location (SM5);
- ✓ On the upstream of Khangal River (one of the tributary of Orkhon River) at Erdenet location (SM6, SM7,SM8);
- ✓ On the Kharaa River (One of tributary of Orkhon River) near Darkhan location (SM9, SM10);
- ✓ On the Yeroo River (one of the tributary of Orkhon River) before confluence into Orkhon River (SM11);
- ✓ On the Orkhon River, before confluence into Selenge River (SM12);
- ✓ On the Selenge River, before inflowing of Orkhon River (SM13) and after confluence of Orkhon River (SM14);
- ✓ On the Shar River, near to Gold mining area (SM15 and SM16).

In Russian site (Buryatia)

- ✓ On the Selenge River, at Mongolian-Russian boundary (SR1);
- ✓ Dzhida, Temnik, Chikoi, Khilok, and Uda Rivers before confluence into Selenge River at SR1, SR3, SR4, SR5, and SR7, respectively;
- ✓ On Selenge River, upstream (SR6) and downstream (SR8) the Ulan-Ude city and confluence with Uda River;
- ✓ The downstream along the Selenge River, near Selenginsk settlement (SR9), Selenginsk Pulp-and-Paper Plant (SM10), Kabansk (SR11), and Murzino (SR12).

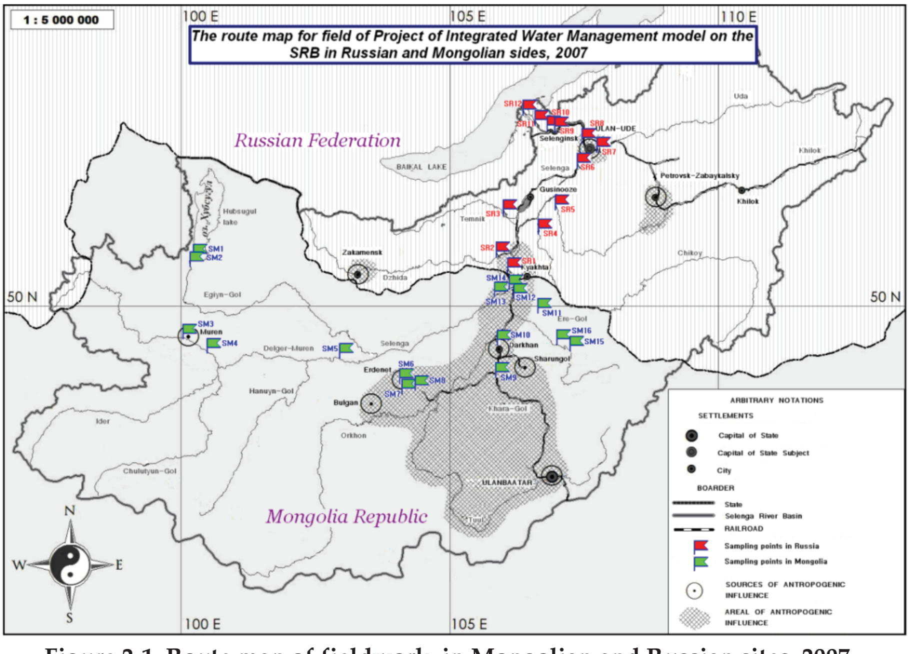


Figure 2-1. Route map of fieldwork, in Mongolian and Russian sites, 2007

Water quality measurements and analysis in 2008

Sampling sites of the second study were selected from 37 areas (23 in Mongolia and 14 in Russia). In order to understand the present condition of water quality and distribution of pollution sources within the Selenge River Basin, the measurements and samples for analyses were taken at Hot Spot areas (HSA's). In Mongolian side: Zaamar and Ulaanbaatar areas at Tuul river and Erdenet area at Khangal river. In Russian side: Zakamensk area at Modongkul river, Selenginski area and Ulan-Ude area at Selenge river. Figure 2 -2 shows the sampling sites in 2008.

In 2008, the samplings were taken (in order - from upstream to downstream):

In Mongolian site

- ✓ Near Ulaanbaatar city, site related to the Tuul River at SM1, SM2, SM3, and SM4;
- ✓ The downstreamalong Tuul River from Ulaanbaatar location at SM6, SM7, SM8;
- ✓ The downstream along Tuul River, on Zaamar Mining area at upstream of Zaamar area (SM23) not affected by mining , SM11, SM12, SM13, SM13-1, and SM14;
- ✓ The downstream along Orkhon River, from upstream - SM 20, SM19, SM21, SM18, SM17, SM22, Ugi lake - SM16, SM15.
- ✓ On Kharaa River, at SM9 and SM10

In Russian site

- ✓ At Zakamensk area (Dzhidinski Mining operation, closed company), SR8, SRS9, SR10, SR11, SR12;
- ✓ At Ulan-Ude city, SR6, SR7, SR5;
- ✓ Along the Selenge River, SR4, SR3, SR2, SR1

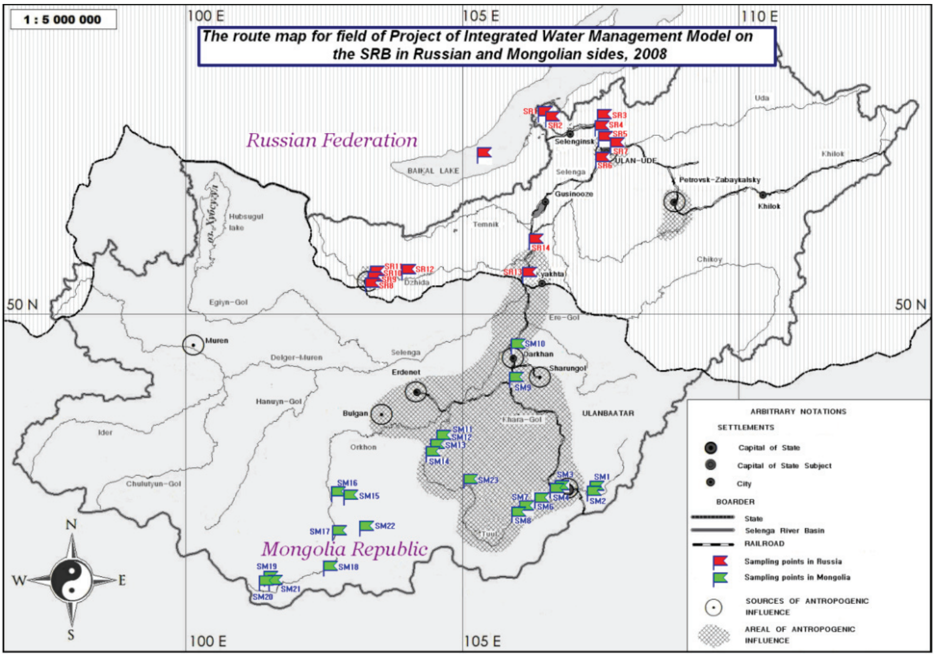


Figure 2-2. Route map of fieldwork, in Mongolian and Russian sites, 2008

Water quality measurements and analysis in 2009

For the third year of the study, 34 sides were sampled and monitored. There were 23 sites in Mongolia and 11 in Russia, which were selected by KEI/IGMAS/BINM research team. This study consists of following HAS's: in Mongolia were Erdenet copper mining area, Ulan-Bator and Darkhan industrial cities, and in Russia (Republic of Buryatia) were at Zakamensk (Dzhidinski Wolfram-Molybdenum mining area), Gusinoozerski (Heat power plant), and Ulan-Ude (industrial cities), Selenginski (Pulp-and-Paper plant) areas. Sampling sites in 2009 is shown on Figure 2-3.

In 2009, the sampling sites were taken from the following HAS's:

On Mongolian site

- ✓ Near Ulaanbaatar location, SM1, SM16, SM17, SM18, SM19, SM15, SM14, SM13;
- ✓ Near Erdenet location: SM2, SM3, SM4, SM5, SM6, SM7;
- ✓ Near Darkhan location: SM12, SMN11, SM8, SM9, SM10.

On Russian site

- ✓ Near Zakamensk location: SR1, SR2, SR3;
- ✓ Around Gusinoozerski location: SR4, SR5, SR6;
- ✓ Near Ulan-Ude city: SR9, SR10, SR11;
- ✓ Near Selenginski location: SR8, SR7.

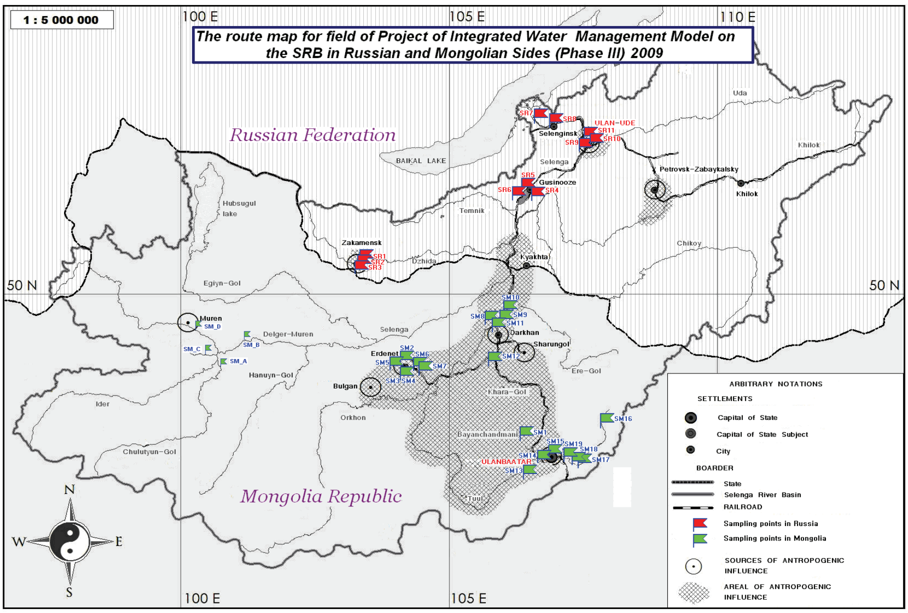


Figure 2-3. Route map of fieldwork, in Mongolian and Russian sites, 2009

b. Field measurement

Field surveys were conducted during 3 years in the summer time considering the characteristics of Selenge River basin (long winter, short summer): the first survey from 2007.7.17 to 2007. 7. 27; the second survey from 2008.6.25 to 2008.7.08; and 3rd survey from 2009.7.28 to 2009.8.31 in Mongolia and Russia. The samples were collected for heavy metal analysis at the 58 sites in Mongolia and the 37 sites in Russia during three years.

Preparation for measurement and analysis

Table 2-1 provides the list for the field survey and sampling materials. The preparation includes:

- Sampling bags (1liter volume) and plastic flasks (5 liters volume) for water sampling;
- A set of field filtration for removing suspended materials in the sample (filter sets, GF/C, hand pumps, pincettes);
- Nitric acid (HNO_3 = 63.01) for fixing heavy metals in the sample;
- An *in-situ* multi-water quality measurement checker to measure surface water quality parameters (DO, pH, temperature, conductivity, turbidity) and calibration solution (electrolyte R-5C, pH standard 4.01, 6.86 solutions for calibration).

Table 2- 1. Field survey and water sampling materials

Materials	Purpose
5L plastic beaker	For water samples
HNO3(liquid)	For water samples
Sample bag	For water samples
Pipette aid	For water samples
Micropipette & tip	For water samples
Plastic pipette	For water samples
SS Filter set	For water samples
GF/C	For water samples
Pincett	For water samples
Hand pump	For water samples
Multi water quality checker (including calibration solution)	For water quality measurement
GPS	For site coordinates
Ice box	For water samples
Silicon tubing	For water samples
Distilled water bottle	For washing and calibration
Tissue	For Cleaning

Water sampling

Figure 2-4 shows the water sample taking scenes using a plastic flaskfrom the sampling site. The samples were filtered using GF/C filter. After the filtration, SS filter set was used for keeping the sample. Generally the water sample were preserved by putting 2mL of HNO3 (FW 63.01, 60%) into a 1L sample bag. There were used two water samples: 1st water sample for heavy metals analysis and 2nd one for the conventional pollutant analysis in 2009.

The water samples were preserved by putting 0.1mL of HNO3 (FW 63.01, 60%) into a 50ml centrifuge tube (for heavy metal analysis). The water samples fromorganic matter and nutrients analysis were put into a 1L sample bag (no filtration).

Figure 2-4. Water sampling procedures in filed works on the SRB

The field measurement was conducted at the same time with taking samples (Figure 2-5). The measurements were taken by using U-10 water checker (Horiba, Japan) or WQC-22A (DKK TOA, Japan). The following measurement parameters were taken: temperature, DO, pH, Conductivity and Turbidity (Table 2-3). The Suspended Solid (SS) sampling, GF/C filter mass, and SS sampling were measured before and after filtering. The GF/C filter was analyzed in the laboratory according to the standard method of analysis.

Figure 2-5. In-situ field measurement of physical-chemical parameters

Table 2-2. WQC-22A parameters (DKK TOA, Japan), 2007

Parameters	*Range of measurement*	*method*
pH	0~14 pH	WQC-22A
Conductivity	0~200 mS/m	WQC-22A
Turbidity	0~800 NTU	WQC-22A
DO	0~20.0 mg/L	WQC-22A
Temperature	0.~50℃	WQC-22A

Table 2-3. U-10 Water checker parameters (HORIBA, Japan), 2008-2009

Parameters	*Range of measurement*	*method*
pH	0~14 pH	U-10 water quality checker
Conductivity	0~100 mS/cm	U-10 water quality checker
Turbidity	0~800 NTU	U-10 water quality checker
DO	0~19.9 mg/L	U-10 water quality checker
Temperature	0.~50℃	U-10 water quality checker

c. Laboratory analysis

Heavy metals analysis

The filtered samples were brought to the laboratory (South Korea) for the analysis from Mongolia and Russia. For the identification of heavy metals (Cr, Fe, Ni, Cu, Pb, Mn, As, Cd, Zn), researchers used filtered preserved water samples. As for preservation, the concentrated nitric acid with a proportion of 3 to 5 ml per 1 liter of sample was used.

In this experiment, iCAP 6500 ICP-AES (Figure 2-6) (Thermo elemental Ltd., UK) X-7 series ICP-MS (Thermo elemental Ltd., UK) and the UV-Vis Spectrometer analyzed the elements (Cd, Cu, Zn, Cr, As, Mn, Fe, Ni, Pb) from 95 samples. The two elements of heavy metals (Co and Ag) were added in 2009. The condition of the equipment is documented in the tables for signal stabilization (Table 2-4). 75 seconds of a sample read delay time was given. 75 seconds rinse time using 5 percent HNO3 in: (1) between samples and (2) between the sample and the standard was set.

From 2007 to 2008, ICP-AES was used to analyze of heavy metals with ICP-MS. ICP-AES was not used for analyzing of heavy metals in 2009. ICP-MS is able to measure even lower concentrations of heavy metals than ICP-AES. So ICP-MS was used to analyze the elements of heavy metals in 2009.

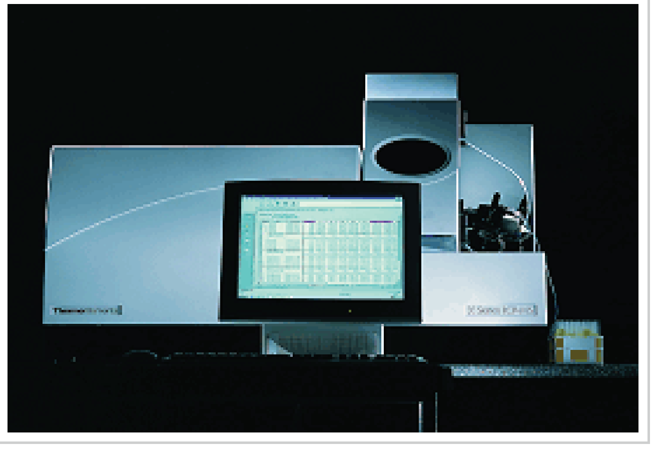


Figure 2-6. Inductively Coupled Plasma Mass Spectrometer

Table 2-4. ICP-MS specifications

Items	specification
Size	72 cm x 99 cm x 110 cm
Weight	295 Kg
ICP generator	free-running
Frequency (MHz)	40.68
Power (Watt)	1500
Argon flow (L/min)	16
Long-Term Stability	<4% RSC over 4 hours
Sensitivity	>40 M cps/mg/L 115In
Vacuum system	3-stage
Mass filter	quadrupole
Mass range	1-270
Resolution	0.3-3.0 amu

Conventional pollutants: Organic matters and Nutrients

During all three years (2007-2009), researchers were focused on analyzing heavy metal. But in the last research work (2009),conventional pollutants located near big cities and indentified pollution sources related to domestic and industrial wastewaters and livestock's wastes were additional analyzed. So in order to analyze the organic matters and nutrients, such as COD, T-N, T-P, NO3-N, NO2-N, NH3-N, PO4-P along with heavy metals analysis, water samples were collected from each sites. For conventional pollutants analyses were preferred to use "analysis kit" method, because it is consider being simple and quick, than "standard method", which takes much time and needs many reagents and equipments. Because IGMAS was ill-equipped for this analysis and preservation time of organic matter and nutrients was even shorter than heavy metals, we had to analyze them in IGMAS (Mongolia). So we took analysis equipments and analysis kits to Mongolia.

The non-filtered samples were brought to the IGMAS (Mongolia) as well and used them for identification of organic matter and nutrients in a ratio 1 unit to 5mL of sample per 1 unit of vial. The methods of the "analysis kit" for each conventional pollutant have different analyzing processes, reagents and a range of determining options (high, low, ultra low) (Table 2-5). So we had analyzed using the following manual (Figure 2-7):

- ✓ COD: add 2mL of sample(D.W.) to the vial → heat (150℃) the vials for 2 hours using COD reactor → place the blank into the cell holder, touch zero (HACH DR 2800) → place the sample vial into the cell holder, touch enter. → Results will appear;
- ✓ T-P: Add 5mL of sample (D.W.) to the vial →Add reagent to the vial → heat (150℃) the vials for 30 minute using COD reactor → Add 2mL of TP solution to the vial → place the blank into the cell holder, touch zero (HACH DR 2800) → place the sample vial into the cell holder, touch enter. → Results will appear;
- ✓ T-N: Add persulfate reagent to the hydroxide vial→ Add 5mL of sample (D.W.) to the vial→ heat (105℃) the vials for 30minute using COD reactor → Add reagent 1 to the vial, also reagent 2→Add 2mL of treated sample (blank) to Acid vial → place the blank into the cell holder, touch zero (HACH DR 2800) → place the sample vial into the cell holder, touch enter. → Results will appear;
- ✓ PO4-P: Add 5mL of sample (D.W.) to the vial → Add reagent to the vial → place the blank into the cell holder, touch zero (HACH DR 2800) → place the sample vial into the cell holder, touch enter. → Results will appear;
- ✓ NO3-N: Add 1mL of sample (D.W.) to the vial → Add reagent to the vial → place the blank into the cell holder, touch zero (HACH DR 2800) → place the sample vial into the cell holder, touch enter. → Results will appear;
- ✓ NO2-N: Add 1mL of sample (D.W.) to the vial → place the blank into the cell holder, touch zero (HACH DR 2800) → place the sample vial into the cell holder, touch enter. → Results will appear;
- ✓ NH3-N: Add 2mL of sample (D.W.) to the vial → Add reagent to the vial → place the blank into the cell holder, touch zero (HACH DR 2800) → place the sample vial into the cell holder, touch enter. → Results will appear.

Table 2-5 provided the list of analysis materials for organic matter and nutrients.

Table 2-5. Analysis materials for organic matter and nutrients

Materials	Purpose
Analysis Kits	For analysis
COD reactor	For analysis
Micropipette & tip	For analysis
Spectrophotometer (HACH DR 2800)	For measurement
Scissors & cutter	For cut
Distilled water (D.W.)	For washing and blank
Kimwipes wipers	For Cleaning

Figure 2-7. Analysis procedure of organic matters and nutrients

All water quality data for physical-chemical parameters, heavy metals and conventional pollution (conducted in 2009) is in Appendix B.

B. Water Quality Characteristics of SRB

a. Prior Research

This section discusses the previous studies done in Mongolia and Russia. Collaborative and related studies are incorporated.

Studies in Mongolia

Natural chemical composition of the Selenge River, Mongolian part

A feature of chemical composition of the rivers in the Selenge River basin is ion relation and balance such as hydro carbonate ion and calcium ion are more dominant in fresh, and soft water compared to the same kind of fresh water rivers of the world. As per chemical composition and ion balance in water of the Selenge river and its tributaries its cation balance is $Ca^{2+}>Na^{+}+K^{+}>Mg^{2+}$, and the anion balance is $HCO_3^{-}>SO_4^{2-}>Cl^{-}$. In fact, hydro-chemical study in the Selenge River and its tributaries has been done for many years, seasonal changes of the chemical composition have been observed and its character depends on its discharge. The highest mineralization was in winter as 300-320 mg/l and 200-210 mg/l in spring (when it is fed by rain and snow melt).

At the all sample sites along Selenga river, water is soft (2.00-2.70 mg-eq/l), with pH=8.30-8.50 and belongs to 1-2nd types of Calcium group of Hydro carbonate class. The concentration of dissolved oxygen fluctuated between 6 to 9 mg/l and the concentration of NH_4 ranges 0.1 mg/l and 0.0-3.0 mg/l concentration of NO_3 mg/l. See figure below.

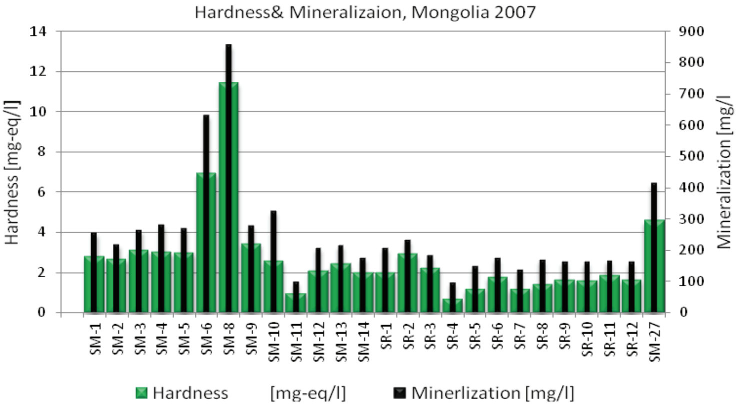


Figure 2-8. Hardness and mineralization, Mongolia 2007

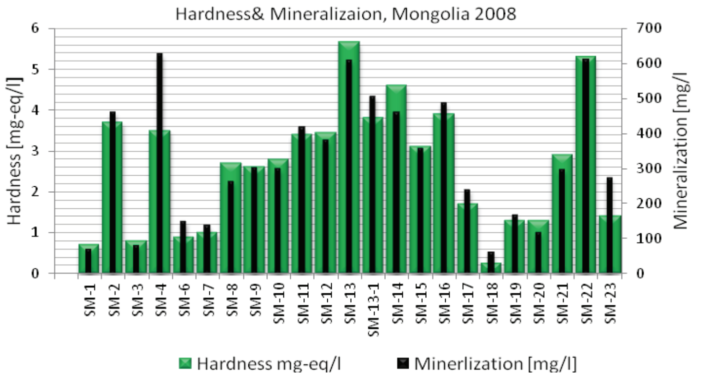


Figure 2-9. Hardness and mineralization, Mongolia 2008

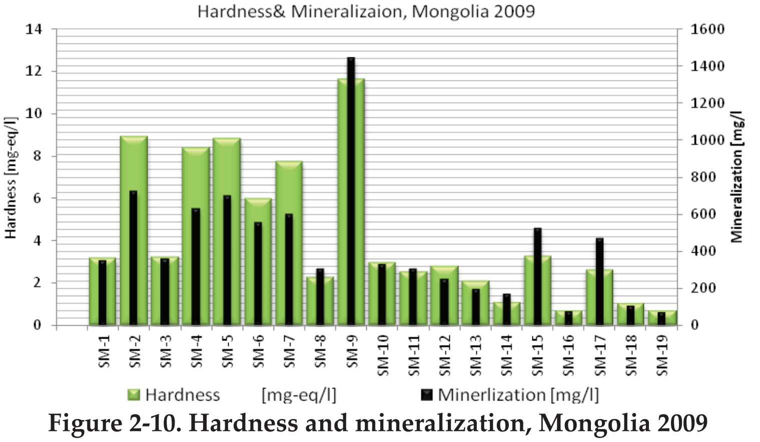


Figure 2-10. Hardness and mineralization, Mongolia 2009

Pavlov et al. (2002) studied the toxicity of sediments in the Selenge River Basin in Mongolia. The analysis of the bottom sediment (BS) from the sampling sites had shown that the concentrations of some heavy metals (HM) which includes As, Cd, Cu, Pb, Cr, and Mo in BS were high and potentially toxic. The BS samples taken from the Selenge River near the Mongolia–Russia boundary were non-toxic. This suggests that the main influence of Lake Baikal from the Mongolian part of the Selenge catchments area could not adversely affect the state of the lake.

Tsengelmaa et.al (2004) did an assessment on the overall ecological impact of the Tuul River. Part of the study included water quality tests and benthos assessments. This was done by analyzing the change of abundance and the diversity of the macro-zoo-benthos and the change of the water quality parameters. The study revealed that from Lun Bridge to Tuul garam, along the length of the river, pH ranged 6.9 to 7.62. Hardness was between 1.20 to 1.75 mg-eq/l, and mineralization fluctuated between 147.6 to 186.7 mg/l. Suspended matter in the gold wash wastewater is 1 to 110 times larger than the allowed maximum level to surface water sources according to water quality standards. Increased sedimentation in the river resulted in a reduction of penetrable sunlight into the water. This in turn causes a decrease in photosynthesis, which creates suitable living conditions for the growth of algae and other undesirable microorganisms. Bottom sediments of the Tuul River at the Lun Bridge sample point, before the start of intensive gold mining activity, are in the 'fine to medium sand' class according to Oxotin's soil classification. At the five sample points at 'Shijir Alt' the bottom sediments were classified as 'very fine', 'medium clay loam' and 'light clay loam'. Thus, the bottom sediments of the river were changing in structure and becoming very fine.

In another study conducted by Javzan et al (2007), the chemical component and characteristics of the surface water of Orkhon River were examined. Gold mining companies and livestock are present near the Orkhon River. Water quality assessments were also been made. This study showed that the river, which originates from Khangai Mountain, was not affected by the anthropogenic activities in Urd, Khoid Tamir, Ulaan and Tsagaan River and those tributaries. Surface water of those rivers is in natural condition. The Khangal River was found to have high mineralization, hard and polluted.

Gold mining affected Tuul, Kharaa, Yeroo, and the Shar Rivers.

Studies in Russia

Semenova and Myagmarjava (1977) described the hydrological regime of the rivers of the Selenge River Basin. The study suggests that the surface water mineralization in Russia was less than that in Mongolia.

Recent studies had been primed as well. Laperdina (2002) estimated the mercury and other heavy metal contamination of the traditional gold mining areas of Transbaikalia. Extensive investigations were carried out in the two river basins of the Lake Baikal catchments. Results showed that there had been significant deterioration of the water quality with respect to the following parameters: pH, turbidity, electric conductivity, and content of metals. Mercury contamination varied depending on the time and level of mining activity. Areas using mercury amalgamation techniques are severely contaminated. Mercury concentrations from gold-mining areas and background sites varied from <0.001 to 0.78 mg kg^{-1} for bedrock. Minerals had values of <1 to 183 ng m^{-3} for the atmosphere, 0.013 to 3.59 mg kg^{-1} for soils, <5 to 5000 ng l^{-1}, and <5 to 27 800 ng l^{-1} for dissolved and particulate water fractions, respectively, and 0.008 to 54.2 mg kg^{-1} for river-bottom sediments.

Khazheeva et al. (2005) looked into seasonal and spatial dynamics of TDS and major ions in the Selenge River. There had been hydro physical, hydro chemical and hydro biological expeditions. The result revealed that the components SO S, Cl^-, Na^+, and K^+ (reactive) were by some means stemmed from the anthropogenic activities. River run-off variations contributed to the seasonal variations of major ions and TDS. Intra-annual variations in run-off had shown a relationship with the dynamics of variations in the concentrations of non-reactive ions such as Ca^{2+}, Mg^{2+}, and HC. Non-reactive components, however, lessen in open-channels.

Collaborative Studies

Regarding the Lake Baikal Watershed Brief (2001), there have been studies conducted by Mongolians in collaboration with other countries. These are discussed below:

In order to identify sediment levels in the river, the Mead Foundation and the Tahoe-Baikal Institute, an international team of Mongolian, American, and

Russian researchers studied the portion of the Selenge watershed. This was conducted from 1 to 26 August, 2001.

Water samples from each site were taken one to three times. Water quality characteristics were described using the following parameters: Turbidity, Nitrate, Phosphate, Ammonia, Oxygen, pH, Temperature, Conductivity, Total Dissolved Solids, Total Suspended Sediment, Total Phosphorus, and Discharge. Results showed that the Tuul River had the highest level of disturbance due to gold mining activities.

Prior research conducted by KEI focused on the water quality and problems related to gold mining in Mongolia. This research contributed to the water quality data and the identification of pending problems.

Joint research between Korea and Mongolia on Water Quality and Contamination of the Transboundary Watershed in Northern Mongolia was conducted in 2005 and 2006 (KEI 2005, 2006). The results showed that mining, industry, logging, overgrazing, agriculture, and residential areas contributed to water quality degradation. Of the 35,000 groundwater wells constructed prior to 1990 roughly 30 percent are working as of 2000.

The results showed strong alkalinity and high turbidity. Turbidity values were 0.2 to 742 NTU. The mean was 78 NTU. The pH ranged from 7.2 to 9.0. The mean was 8.1. High turbidity was due to the influx of soil particles, which could be explained by erosion, overgrazing, agricultural activities, cultivation, and mining.

b. Temporal and Spatial Variations

Temporal: Water Samplings and Measurements (S&M's) were taken once in the middle summer time for three years. In order to check and define the data on subjected river reaches in the Selenge River Basin,the same sampling stations (Figure 2-11) in different time during all period (2007-2009) of our fieldwork surveys in Mongolia and Russia were taken.

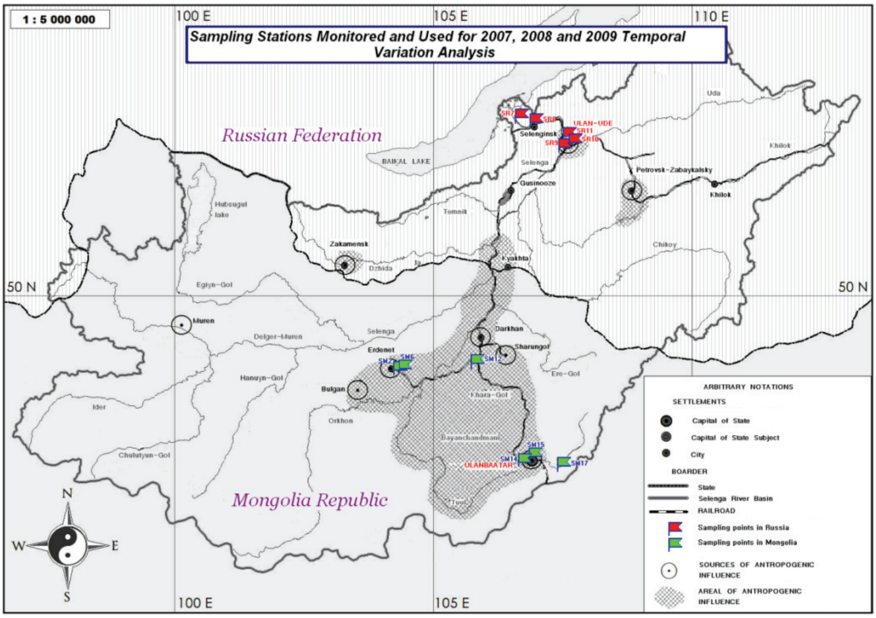


Figure 2-11.Sampling Stations monitored and used at the same sites for year 2007, 2008 and 2009

These stations were monitored and samples were collected to continue the study of temporal variations in the river (Table 2-6). Temporal analysis of the trend regarding heavy metals was observed by comparing the data collected in July 2007, end of June 2008 and end of July 2009. If the heavy metals in some reaches of the river show high or very high values for two or three years on end, we can state that this reach is under continuous pollution either by anthropogenic or natural factors, depending on specific pattern of location and need to undertake some management measurements for preventing river pollution.

There are two factors for water quality issues and its variations in the Selenge River Basin. First is anthropogenic factor such as mining activities, agricultures, breeding, dumping of waste water into the water bodies and its water use. Second is natural factor, such as meandering rivers with following erosion processes, weathering, and geological background of landscape. It can be noticed that the factors affected on the state of the Selenge River Basin are relatively different for different sites.

The temporal variations of heavy metals of water samples were selected from 11 monitoring sites. Since the storm water runoff was high in the summer, heavy metals from mining industries, domestic and paved surfaces were washed out and flown directly into the water body.

Table 2-6. The sites taken in the same location within 2007 - 2009 and its descriptions

2007	2008	2009	Site Description
SM-6		SM2	Khangal River bridge, After Erdenet City
SM-8		SM-6	Erdent river, near Erdenet Copper mining
	SM3	SM14	Tuul River, downstream of wastewater plant
SM-9	SM9	SM12	Kharaa River, Bridge upstream of Darkhan City
	SM4	SM15	Ulaanbaatar WWTP outfall
	SM2	SM17	Wastewater of Nailakh settlement
SM-10		SM11	Darkhan WWTP outlet
	SM1	SM16	Tuul River, Tuul bridge road to Terelj resort
	SR8	SR1	Upstream of Modongkul Stream
SR12	SR1	SR7	Selenge River, Murzino settlement
SR9		SR8	Selenge River, Selenginsk settlement
	SR6	SR9	Selenge R., Upstream of Ulan-Ude City
SR7	SR7	SR10	Uda River, before confluence with Selenge River
	SR5	SR11	Selenge R., Downstream of Ulan-Ude City, after confluence with Uda R.
2007	2008	2009	Site Description

In Mongolian site

Figure 2-12 shows the comparison of heavy metals from 2007 to 2009. Most values of heavy metals were higher in 2008 compared to those in 2009. But in 2009, Cu value was very high at SM2 (Khangal River – after Erdenet). Moreover, the sampling stations below the Ulaanbaatar WWTP outfall and Waste Water of Nailakh mainly showed high values in both years (2008-2009).

During these fieldworks, flow data measurements were not taken. Thus it is impossible tofully interpret the concentration of heavy metals.

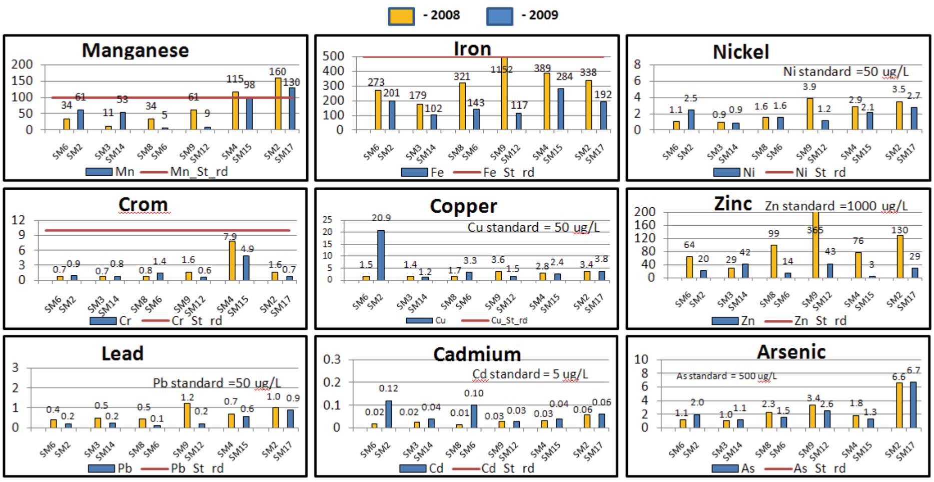


Figure 2-12. Temporal variation of heavy Metals, Mongolian Site, 2008-2009

In Russian site

Figure 2-13 shows the comparison of heavy metals from 2007 to 2009. Most values of heavy metals were highest in 2008 compared to those from 2007 and 2009. Moreover, the most of sampling stations on the Selenge River at the Murzino settlement, upstream and downstream of Ulan-Ude city showed high values of heavy metals. The sampling station on the Uda River at Ulan-Ude city also showed high values of heavy metals. The cuause of this results is regarded as anthropogenic factor from city as point and non-point source pollution into the river as well as natural factor.

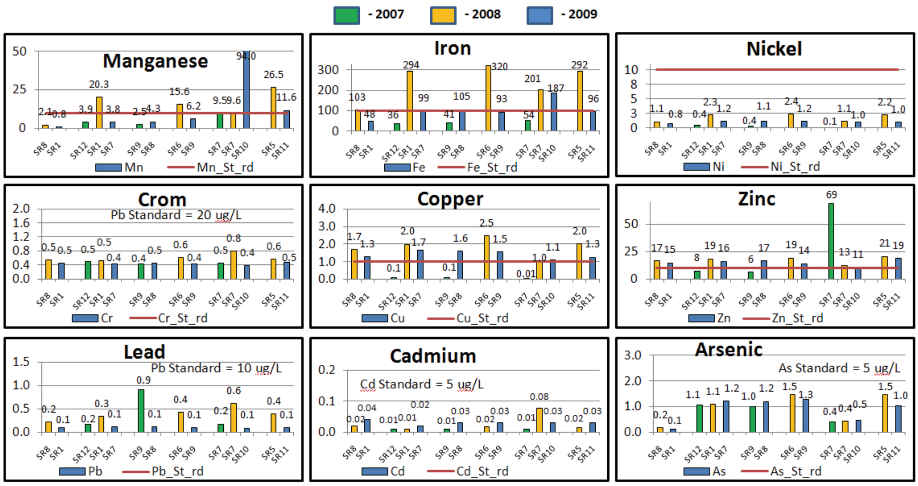


Figure 2-13. Temporal variation of heavy Metals, Russian Site, 2007-2009

The repeated excess event of water quality standards and high pollutions suggests focusing on the need to adherence to the specifications of the Waste Water Treatment Plant.

Spatial: The strategies of taking S&M's were different every year:

In 2007, S&M's were taken from main tributaries related to the Selenge River. In order to have the general picture of the Selenge River Basin (SRB), physical-chemical parameters (NTU, EC, DO, pH, and Temperature) and heavy metals (Mn, Fe, Ni, Cr6+, Cu, Zn, Pb, Cd, and As) analyses were implemented.

In 2008, S&M's were taken near potential Hot Spot Areas (HSA's) such as mining and industrial areas. In order to investigate the most influenced areas, the surface water was measured for the same five parameters from the previous year in addition to SS. And surface water samples were analyzed for heavy metals within the Selenge River Basin mentioned above.

In 2009, S&M's were taken at chosen HSA's in more detail. Additional heavy metals such as Co and Ag were also taken The conventional pollutatns (COD, TN, TP, PO4-P, NO3-N, NO2-N, NH3-N) were also added into the list of analyses. These measurements would help to understand the nature of water quality issues and undertakes the proper management measures for improving water quality conditions. Unfortunately, the flow measurement data were not taken.

Selenge (MGL)-Selenge (Rus) River, along the full length, 2007

- SM5 –Khutag-Ondor area;
- SM13 – before confluence of Orkhon R.;
- SM14 – after confluence of Orkhon R.;
- SR1 – Mongolian-Russian Boundary;
- SR6 – before confluence of Uda R;
- SR8 – after confluence of Uda R.;
- SR9 – at Selenginsk settlement;
- SR10 – nearby Pulp and Paper Plant (PPP);
- SR11 – at Kabansk settlement;
- SR11 – at Kabansk settlement;
- SR12 – at Murzino settlement

The results of the physical-chemical measurements along the Selenge River show the list what result showed in space dimension (Figure 2-14). The values of dissolved oxygen ranges 6.0 ~ 8.0 mg/L and water temperature remain stable at 21.0 ~23.3 °C. The values of electro conductivity are nearly on the same level but the values of turbidity are higher close to the bridge (SM5) in Khutag-Ondor area at the top of Selenge River and the Mongolian-Russian boundary (SR1). The values of pH are within the range (8.1-8.6) in which the highest is after the inflow of Orkhon River and the lowest is at SM5 station.

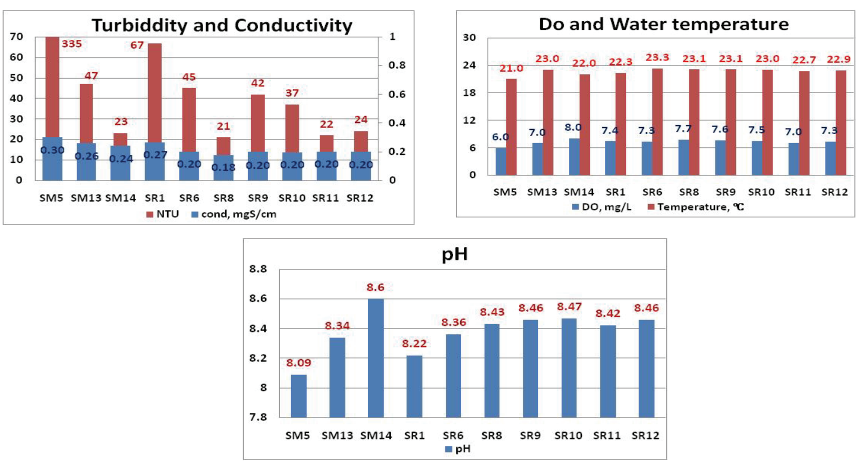
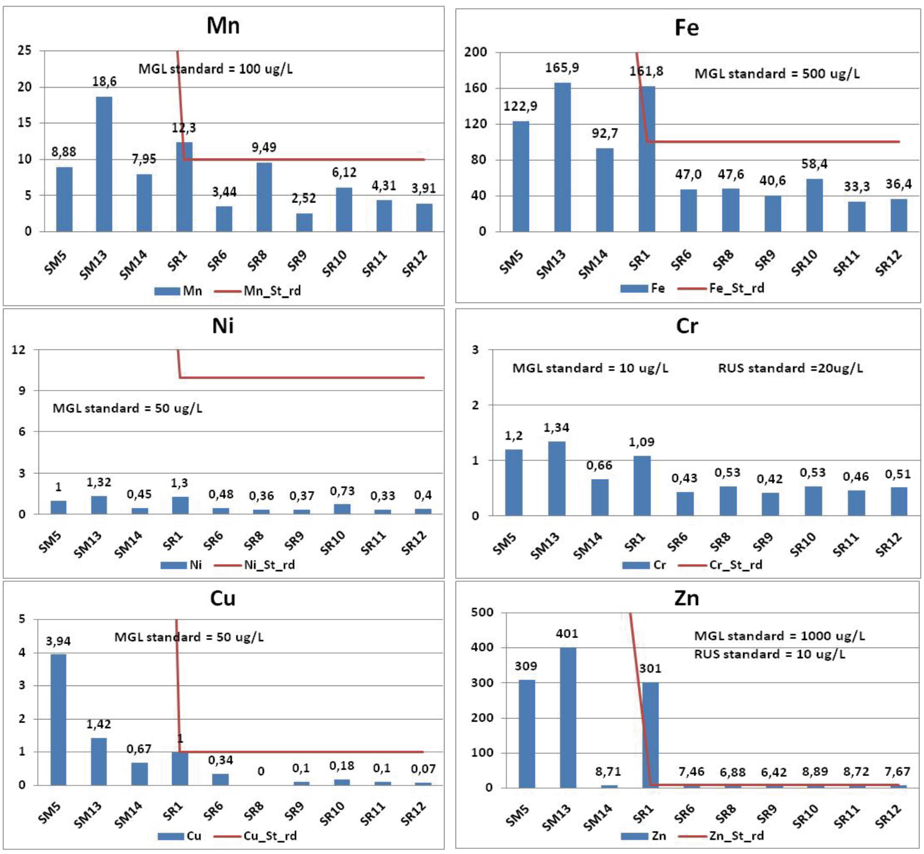


Figure 2-14. Physical-chemical parameters, Selenge (MGL) - Selenge (Rus) River along the whole length

As shown on Figure 2-15, there is no excess event of “Ambient WQ standard”, except for Mn, Fe and Zn metals at the Mongolian-Russian Boundary (SR1). It is affected by the upstream flowing from Mongolian site. Values of metals such as Mn, Fe, Cu, and Zn have higher values on the Mongolian Site than on Russian site. The values of heavy metals are decreasing. At present, the assimilative capacity of the Selenge River Basin is able to cope with it, but it can be lost by intensive processes of anthropogenic activities and can be badly reflected in the nearest future.



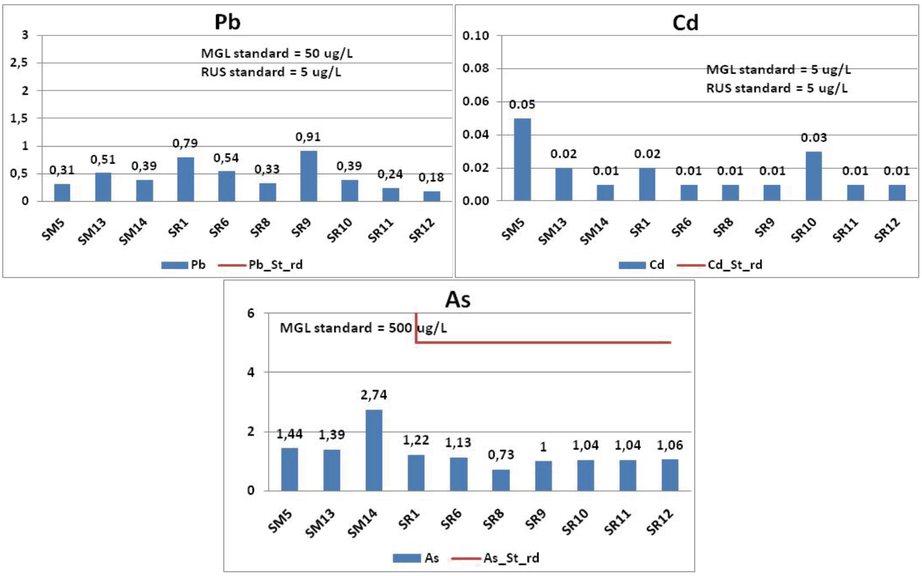


Figure 2-15. Concentration of heavy metals, along the Selenge (MGL) – Selenge (Rus) River, 2007

Fieldwork, 2007

On Mongolian site

- SM1 – Lake Khovsgol;
- SM2 – Khovsgol Outlet;
- SM3 – Delger River at Muren;
- SM4 – Delger River, Muren bridge;
- SM6 – Khangal River, Erdenet area ;
- SM9 – Kharaa River;
- SM15, SM16 – Shar(in) River;
- SM11 – Yeroo River;
- SM12 – Orkhon River.

The Figure 2-16 shows the results of the physical-chemical measurements on Mongolian site: at Khovsgol Lake (Eg River), Muren location (Delger River), Erdenet city and copper mining area (Khangal River), Darkhan area (Kharaa River), gold mining area (Shar River), and on the Orkhon River before the inflow of the Selenge River. The values of dissolved oxygen are higher at Khovsgol location, due to low temperature of lake's water at SM1 and downstream of Khovsgol outlet through the weir at SM2 (DO=11mgO/L). The lowest value of DO is noted on Shar River downstream of gold mining area. On other sampling stations the DO values are within the range (7-9 mg/L). The values of turbidity are high at downstream (Khangal River) of

Erdenet city within Erdenet copper mining area (SM6), on Shar River at SM15 and SM16 stations within gold mining areas, and on Orkhon River at SM12 before the inflow of the Selenge River – high meandered reach. The values of electro conductivity are high at SM6 (Erdenet area) and SM15 (gold mining area). The pH values are within the range (8.1-8.6)

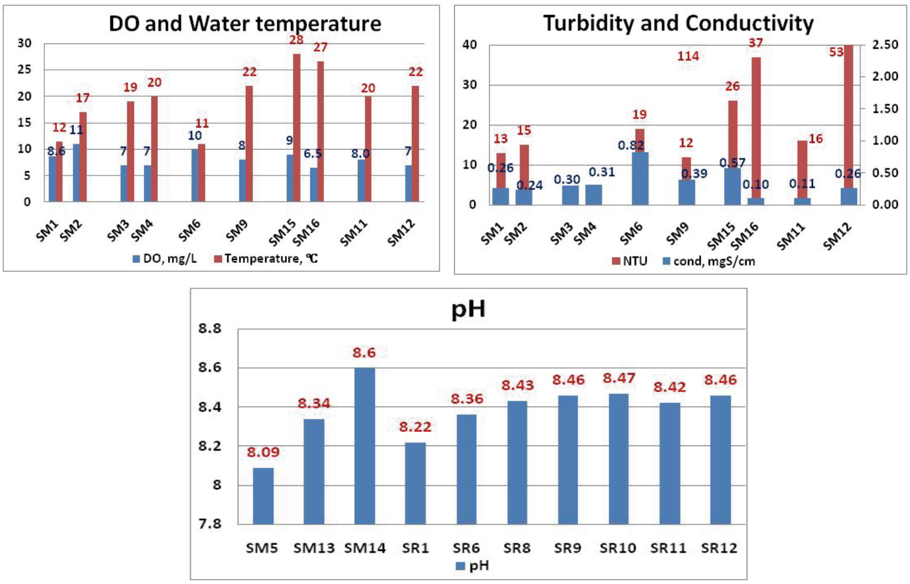


Figure 2-16. Physical-chemical parameters, on Mongloian Sites, 2007

The Figure 2-17 shows the results of heavy metal analyses from the Mongolian site from fieldwork in 2007. There is no excess event of "Ambient WQ standard" on the whole monitored reaches of the rivers. In comparison the the results of Heavy Metals, the standard value of Grade II (Pure water) is used from the classification of "Ambient WQ" standard. At Khovsgol and Muren locations, the values are low, causing the water samples to be are taken from upstream of rivers, which are not affected by anthropogenic factors, especially by mining. It is noted the values are giving high values at stations near mining areas (SM6, SM15 and SM16) and particularly at SM11 for Fe and SM12 for Zn. The non-point sources are flowing from mining areas as a result of ineffective land restorations and unorganized (poor) mining activities.

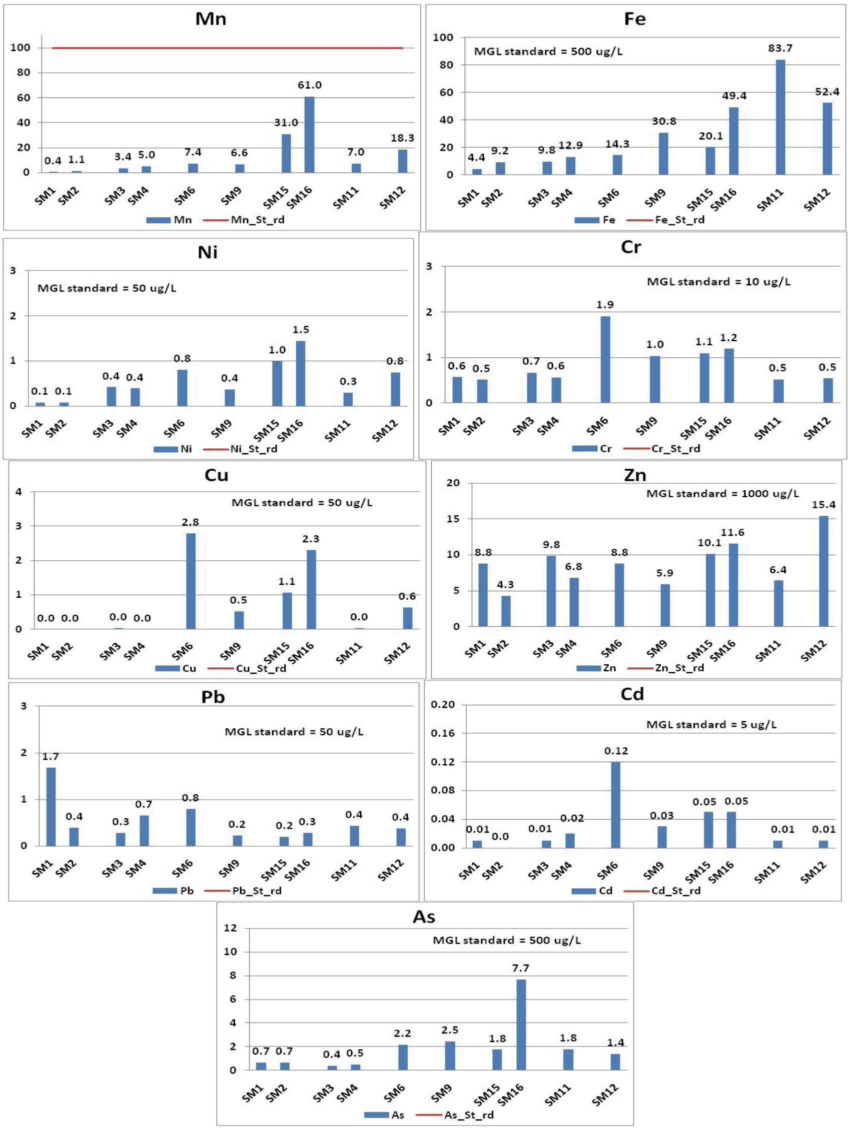


Figure 2-17. Concentration of heavy metals, Mongolian Sites, 2007

On Russian site

- SR1 – Selenge River
- SR2 – Dzhida River;
- SR3 – Temnik River;

- (Mongolian-Russian Boundary);
- SR4 – Chikoi River;
- SR5 – Khilok River;
- SR7 – Uda River

The results of the physical-chemical measurements on Russian site: at Mongolian-Russian boundary and the Selenge's main tributaries show the following relationship in space dimension (Figure 2-18). The values of conductivity and turbidity at all locations are low, except for turbidity at SR1 (Mongolian-Russian boundary) and for conductivity at SR4 (inflowing Chikoi River). The values of dissolved oxygen ranged from 7.29-8.04mg/L and remained at a stable temperature 19.6-23.3 ˚C. The values of pH are within the range (8.3-8.5) on Russian site no dangerous activities were located near rivers, except for the Zakamensk area.

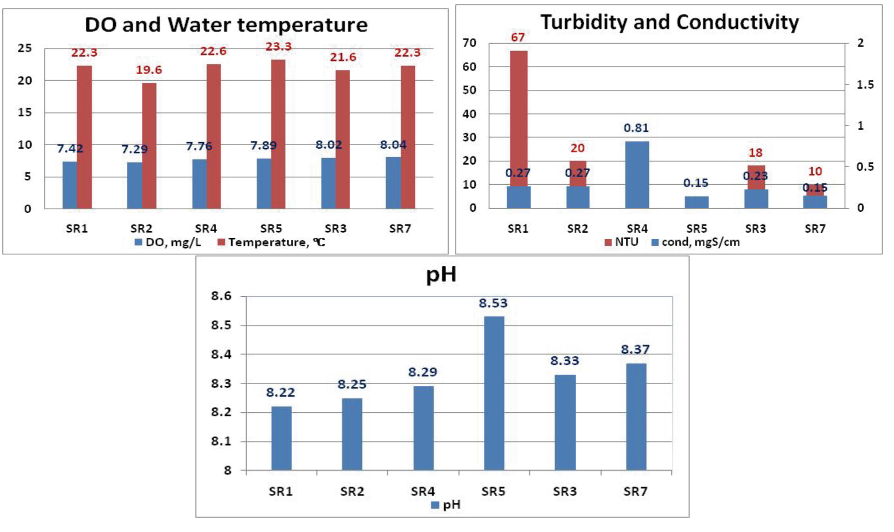


Figure 2-18. Physical-Chemical parameters, on Russian site, 2007

There is no excess event of "Ambient WQ standard", except for the Russian-Mongolian boundary at SR1 station (water pollution coming from Mongolia) and Zn from Uda River (SR7). It is caused by natural and anthropogenic factors. As for the last factor, it cans occurr by aggregation of heavy industries which is located in the city along the Uda River. As observed, the values are not very high even through the use of a tight water quality standard (for fishery water usage).

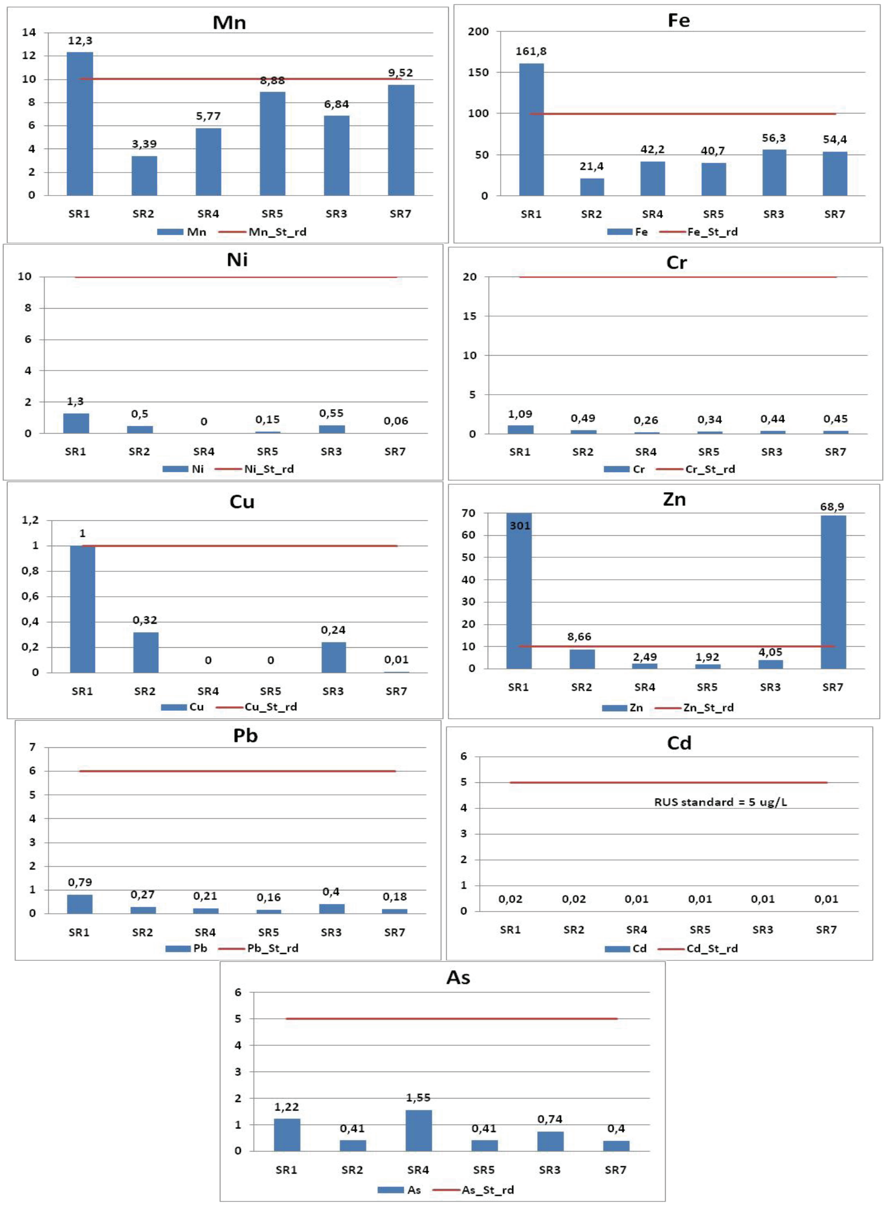


Figure 2-19. Concentration of heavy metals, Russian Site, 2007

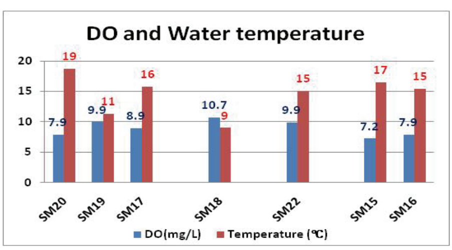
Fieldwork, 2008

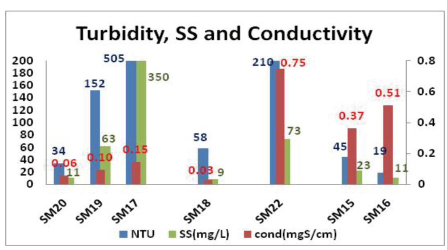
On Mongolian site

On upper part of Orkhon River

- SM20– Top of Orkhon River;
- SM19 – Upstream of Orkhon after SM20;
- SM17 – Orkhon River at Khar khorin city;
- SM18 – Ulan River before inflowing into Orkhon R.;
- SM22 – "Khugshen Orkhon" River;
- SM15 – inlet of Lake Ugi;
- SM16 – Lake Ugi.

The results of the physical-chemical measurements from the Mongolian site: at Orkhon River and connected water bodies, show the following relationship in space dimension (Figure 2-20). The values of turbidity are very high at Khara Khorin (SM17) (meandering processes), upstream of Orkhon Rivers (SM19) (gold mining), and "Khugshin Orkhon" River (SM22) (old river). The SS values are also high at SM19, SM22 and very high at SM17. The conductivity is high at the bridge on "Khugshin Orkhon" River. The DO values are respectively high and there is no relationship with turbidity. The values of pH are range from 6.88 to 8.45.





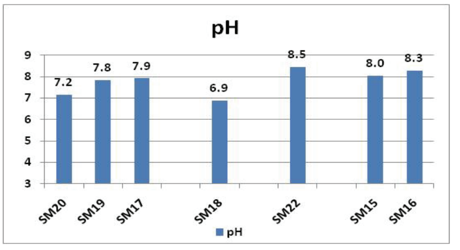
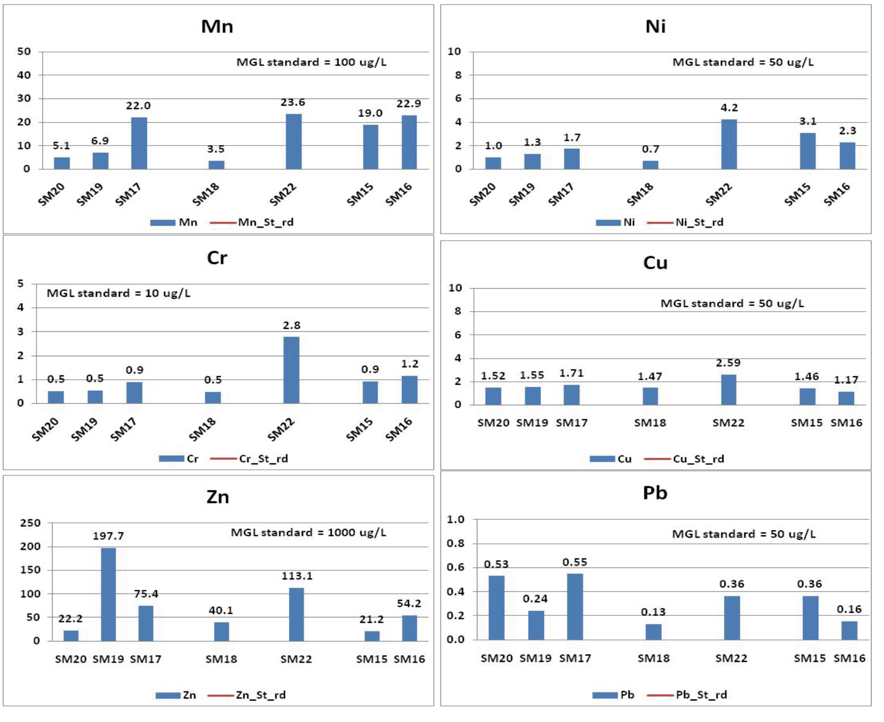


Figure 2-20. Physical-Chemical parameters, related to upper part of Orkhon River, 2008

As shown on Figure 2-21, there is no excess event of "Ambient WQ standard". High values are at Kharkhorin (SM17), "Khugshen Orkhon" River bridge (SM22), and inlet of Lake Ugi upstream of Orkhon River (SM19 – gold mining). It is occurred by natural (Fe and Mn) and anthropogenic factors.



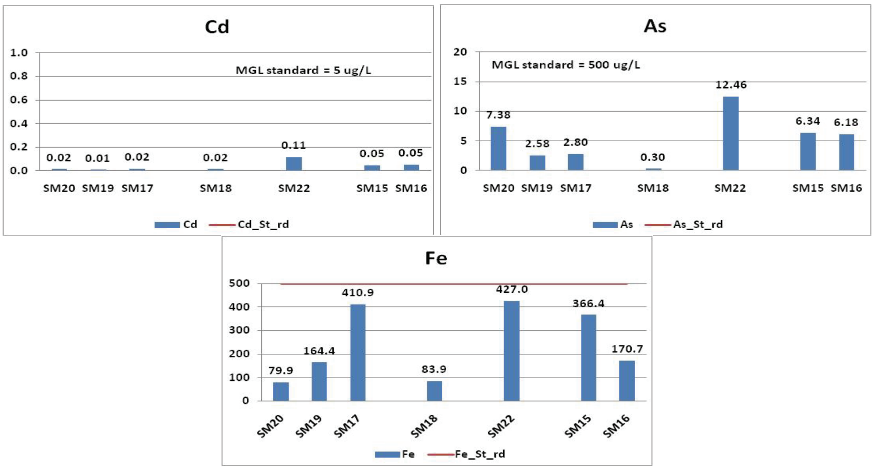


Figure 2-21. Concentration of heavy metals, related to upper part of Orkhon River, 2008

On Tuul River subwatershed, Mongolian site, 2008

- SM1 – at Tuul Bridge, directing to the Terelj National Park;
- SM3 – Downstream of Ulaanbaatar city before mixing of Waste Waters;
- SM6 – at "Tavan tolgoi" bridge;
- SM7 – at "Altan-bulag" bridge;
- SM8 – at Khustai National Park;
- SM23 – "Lun" bridge;
- SM11 – "Zaamar" bridge;
- SM12 – "Shijir Alt" bridge.

The results of physical-chemical measurements from the Mongolian site along the Tuul River show the following relationship in space dimension (Figure 2-22). The values of turbidity are very high at "Tavan Tolgoi" and "Altan-bulag" bridges due to meandering processes and cattle pasturing along the river. The SS has a similar pattern for turbidity. The conductivity is increasing along the downstream. It is caused by intensive mining activity at Zaamar area. The DO values are decreasing along the River, and the temperature is increasing at the same time. The values of pH are increasing and are within the range (6.77-8.1).

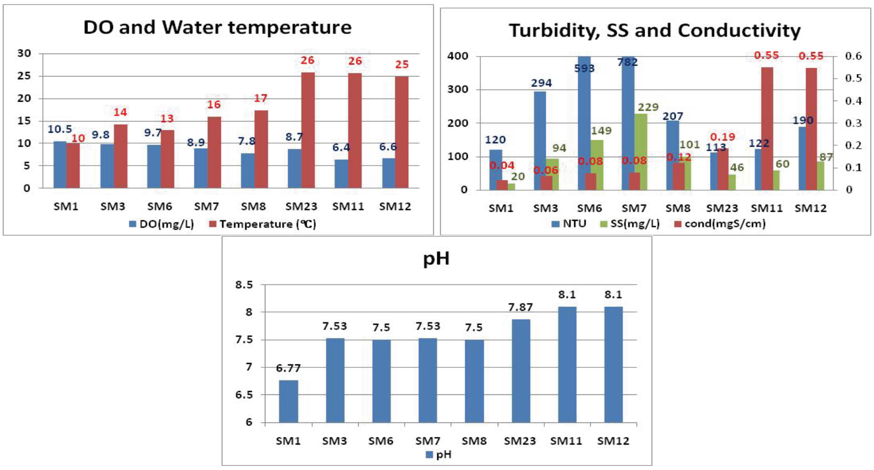
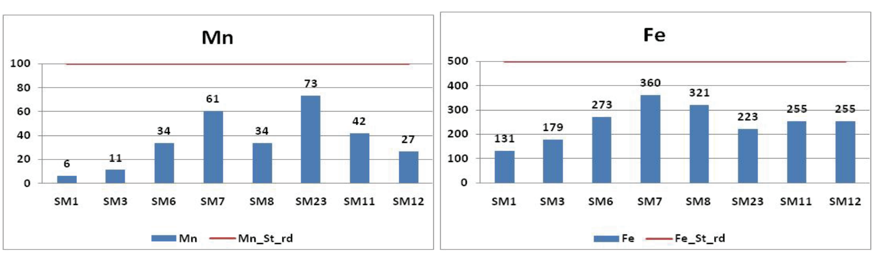


Figure 2-22. Physical-Chemical parameters, on Tuul River watershed, 2008

As shown on Figure 2-23, there is no excess event of "Ambient WQ standard". The values are giving high values at stations SM7 (downstream of small settlement), and near the mining areas (SM11 and SM12). The increasing tend is noted for most heavy metals along the downstream. The recent mining activities are main water polluters and natural geological background is additive factor. The pollution sources are flowing from mining areas directly into the river is the sequence of ineffective land restorations and unorganized mining activities. At station SM1, there are respectively high values of metals and is caused by natural geological band, not by anthropogenic factor.



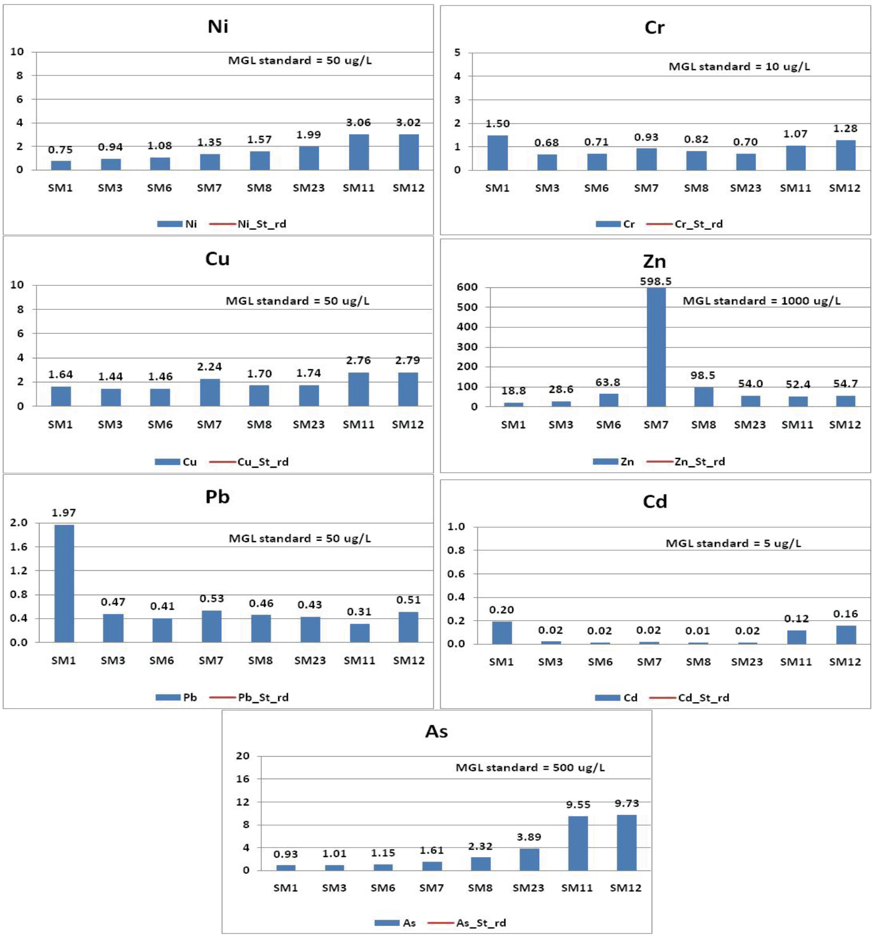


Figure 2-23. Concentration of heavy metals, on Tuul River sub-watershed, Mongolian Site, 2008

Fieldwork, 2009

On Mongolian site

Erdenet location

- SM6 – Erdent river, near Erdenet Copper mining;
- SM4 – Erdenet River, upstream in front of Erdenet WWTP outfall SM2 - Khangal river bridge , after Erdenet city;

- SM7 - Khangal river agricultural area near to Erdenet city;
- SM7 - agricultural area near to Erdenet city;

Ulaanbaatar location

- SM16 – Tuul river, at the bridge to Terelj Nat'l park;
- SM19 – Tuul river, at the bridge "Bayanzurkh";
- SM14 – Tuul River,downstream of Ulaanbaatar city.
-

Darkhan Location

- SM12 – Kharaa river, at the bridge upstream of Datkhan sity
- SM8 – Kharaa-Orkhon joint point.

The Figure 2-24 shows the results of the physical-chemical measurements on Mongolian site.

The results in Erdenet area show the following relationship in space dimension: the values of suspended solid (turbidity) and electro conductivity are high at Erdenet copper mining (SM6, SM4, SM2 and SM7) and have the tendency to increase up to SM2 and decrease to SM7. The values of dissolved oxygen are within the range (10.3-12.5mg/L) in decreasing order along the river on Khangal River. The values of pH are within range (7.87-8.1).

The results from the Ulaanbaatar area show the following: the values of suspended solid and electro conductivity are high along the downstream of Ulaanbaatar (SM14). The values of dissolved oxygen are with in the range (8.3-10.41). The values of pH are slightly low at SM 16 and SM19.

The results from the Darkhan area show the following: the values of suspended solid are decreasing from SM12 (40mg/L) to SM8 (34 mg/L). The values of electro conductivity are increasing from 0.306 to 0.455mgS/cm. DO values are decreasing from 9.1mg/L to 7.47mg/L (slightly lower values). The same features are for pH values.

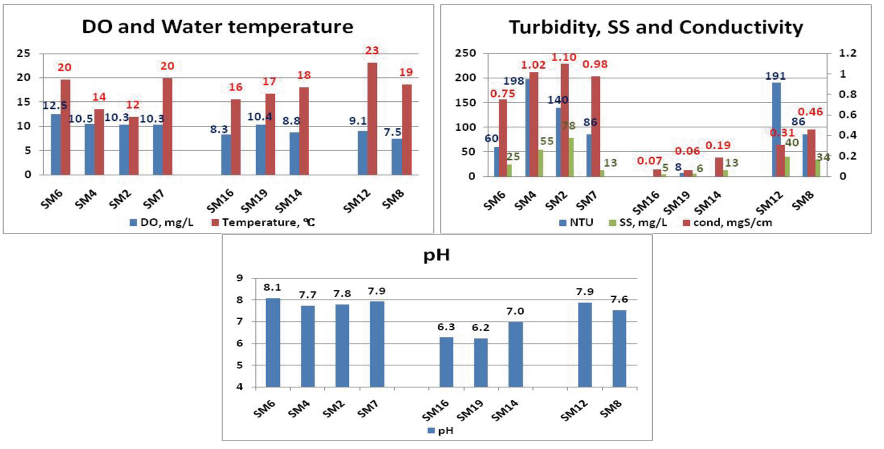


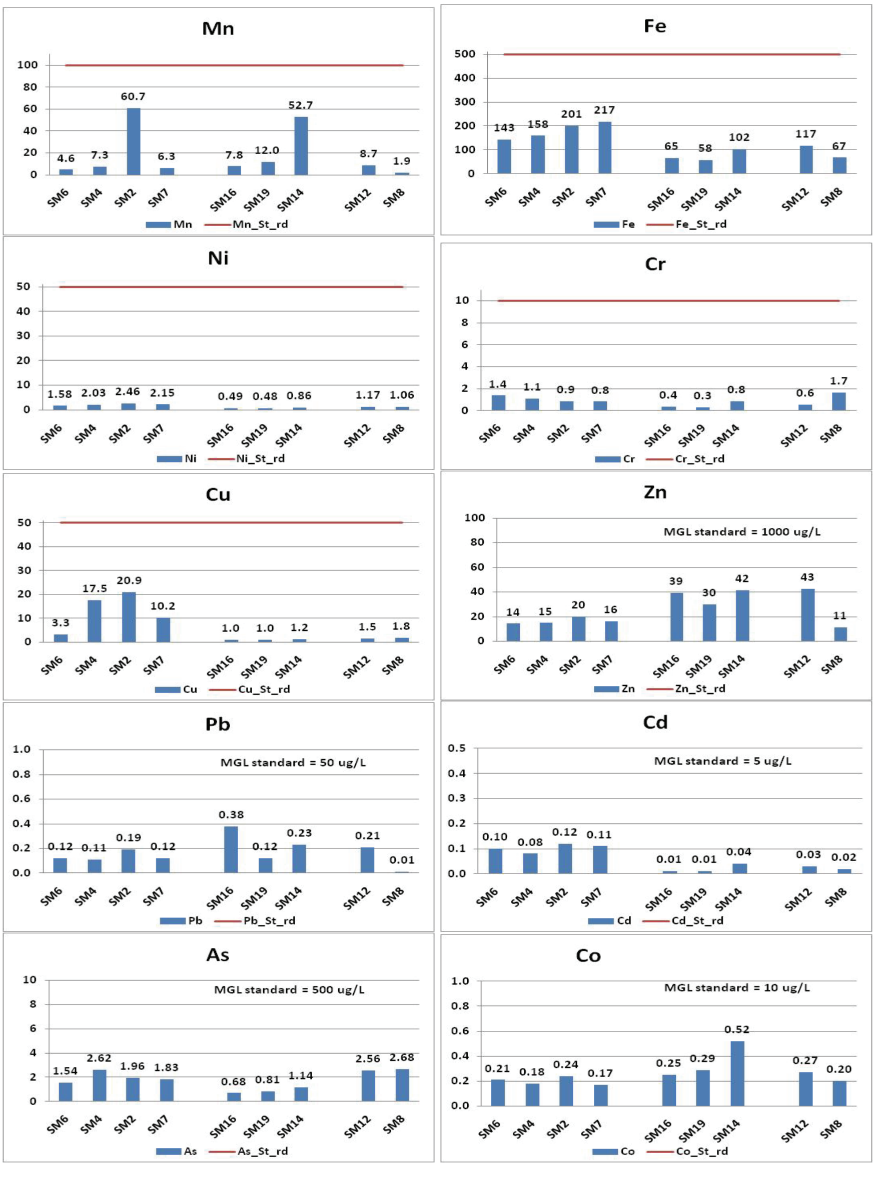
Figure 2-24. Physical-Chemical parameters, Mongolian Site, 2009

The Figure 2-25 shows the results of the heavy Metal analyses from the Mongolian site during fieldwork in 2009.

As shown in the figure, at the Erdenet copper mining area, there is no excess event of "Ambient WQ standard". There were high values of Cu metal at SM2 (20.88 μg/L), SM4 (17.5μg/L), and SM7 (10.2μg/L). Fe metal at all sampling points (143-217 μg/L), and Mn metal at SM2 (60.65 μg/L). Except for the three heavy metals mentioned, the remaining metals have low values nearly on the same levels along the downstream. The remaining, out of considering, sampling stations are not very impacted and contaminated by heavy metals.

At Ulaanbaatar area, there is no excess event of "Ambient WQ standard". Both Fe and Mn have higher values than other metals. Except for the two mentioned heavy metals, the remaining heavy metals have low, nearly the same levels, concentration along the downstream. But, the station at SM14 has a slightly higher value than in upstream, except for Pb.

At Darkhan area, there is no excess event of "Ambient WQ standard". Both Cr and Fe have higher values than the other metals. For Cu, Cd, As, Co, and Ni metals have low, nearly the same levels of concentration along the downstream. Except for Cr, Cu, As, the remaining heavy metals have a decreasing trend from upstream SM12 to downstream (SM8).


Mn
4.6 7.3 60.7 6.3 7.8 12.0 52.7 8.7 1.9
SM6 SM4 SM2 SM7 SM16 SM19 SM14 SM12 SM8
Mn Mn_St_rd
Fe
143 158 201 217 65 58 102 117 67
Fe Fe_St_rd
Ni
1.58 2.03 2.46 2.15 0.49 0.48 0.86 1.17 1.06
Ni Ni_St_rd
Cr
1.4 1.1 0.9 0.8 0.4 0.3 0.8 0.6 1.7
Cr Cr_St_rd
Cu
3.3 17.5 20.9 10.2 1.0 1.0 1.2 1.5 1.8
Cu Cu_St_rd
Zn
MGL standard = 1000 ug/L
14 15 20 16 39 30 42 43 11
Zn Zn_St_rd
Pb
MGL standard = 50 ug/L
0.12 0.11 0.19 0.12 0.38 0.12 0.23 0.21 0.01
Pb Pb_St_rd
Cd
MGL standard = 5 ug/L
0.10 0.08 0.12 0.11 0.01 0.01 0.04 0.03 0.02
Cd Cd_St_rd
As
MGL standard = 500 ug/L
1.54 2.62 1.96 1.83 0.68 0.81 1.14 2.56 2.68
As As_St_rd
Co
MGL standard = 10 ug/L
0.21 0.18 0.24 0.17 0.25 0.29 0.52 0.27 0.20
Co Co_St_rd

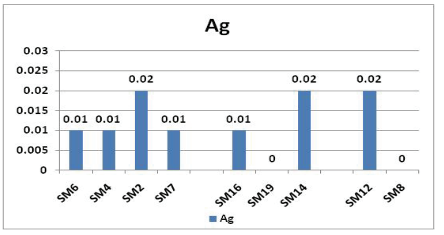


Figure 2-25. Concentration of heavy metals, Mongolian Site, 2009

The Figure 2-26 shows the analysis results of conventional pollutants (COD, T-N, T-P, NO3-N, NO2-N, NH3-N, T-P, PO4-P) from the Mongolian sites during fieldwork in 2009.

The results of the conventional pollutants analyses are showed the following: The high values of conventional pollutants were observed at upstream of Erdenet city (SM6), and traced on the downstream (SM2) of Erdenet city, at upstream (SM12) of Darkhan city in Kharaa River. Moreover, Some tendency of content of conventional pollutants in upstream of rivers are shown, it can be explained by following facts: pasturing of sheep and cattle and local agricultural activity.

The brief descriptions of the result for conventional pollutants:

CODcr ranges from 2.5~22.5 mg/L. SM-14, SM-2, SM-12 sites have a high value of analyzed CODcr. SM-14 sites have highest value of measured CODcr.

T-N ranges from 0.4~5.6 mg/L. SM-6, SM-7, SM-14 sites have high values of analyzed T-N. SM-6 sites have highest value of analyzed T-N.

NO3-N ranges from 0.04~3.20 mg/L. SM-4, SM-6, SM-2 sites have high values of analyzed NO3-N. SM-4 sites have the highest value of analyzed NO3-N.

NO2-N ranges from 0.005~0.030 mg/L. SM-2, SM-8, SM-4 sites have high values of analyzed NO2-N. SM-2 sites have the highest value of analyzed NO2-N.

NH3-N ranges from 0.10~2.58 mg/L. SM-14, SM-7, SM-19 sites have high values of analyzed NH3-N. SM-14 sites have the highest values of analyzed NH3-N.

T-P ranges from 0.2~0.55 mg/L. SM-4, SM-14, SM-2, SM-8 sites have high values of analyzed T-P. SM-4 sites have highest value of analyzed T-P.

PO4-P ranges from 0.18~0.53 mg/L. SM-4, SM-14, SM-2, SM-8 sites have high values of analyzed PO_4-P. SM-4 site has highest value of analyzed PO_4-P.

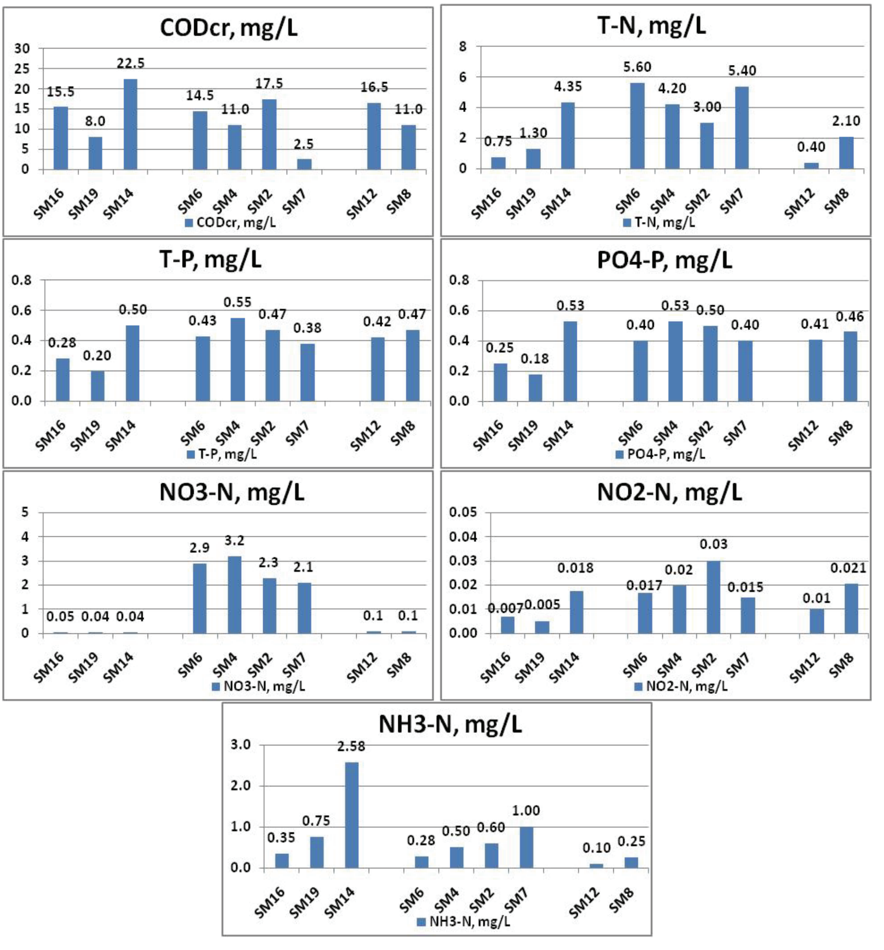


Figure 2-26. Concentration of Conventional pollutions, Mongolian Site, 2009

On Russian site

Zakamensk

- SR1 – Upstream of Modongkul River;
- SR2 – Tailing mine waters from Mining areas;
- SR3 – downstream of Modongkul Stream.

Gusinoozersk city

- SR5 – Goose Lake, at abstraction point;

- SR4 – downstream from discharging point;
- SR6 – Goose Lake.

<u>*Ulan-Ude city*</u>

- SR9 – Selenge River, Upstream of Ulan-Ude city;
- SR10 – Uda River, before flowing into Selenge River;
- SR11 – Downstream of Ulan-Ude City, after confluence of Rivers.

<u>*Selenginski settlement*</u>

- SR8 – Selenge River, downstream of Selenginski "Pulp and Paper Plant" (PPP);
- SR7 – Selenge River, downstream from SR7, at Murzino settlement.

The Figure 2-27 shows the results of the physical-chemical measurements from the Russian site from fieldwork in 2009.

The results at Zakamensk area show the following: the values of suspended solid and electro conductivity are extremely high at SR2 (tailing mine waters). And its impact on downstream of Modongkul (SR3) is evident. At the same sampling station, the values of pH is very low (3.2) – highly acidic water. But the value on the downstream (SR3) is stabilized up to 7.1.

The results at Gusinoozersk area show the following: the values of suspended solid fall within the range of 1.3 to 4 mg/L. The values of electro conductivity vary from 0.367 to 0.372 mS/cm. As for temperature, the values are depended on Gusinoozerski "Heat Power Plant (HHP)", as HHP is dumping warm waters into Goose Lake from the cooling system. "Thermal pollution" from HHP is considered the main problem for the local environment. The values of pH range from 8.38 to 8.55.

The results at Ulan-Ude area show the following relationship in space dimension. The values of suspended solid range from 4 to 18 mg/L. Electro conductivity values range from 14 to 18mgS/cm. As for pH, the values varied from 7.83 to 8.53. The confluence of Uda River into Selenge River is not significantly affected by the physical-chemical parameter values of the Selenge River.

The results from the Selenginsk area show the following relationship in space dimension. The values of suspended solid and electro conductivity are high at downstream along Selenginski PPP (SR8) and are dilute along the downstream of the Selenge River. The temperature and pH values are ranged about 21.3-21.7 °C and 8.04-8.06, respectively. The Selenginski PPP, which is located nearby station SR8, has a closed-circuit water supply. So, this plant can not affect teh water quality, significantly.

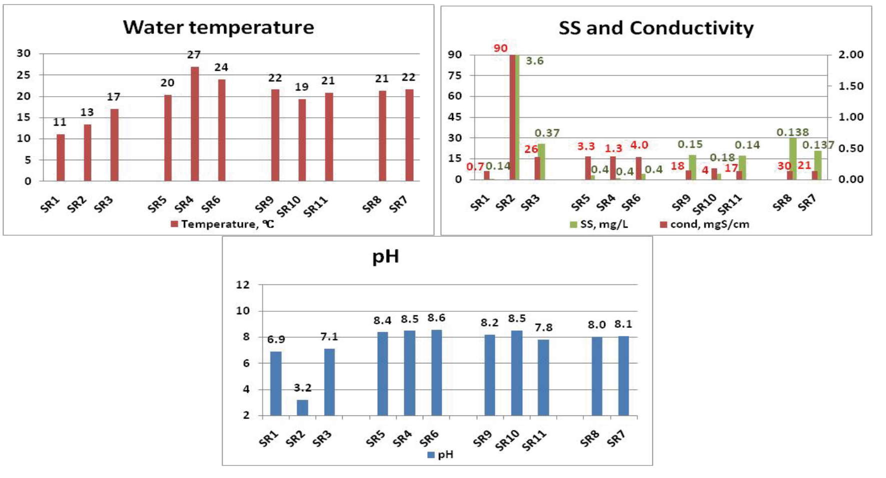


Figure 2-27. Physical-Chemical parameters, Russian site, 2009

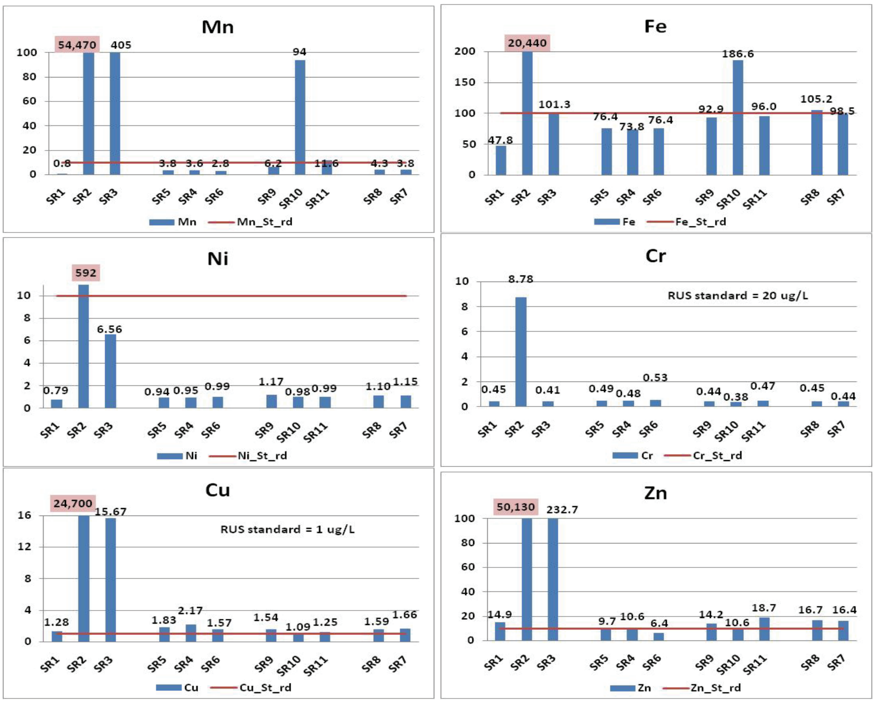
The Figure 2-28 shows the results of heavy Metal analyses on Russian site from fieldwork in 2009.

At the Zakamensk area, there was an excess event of water quality standard for all heavy metal concentrations at SR2 (tailing mine waters). Moreover, the effect of tailing mine water is traced at downstream along SR3. The local assimilative capacity and settling rate of heavy metals, the values of metals are reduced.

At the Ulan-Ude area, there were excess events of Water Quality Standard for Cu and Zn in all sampling points, and Fe and Mn at station SR10 (Uda River). Cr, Pb, Cd, Co, and Ni metals have nearly the same levels of concentration along the downstream. Moreover, Fe and Mn have some dependence of upstream SR10 on downstream SR11. Zn, there has a high value at downstream along SR11.

At the Gusinoozerski area, there were excess events of water quality standard for Cu at all stations, and for Zn at SR4 (downstream of discharging station). Except for the two metals mentioned, the remaining heavy metals have nearly the same levels of concentrations along the downstream. There is not observed the impact of "Heat Power Plant" on Goose Lake (SR6) (Gusinoe) by heavy metals.

At the Selenginski area, there are noted the excess events of water quality standard for Cu, Fe, Zn. Except for Fe metal, remaining heavy metals have nearly the same levels of concentration along the downstream. For Fe, there is observed the diluting process along the downstream. As, for Zn and Cu are might be been caused by natural processes and it's geological background.



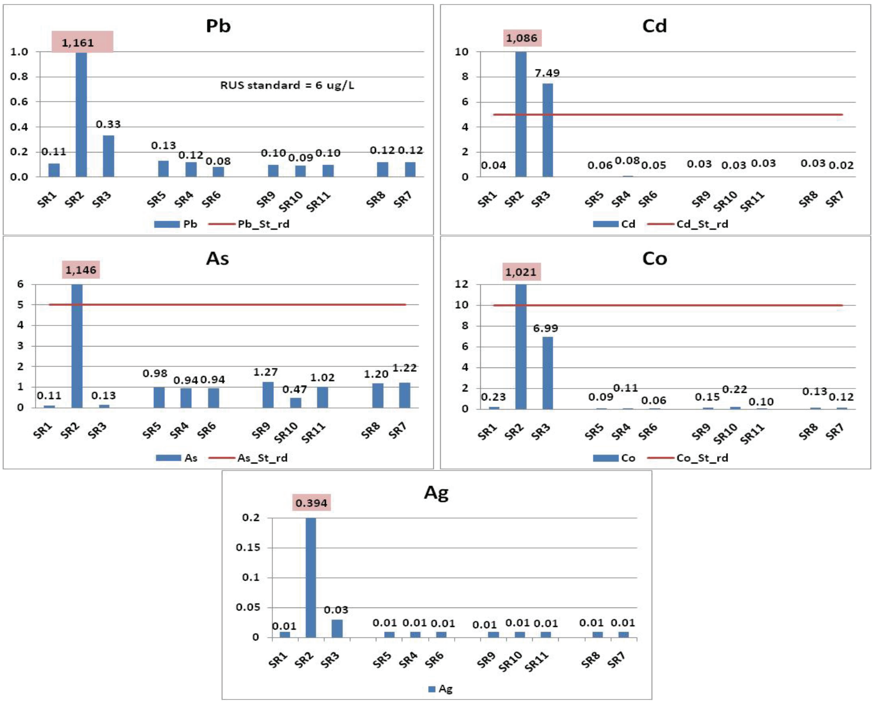


Figure 2-28. Concentration of heavy metals, Russian Site, 2009

The Figure 2-29 shows the analyses results of the conventional pollutants (COD, T-N, T-P, NO3-N, NO2-N, NH3-N, T-P, PO4-P) in Russian sites from fieldwork in 2009.

The values of conventional pollutants were observed in the mine waste water of Dzhidinski Wolfram-Molybdenum complex (tailing dump) for NO2-N and NH3-N in highest degree, at Gusinoozersk area in Goose Lake, at Ulan-Ude area and especially at downstream (SR11), and at downstream of Selenginsk area (SR8) and its diluting along the downstream. There are well shown predominant high concentration at downstream of big cities or settlements. Moreover, the tendency of content of conventional pollutants in upstream of rivers, it can be explained by following: local agricultural activity, pasturing of sheep and cattle in low degree in comparison with Mongolian site.

The brief descriptions of the result for the conventional pollutants are shown below:

CODcr ranges from 4.0~22.5 mg/L. SR-5, SR-3, SR2, SR-8 sites have high value of analyzed CODcr. SR-5 sites have the highest value of measured CODcr

T-N ranges from 0.2~3.9 mg/L. SR-5, SR-3, SR-2, SR-8 sites have high value of analyzed T-N. SR-5 sites have the highest value of analyzed T-N.

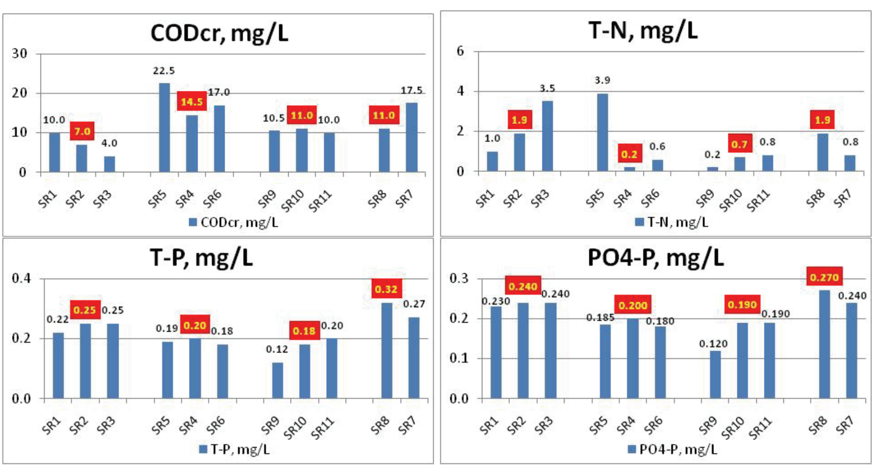
NO3-N ranges from 0.10~0.630 mg/L. SR-3, SR-2, SR-1 sites have high value of analyzed NO3-N. SR-3 sites have the highest value of analyzed NO3-N.

NO2-N ranges from 0.0035~0.1585 mg/L. SR-2, SR-8, SR-11 sites have high value of analyzed NO2-N. SR-2 sites have the highest value of analyzed NO2-N.

NH3-N ranges from 0.10~1.50 mg/L. SR-2, SR-3, SR-5, SR-8 sites have high value of analyzed NH3-N. SR-2 sites have the highest values of analyzed NH3-N.

T-P ranges from 0.12~0.32 mg/L. SR-5, SR-7, SR-2, SR-3 sites have high value of analyzed T-P. SR-5 sites have the highest value of analyzed T-P.

PO_4-P ranges from 0.12~0.27 mg/L. SR-8, SR-7, SR-2, SR-3, SR-1 sites have high value of analyzed PO_4-P. SR-8 site has the highest value of analyzed PO_4-P.



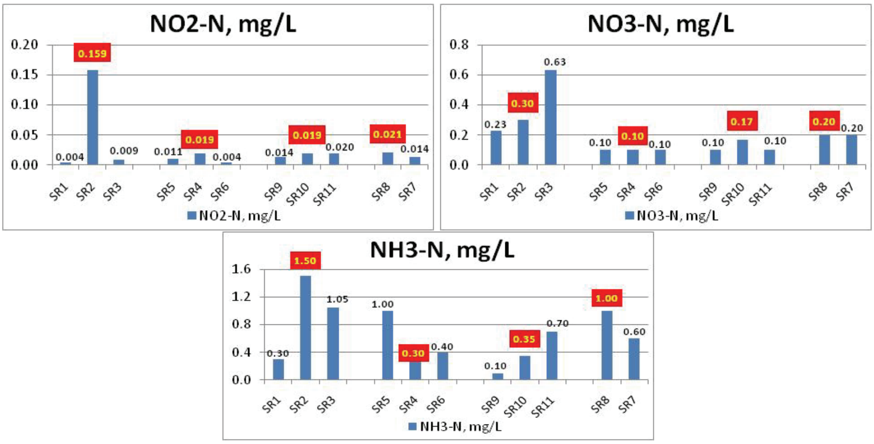


Figure 2-29. Concentration of Conventional pollutions, Russian Site, 2009

c. Relationships between WQ Parameters

Pearson correlation analysis

The correlation coefficient allows researchers to determine if there is a possible linear relationship between two variables measured on the same subject. When these two variables are of a continuous nature the measure of association most often used is Pearson`s correlation coefficient. This association may be expressed as a number that ranges from -1 to +1. The population correlation is usually expressed as the Greek letter rho and the sample statistic (correlation coefficient) is r. The correlation measures how well a straight line fits through a scatter of points when plotted on an x-y axis. If the correlation is positive, it means that when one variable increases, the other tends to increase. If the correlation is negative, it means that when one variable increases, the other tends to decrease. When a correlation coefficient is close to +1(or -1), it means that there is a strong correlation – the points are scattered along a straight line.

For example, a correlation of r=0.7 may be considered strong. However, the closer a correlation coefficient gets to 0, the weaker the relationship, where the cloud (scatter) of points is not close to a straight line.

For example, a correlation of r=0.1 might be considered weak. For scientific purpose, a t-test is utilized to determine if the correlation coefficient is “strong” or “significant” or not.

In order to find the relationship among measured parameters correlation the Spearman-R correlation matrix ($p < 0.01$) was used. In Appendix 1, when correlation coefficients are greater than 0.1 it shows correlation (Spearman's $R > 0.1$).

On Mongolian site

Fieldwork, in 2007

Turbidity was positively correlated with Fe and Zn. Electro-conductivity was positively correlated with As, Cd, Cr, Cu, and Ni. Dissolved oxygen was negatively correlated with As, Cd and Cu. Water temperature was negatively correlated with Pb. The pH was positively correlated with As, Cd and Cu. Arsenic was positively correlated with Cd, Cu and Ni. Pb was not correlated well with no one. Fe was positively correlated with Zn. Cd was positively correlated with Cu. Cr was positively correlated with Ni. Cu was positively correlated with Ni. Mn was positively correlated with Ni. Zn was positively correlated with Ni.

Fieldwork, in 2008

Turbidity was positively correlated with SS, Pb, Fe, Cu, and Zn. Electro-conductivity was positively correlated with pH, As, Cr, and Ni, as well as negatively correlated with DO. Dissolved oxygen was negatively correlated with Cr. Water temperature was positively correlated with pH, Cu and Ni. The pH was positively correlated with As and Ni. Arsenic was positively correlated with Ni. Pb was positively correlated with Fe. Fe was positively correlated with Cu, Zn and Ni. Cd was not correlated well with no one. Cr was not correlated well with no one. Cu was positively correlated with Mn. Mn was not correlated well with no one. Zn was not correlated well with no one.

Fieldwork, in 2009

Turbidity was positively correlated with SS, Fe and Co. Electro-conductivity was positively correlated with As, Cu, Mn, Ni, T-N and NO3-N. DO was negatively correlated with Cr, Ag and COD. Water temperature was positively correlated with pH. The pH was not correlated well with no one. Suspended solid was positively correlated with Fe and Co. Arsenic was positively correlated with Mn, Ni and Co. Pb was positively correlated with T-P and NH3-N. Fe was positively correlated with Co and COD. Cd was positively correlated with Cu. Cr was positively correlated with Ag, COD, T-P and NH3-N. Cu was not correlated well with no one. Mn was positively correlated with Ni, Co, COD, T-N and NO3-N. Zn was not correlated well with no one. Ni was positively correlated with Co, T-N and NO3-N. Co was positively correlated with COD and T-N. Ag was positively correlated with COD, T-P and PO4-P. COD was positively correlated with T-N, T-P, PO4-P and NH3-N. T-N was positively correlated with NO3-N and NO2-N. T-P was positively correlated with PO4-P and NH3-N. PO4-P was positively correlated with NO2-N and NH3-N. NO3-N was positively correlated with NO2-N. NO2-N was not correlated well with no one.

On Russian site

Fieldwork, in 2007

Turbidity was positively correlated with As, Pb, Fe, Cr, Cu, Zn, and Ni. Electro-conductivity was positively correlated with Cr, Cu and Ni. Dissolved oxygen was not correlated well with no one. Water temperature was positively correlated with pH. The pH was negatively correlated with Cu and Zn. Arsenic was not correlated well with no one. Pb was positively correlated with Fe, Cr, Cu, and Ni. Fe was positively correlated with Cr, Cu, Mn, Zn, and Ni. Cd was positively correlated with Ni. Cr was positively correlated with Cu, Mn, Zn, and Ni. Cu was positively correlated with Zn and Ni. Mn was positively correlated with Zn. Zn was positively correlated with Ni.

Fieldwork, in 2008

Water temperature was positively correlated with pH and As. pH was not correlated well with no one. Arsenic was not correlated well with no one. Pb was positively correlated with Fe, Cd, Cr, Cu, Mn, Zn and Ni. Fe was positively correlated with Cd, Cr, Cu, Mn, Zn and Ni. Cd was positively correlated with Cr, Cu, Mn, Zn and Ni. Cr was positively correlated with Cu, Mn, Zn, and Ni. Cu was positively correlated with Mn, Zn, and Ni. Mn was positively correlated with Zn and Ni. Zn was positively correlated with Ni.

Fieldwork, in 2009

Electro-conductivity was positively correlated with SS, Pb, Fe, Cd, Cr, Cu, Mn, Zn, Ni, NO2-N and NH3-N and negatively correlated with pH. Water temperature was positively correlated with pH, As and COD as well as negatively correlated with NO3-N. The pH was negatively correlated with SS, Pb, Fe, Cd, Cr, Cu, Mn, Zn, Ni, Co, Ag, NO2-N, and NH3-N as well as positively with COD. Suspended solid was positively correlated with Pb, Fe, Cd, Cr, Cu, Mn, Zn, Ni, Co, Ag, NO2-N and NH3-N. Arsenic was negatively correlated with NO3-N. Pb was positively correlated with Fe, Cd, Cr, Cu, Mn, Zn, Ni, Co, Ag, NO2-N and NH3-N. Fe was positively correlated with Cd, Cr, Cu, Mn, Zn, Ni, Co, Ag, NO2-N and NH3-N. Cd was positively correlated with Cr, Cu, Mn, Zn, Ni, Co, Ag, NO2-N and NH3-N. Cr was positively correlated with Cu, Mn, Zn, Ni, Co, Ag, NO2-N and NH3-N. Cu was positively correlated with Mn, Zn, Ni, Co, Ag, NO2-N and NH3-N. Mn was positively correlated with Zn, Ni, Co, Ag, NO2-N and NH3-N. Zn was positively correlated with Ni, Co, Ag, NO2-N and NH3-N. Ni was positively correlated with Co, Ag, NO2-N and NH3-N. Co was positively correlated with Ag, NO2-N and NH3-N. Ag was positively correlated with NO2-N and NH3-N. COD was negatively correlated with NO3-N. T-N was positively correlated with NO3-N and NH3-N. T-P was positively correlated with PO4-P. PO4-P was positively correlated with NO3-N and NH3-N. NO3-N was not correlated well with no one. NO2-N was positively correlated with NH3-N.

d. Relationships between Pollution Sources and Water Quality

On Mongolian site

Fieldwork, 2007

The results of the physical-chemical measurements and heavy metals analyses are shown on Figure 2-30 and 2-31.

Erdenet copper mining location

- SM6 – Khangal River (downstream the Erdenet city)
- SM7 – Tailing dump;
- SM8 – Tailing dump.

<u>*Darkhan location*</u>

- SM9 – Kharaa River, near to Darkhan city;
- SM10 – Darkhan WWTP outfall.

Erdenet copper mining area, Mongolian site, 2007

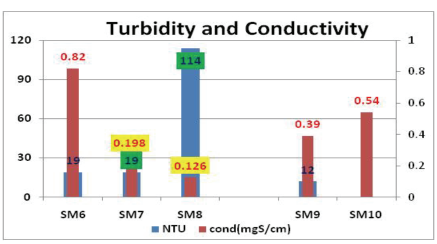
The results of the physical-chemical measurements in the Erdenet area show the following: the values for turbidity are very high at the Erdenet tailing dump SM8; electro conductivity is very high at downstream of Erdenet city (Khangal River); the value of DO is very low (2.3mg/L) at the Erdenet tailing dump SM7; the values of pH are within the range 8.19-9.2.

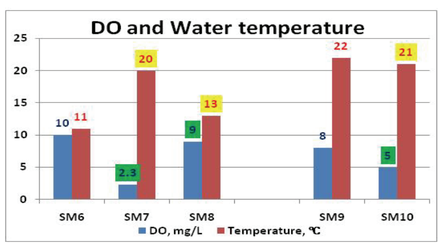
As for the results of heavy metals analyses, there were the high values of Cu and Cd at tailing dump SM7, and Mn at tailing dump SM8 compared to upstream SM6.

Darkhan area, Mongolian site, 2007

The results of the physical-chemical measurements in Darkhan area show the following: the values for turbidity are very high at the WWTP outlet SM10 (the data for electro conductivity is not avaliable); the value of DO is low (5 mg/L) in waste water SM10; the value of pH is 7.6.

The result for heavy metlas show that very low values of all heavy metals in waste water but still higher than at upstream SM9.





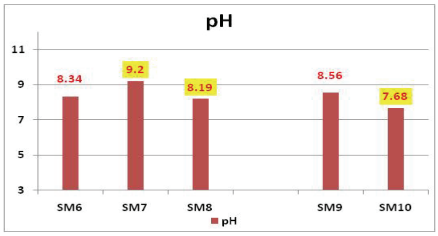
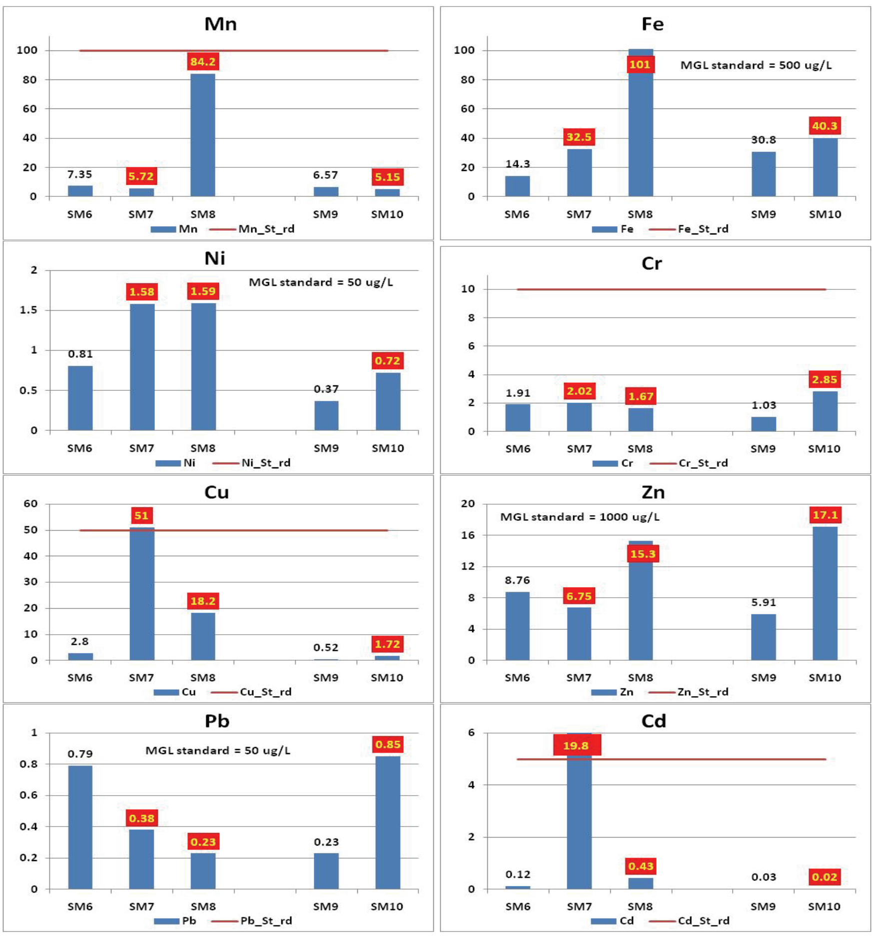


Figure 2-30. Physical-Chemical parameters, Mongolian site, 2007



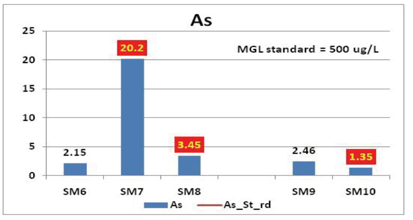


Figure 2- 31. Concentration of heavy metals, Mongolian site, 2007

Fieldwork, 2008

The results of the physical-chemical measurements and heavy metals analyses are shown on Figures 2-32 and 2-33. As in 2008 there was not conducted sampling for conventional pollutants such as COD, T-N, T-P, PO4-P, NO3-N, NO2-N, and NH3-N were not conducted and thus the results are not presented.

Zaamar location

- SM23 – Tuul river, at “Lun” bridge;
- SM14 – “Altan Darnod” ground water;
- SM13 – “Monpolimet” Dredge pond;
- SM12 – Tuul river, “Shijir Alt” bridge;
- SM11 – Tuul river, “Zaamar” bridge.

Ulaanbaatar location

- SM1 – Tuul river, at bridge, direction to the Terelj nat’l park;
- SM2 – waste water of Nailakh settlement;
- SM3 – Tuul river, downstream of Ulaanbaatar, after mixing of waste waters;
- SM4 – Ulaanbaatar WWTP outfall;
- SM6 – Tuul river, at “tavan tolgoi” bridge;
- SM7 – Tuul river, at “Altan-bulag” bridge;
- SM8 – Tuul river, “Khustai” Nat’l park;

Zaamar area, Mongolian site, 2008

The results of the physical-chemical measurements in the Zaamar area show the following: the values of suspended solid (turbidity) are high and very high at “Altan Darnod” ground water SM14 and “Monpolimet” dredge pond SM13, respectively. In the same line for electro conductivity at mining areas, and values of dissolved oxygen values are within 7-10. Moreover, there is noted the effect of mining on downstream water quality SM12 in comparison with upstream of the mining area of SM23.

As for results of heavy metals, Mn, Fe, Ni, Zn, and As metals have higher values than those of other metals.

The Zaamar area is polluted by heavy metals significantly. This Effect from the polluters can be seen from the downstream parts of the mining area along the river.

Ulaanbaatar area, Mongolian site, 2008

The results of the physical-chemical measurements in the Ulaanbaatar area show following: the values of suspended solid and turbidity are increasing from SM1 to SM7 at “Altan bulag” bridge, the values of electro conductivity are very high at SM2 (waste water of Nailakh settlment) and at SM4 (Ulaanbaatar WWTP outlet), and the value of dissolved oxygen is very low at SM4 (1.7 mg/L). Moreover, the effect of waste waters for electro conductivity of water can be clearly noted.

As for results of heavy metals, there is noted Mn, Fe, Ni, Cr (only for SM4), Cu, and As metals have high values at SM2 and SM4. The sequence is not significant.

Ulaanbaatar area is not significantly polluted by heavy metals. The strong influence frowm the pollutaers may not be seen at downstream along WWTP’s.

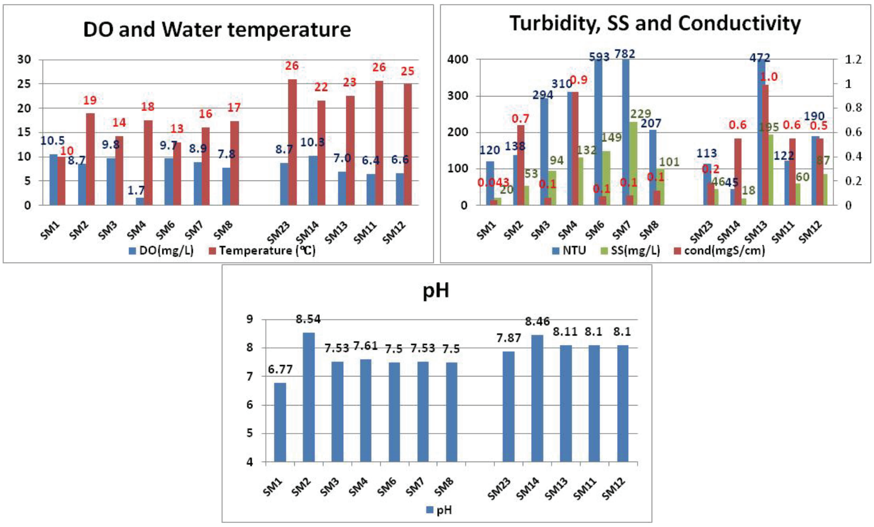
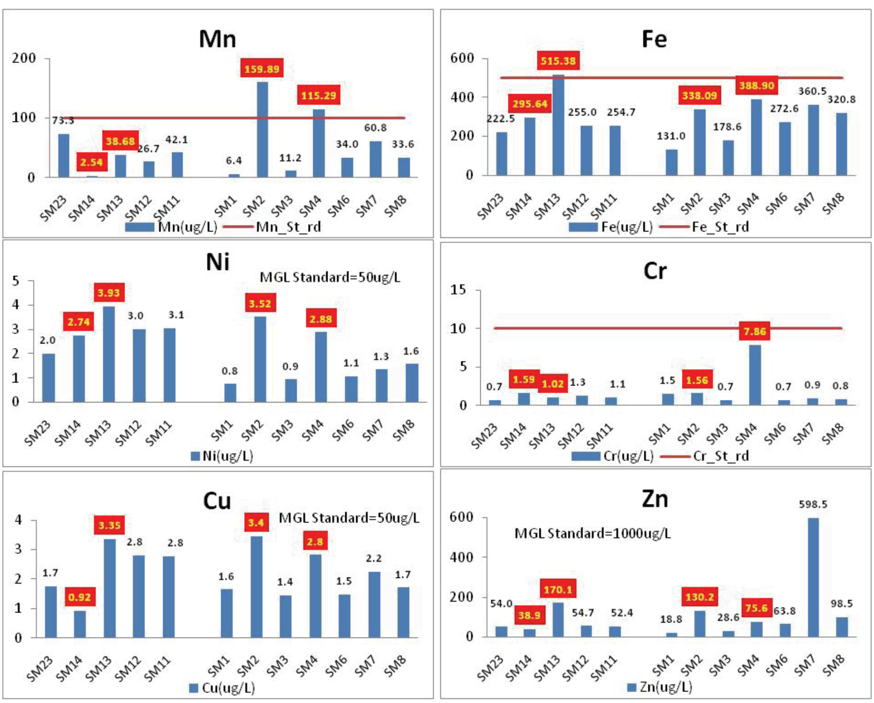


Figure 2-32. Physical-Chemical parameters, Mongolian site, 2008



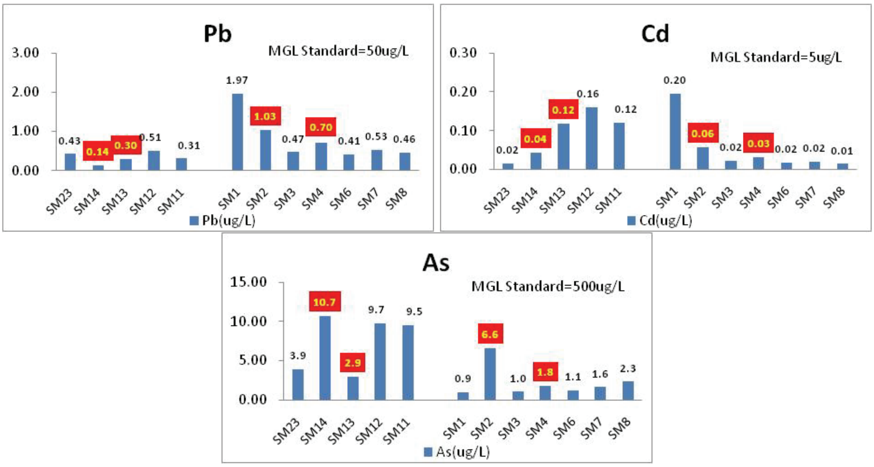


Figure 2-33. Concentration of heavy metals, Mongolian site, 2008

Fieldwork, 2009

The results of the physical-chemical measurements, heavy metals' and conventional pollutants' analyses are shown on Figures 2-34, 2-35 and Figure 2-36, respectively.

<u>*Ulaanbaatar location*</u>

- SM16 – Tuul river, at the bridge to Terelj Nat'l park;
- SM17 – waste water of Nailakh settlement;
- SM19 – Tuul river, at the bridge "Bayanzurkh";
- SM15 – Ulaanbaatar WWTP outfall;
- SM14 – Tuul River, downstream of Ulaanbaatar city.

<u>*Erdenet location*</u>

- SM6 – Erdenet r. near Erdenet Copper mining;
- SM4 – Erdenet r. upstream of Erdenet WWTP;
- SM3 – Erdenet WWTP outfall;
- SM5 – Erdenet tailing Dam re-use pond;
- SM2 – Khangal river, after Erdenet city;
- SM7 - Khangal river agricultural area of Jargalant soum, Erdenet

<u>*Darkhan Location*</u>

- SM12 – Kharaa river, at the bridge, upstream of Darkhan city

- SM11 – Darkhan WWTP outfall.

Ulaanbaatar, Mongolian site, 2009

The results of the physical-chemical measurements in the Ulaanbaatar area show that values of suspended solid and electro conductivity are high at the waste waters of Nailakh (SM17) settlement and UB (SM15) treatment plants (SM14). The values of pH are slightly low at SM 16 (6.28) and SM19 (6.23). DO value is very low at SM15 (0.8 mg/L). The values of pH are within the range of 6.2-8.0. Moreover, the effect of waste waters for electro conductivity of water can be clearly noted.

As for heavy metals, there is no excess event of "Ambient WQ standard". It is noted. All heavy metals except Cd, Cu and Zn have high values at SM17 and SM15.

As for conventional pollutants, there are noted very high values of COD, T-N, T-P, NH3-N, T-P, and PO4-P in waste waters of Ulaanbaatar and Nailakh treatment plants and downstream along the rivers.

Ulaanbaatar area is polluted dominantly by conventional pollutants than by heavy metals. Even though WWTP is operating well, the WWTP needs to be improvied or additional contral systems should be installed form preventing the inflow from s urace area into the revier.

Erdenet Copper Mining area, Mongolian site, 2009

The results of the physical-chemical measurements in the Erdenet area show that values of suspended solid, turbidity and electro conductivity are increasing along the Khangal River. DO values are decreasing a little bit (slightly low values). The features of pH values are stable within the range from 7 to 8.

The results of the heavy metal analyses show that high values of Cu metal at SM2 (20.88 μg/L), SM4 (μg/L), and SM7 (μg/L), for Fe metal at all sampling points (145.31-216.77 μg/L), Mn metal at SM2 (60.65 μg/L). Moreover, sampling point SM6 is considered to be more polluted, than other SM4 and SM7.

As for the conventional pollutants results, there are noted very high values of COD, T-N, T-P, NH3-N, T-P, NO3-N, NO2-N, and PO4-P in waste waters of Erdenet treatment plant and its tracing in downstream along the rivers.

Erdenet area is polluted as by conventional pollutants as well by heavy metals. For that case, even WWTP is operating well but there need to improve the WWTP and install additional control systems for preventing of inflow from surface area into the river. Moreover, near to Erdenet city is located big copper mining operation which can affect the surface water quality of the downstream essentially in some case of emergency situations.

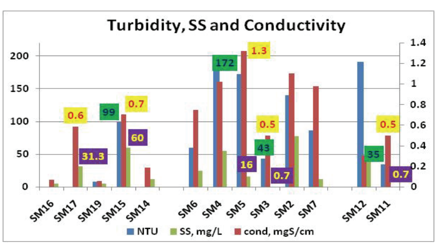
Darkhan, Mongolian site, 2009

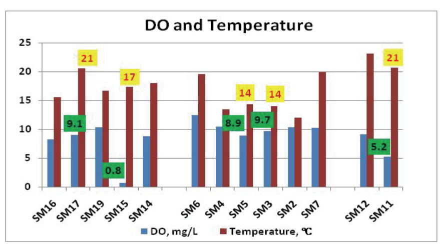
The results of the physical-chemical measurements in the Darkhan area show that values of Suspended Solid are decreasing from SM12 (40mg/L) to SM8 (34 mg/L). The values of Electro Conductivity are increasing from 0.306 to 0.455mgS/cm. DO values are decreasing from 9.1mg/L to 7.47mg/L (considered to be slightly low values). The same features are for pH values.

As for heavy metals, there is no excess event of "Ambient WQ standard". It is noted, both Cr and Fe have higher values than other metals. For Cu, Cd, As, Co, and Ni metals have nearly the same levels of concentration along the downstream. Except for Cr, Cu, and As the remaining heavy metals have decreasing trend from upstream at SM12 to downstream at SM8.

As for conventional pollutants, very high values for all conventional pollutants in waste waters of Darkhan treatment plant were found in comparison to upstream of that area.

Actually Darkhan city is related to the industrial economic sector and not to mining. So consequently, the main pollution should come from waste waters in conventional pollutants.





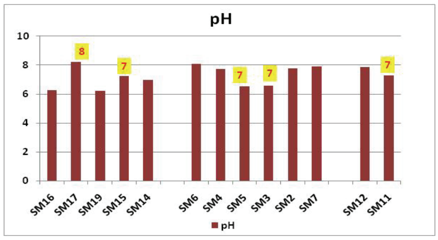
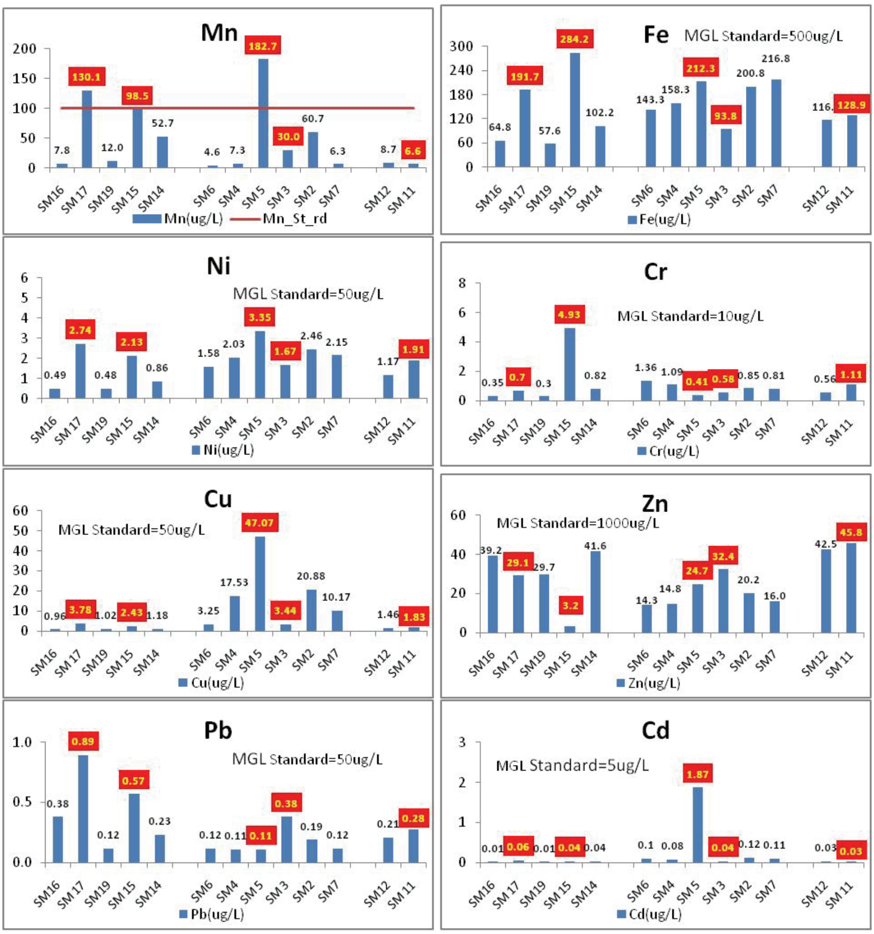


Figure 2-34. Physical-Chemical parameters, Mongolian site, 2009



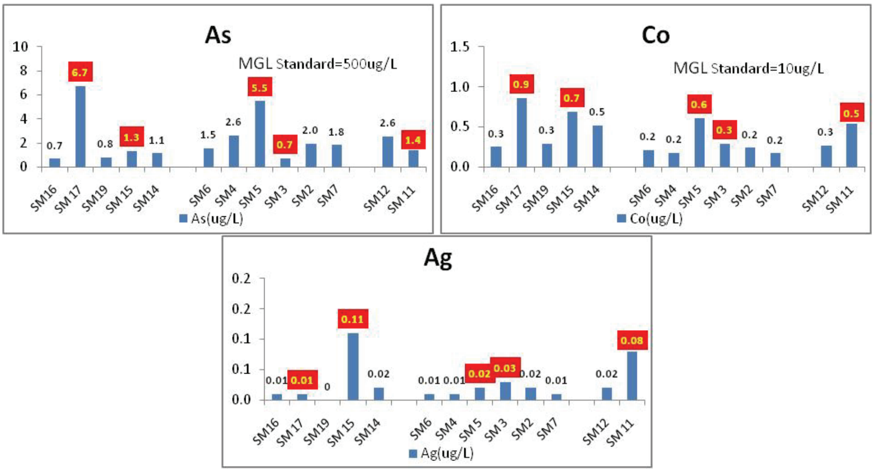
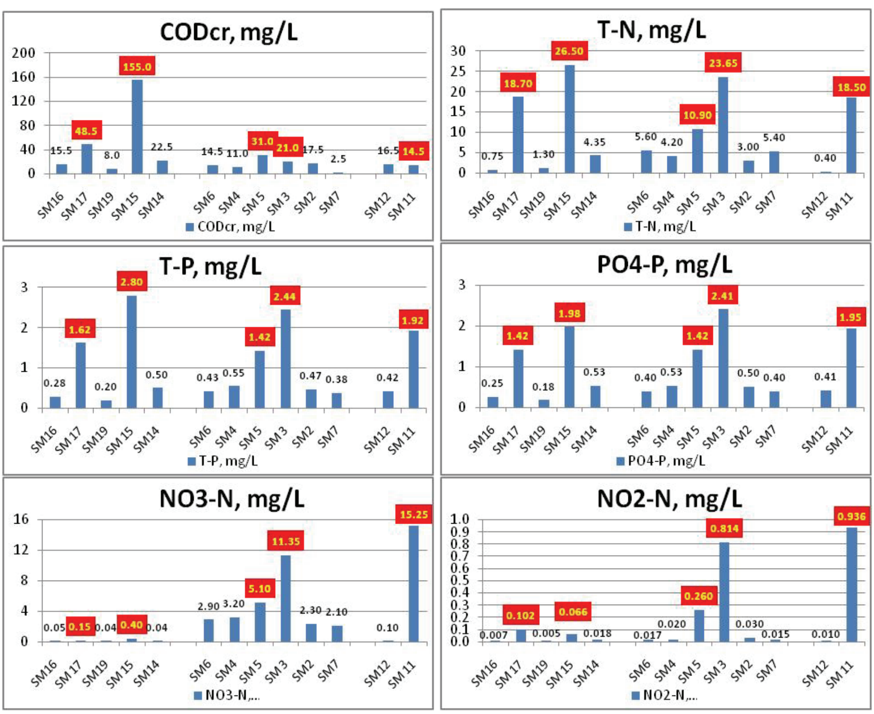


Figure 2-35. Concentration of heavy metals, Mongolian site, 2009



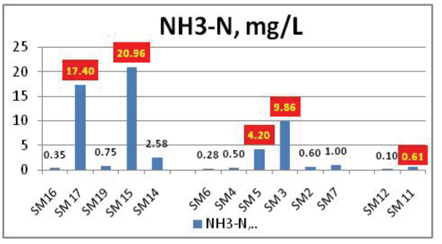


Figure 2-36. Concentration of Conventional pollutions, Mongolian Site, 2009

Russian site

Fieldwork, 2009

The results of the physical-chemical measurements, heavy metals' and conventional pollutants' analyses have been shown (in previous section – spatial variations) on Figures 2-27, 28 and Figure 2-29, respectively. On the Russian site, water measurements and samples were not taken directly from the WWTP's outlets.

Zakamensk location

- SR1 – upstream of Modongkul River;
- SR2 – mine waste water from mining area;
- SR3 – downstream of Modongkul River.

Gusinoozerski location

- SR5 – Lake Goose, at abstraction point;
- SR4 – downstream from the discharging point;
- SR6 – Lake Goose.

Ulan-Ude location

- SR9 – Selenge River, upstream of Ulan-Ude city;
- SR10 – Uda River, before flowing into Selenge River;
- SR11 – Selenge River, downstream of Ulan-Ude city, after confluence of rivers.

Selenginski location

- SR8 – Selenge River, downstream of "Selenginski" Pulp-and-Paper Plant;

- SR7 – Selenge River, at Murzino.

Zakamensk mining area, Russian site, 2009

The results of the physical-chemical measurements in Zakamensk area show that values of suspended solid and electro conductivity are extremely high at SR2 (tailing mine waters). And its impact on downstream of Modongkul (SR3) is evident. At the same sampling station, the values of pH is very low (3.2) – highly acidic water. But the value from downstream at SR3 is stabilized up to 7.1.

As for heavy metals, an extremely high excess event of water quality standard for all heavy metals concentration at SR 2 (tailing mine waters) was found essentially. Moreover, the effect of tailing mine water is traced at downstream (SR3). The values of metals are reduced, depending on the local assimilative capacity and settling rate of heavy metals.

As for conventional pollutants, there are noted high values for NO3-N and NH3-N in mine waste water of Dzhidinski wolfram-molybdenum complex (tailing dump).

The area is mainly polluted by heavy metals rather than by conventional pollutants due to absence of any responsibility from the local control system for preventing of direct inflow of mine waste waters into the Modongkul River.

Gusinoozersk city, Russian site, 2009

The results of physical-chemical measurements in the Gusinoozersk area show the following relationship in space dimension: the values of suspended solid and electro conductivity have low range; The value for water temperature depends on the Gusinoozerski "Heat Power Plant (HHP)" activity, as HHP dumping warm waters into Goose Lake from cooling system. "Thermal pollution" from HHP is considered the main problem.

As for heavy metals, there are excess events of Water Quality standard for Cu at all stations, and for Zn at SR4 (downstream of discharging station). Except for the two metals mentioned, the remaining heavy metals have nearly the same levels of concentrations along the downstream. There is not observed impact of "the Heat Power Plant" on Goose Lake (SR6) by heavy metals.

As for conventional pollutants, there are noted moderate values in Goose Lake.

Gusinoozerski area is not essentially polluted neither heavy metals nor by conventional pollutants. There is no mining operation and WWTP, excluding the dumping of "warm waters" from Gusinoozerski HPP into the Lake.

Ulan-Ude city, Russian site, 2009

The results of the physical-chemical measurements in the Ulan-Ude area show the relationship of the values of suspended solid and electro conductivity is low. As for pH, the values vary from 7.83 to 8.53. The confluence of Uda River into Selenge River is not significantly affected by the physical-chemical parameters values of the Selenge River.

As for heavy metals, there are excess event of water quality standards for Cu and Zn in all sampling points, and for Fe and Mn at station SR10 (Uda River). Cr, Pb, Cd, Co, Ni metals have nearly the same levels of concentration along the downstream. Moreover, for Fe and Mn have some dependence of upstream (SR10) on downstream (SR11). As for Zn, there is noted high value at downstream (SR11).

As for conventional pollutants, there are noted very high values of pollutants in the Uda River inflowing into Selenge River and in Selenge River at downstream along the Selenge River into the city after WWTP. There is an increase trend of conventional pollutants downstream.

The Ulan-Ude area is mainly polluted by conventional pollutants than by heavy metals.

Selenginski settlement, Russian site, 2009

The results of the physical-chemical measurements in Selenginsk area show the following relationship in space dimension. The values of suspended solid and electro conductivity have high values at downstream of the Selenginski pulp-and-paper plant (PPP) (SR8) and is dilute along the downstream of the Selenge River. The temperature and pH values are ranged about 21.3 to 21.7° C and 8.04 to 8.06, respectively. The Selenginski PPP, which is located nearby station SR8, has a closed-circuit water supply. So, this plant cannot affect water quality, significantly.

As for heavy metals, there are excess events of water quality standards for Cu, Fe and Zn. Except for metals mentioned above, remaining heavy metals have nearly the same levels of concentration along the downstream. For Fe, the diluting process was observed along the downstream. As, Zn and Cu might have occurred by natural processes and geological background.

For conventional pollutants, there are high values of pollutants at downstream of Selenginski PPP and its diluting process along the river.

The Selenginski area is mainly polluted by conventional pollutants rather than by heavy metals.

C. Summary

Total of 110 sampling stations and samples were identified and taken, with 73 from the Mongolian site and 37 from the Russian site. One-time monitoring and analysis made it impossible to draw a conclusion on the surface water quality. It is necessary to conduct year-around and annual monitoring.

The results of the water quality analysis are as follows:

Temporal and Spatial variation

The comparative temporal analysis of heavy Metals showed that the highest values of heavy metals were in 2008, for both Mongolia and Russian sites. In Mongolia in 2009 comparing with 2008 Cu value was very high at SM2 station (Khangal River – after Erdenet). In Russian site (Buryatia) in 2007 comparing with 2008 values of Zn and Pb were very high at SR 9 (Selenginsk) and SR7 (Ude River – before confluence), and in 2009 value of Mn was very high at SR10 (Ude River – before confluence).

The results of the physical-chemical measurements along the Selenge River show the following relationship in space dimension. The value of Turbidity has high at Hutag Ondor. The values of Electro Conductivity were the same levels. The values of Dissolved oxygen ranged from 6.00 to 8.00 mg/L. The values of pH were within range of 8.1-8.6.

There was no excess event of "Ambient WQ standard", except for the station located at the Mongolian-Russian Boundary for heavy metals (Zn, Cr, Fe, and Mn). It was caused from upstream from Mongolia. Values of Zn, Cu, Cr, Fe, and Mn had higher values on the Mongolian Site (still below Mongolian Water Quality Standard) than on Russian site. The values of heavy metals are decreasing along the downstream. At present, the assimilative capacity of Selenge River Basin is able to cope with it, but it can be lost by intensive processes, and badly reflected in the nearest future.

Water Quality parameters

The correlations of water quality data have shown the strong relationship in 2009 than before, as the water quality measurements and samplings were taken at hot spot areas. Moreover, for the Russian site, there is one much polluted reach (SR2) flowing into Modongkul River which can affect the result of correlation. As well there is clearly shown the excess of WQ standards in several times.

Pollution sources

In Mongolia, in 2007, high values of Conductivity and high turbidity at downstream of Erdenet location (Khangal River, SR8) was found on the tributaries of Khangal and Shar. Which were affected by mining activities on its upstream Erdenet Copper Mining (Khangal River) and Gold mining (Shar River). In 2008, the values of Turbidity were very high at Khara Khorin (meandering processes), upstream of Orkhon Rivers (gold mining), and "Khugshin Orkhon" River (Old Orkhon river). Conductivity was high at the bridge on "Khugshin Orkhon" River.

At Zaamar Mining the result of analysis of heavy Metal areas did not show the excess of Mongolian WQ standard, in comparison to the Russian WQ standard, in which there was an excesses for Zn, Cu, As, Mn, Fe in overall, and Cr at 23, SM13-1. On those places, in recent time there have been actively conducting mining operation without essential condisering environment condition. At Erdenet Copper mining, the result of heavy Metals did not show the excess event of Mongolian WQ Standard, than the comparison with Russian WQ standard, in which there were the excesses for Cu, Fe, Zn overall, and Mn at SM2 (Khangal River, after Erdenet city). The same feature as in Zaamar's mining area is occurring at Erdenet Copper Mining areas. At Ulaanbaatar city, the result of heavy Metals did not show the excess event of

Mongolian WQ standard, in comparison to the Russian WQ standard in which the excesses occurred for Zn in overall, and for Cu, and Mn at SM 19 (Tuul River, "Bayanzurkh" bridge) and SM14 (Tuul River, downstream of Ulaanbaatar city). There were slackness tendencies in controlling for environment pollution. At Darkhan city, the result of heavy metals did not show the excess event in comparison with Mongolian WQ standard, than comparison with Russian WQ standard, where the excesses were occurred for Zn and Cu in overall, and for Fe at SM12 (Kharaa River, at the bridge). The same features are noted for Darkhan city (big industrialized city).

In the Russian site, at Zakamensk (Dzhidinski Wolfram-Molybdenum Mining – closed 18 years ago) the result of analysis showed a very high excess event above the Russian WQ standard for all water quality parameters at SR2 (mine waste water) and its effect at (SR3) receiving Modonkul River. Moreover, along the downstream the diluting process is occurring, dependently on the local assimilative capacity and settling rate, the values of heavy metals are reduced. At Ulan-Ude city the result of analysis showed the excess event for Cu, Fe, Mn, and Zn in overall. It is caused by aggregative anthropogenic and natural factors. Downstream along the city is influenced by tributary of Uda River which is located along the Ulan-Ude city. At Gusinoozersk city the result of analysis showed the excess event for Cu in overall and Zn at SR4 (downstream of discharging point). The effect from the Gusinoozersk HPP on Lake Goose is considered to be only by temperature effect, as HPP is using abstracted water for "Cooling" technological purpose. At Selenginski Paper and Pulp Plant the result of analysis showed the excess event for Cu, Zn in overall, and for Fe at SR8 along the Selenge River, downstream of Selenginski PPP. The Selenginski PPP is using closed-circuit water supply system and it can not affect on the water quality significantly. The excess event might be caused by natural processes and geological background.

2. Water Environment State of Hotspot area

A. Background of Hotspot Area

Water Quality issues in the Selenge River Basin have been investigated from 2006-2009 as part of a cooperative effort between the Korean Environment Institute (Korea), Institute of Geo-ecology of Mongolian Academy of Sciences (Mongolia) and Baikal Institute Nature Management of Siberian Branch of Russian Academy of Science (Russia). Water quality in the Selenge River Basin is important because much of the population in the area, which includes the Mongolian Part (from upstream) and Russian Part (from boundary of Russia-Mongolia to Lake Baikal), relies on drinking-water source, recreational activities, and fishery water-use.

Selenge River is a trans-boundary river which passes through two countries. The upstream area of the river is in Mongolia and the downstream area is in Russia. Spatial analysis of the water quality of the River has important meaning. These will serve as the baseline information for the analysis of the water quality and water use problems in the upstream area which greatly affects the downstream area of the river.

First year research (2007) of the "Integrated Water Management Model on the Selenge River Basin" focused on the present condition of water as well as the pollution sources and treatments in the Selenge river basin. The field survey done from Khovsgol Lake (Mongolia) to Baikal Lake (Russia) gathered data about the water quality condition and pollution source (refer to the research date 2007).

Second year research (2008) focused on target pollutants and monitoring sites in SRB. Closer investigation discovered the seriousness of heavy metal pollution in hotspots. The general objective of this research is to assess the water quality of the Selenge River Basin in the polluted area.

Specifically:

- ✓ To present the status of the water quality
- ✓ To identify pollution sources
- ✓ To support the development of the IWMModel on the Selenge River Basin.

The objective of this research is to analyze the water quality in the selenge river basin located near big cities and to identify pollution sources related to domestic wastewater and livestock (organic matter, nutrients, and so on), and the research is to investigate heavy metal in mining areas (refer to the research date 2008).

Third year research (2009) focused on eight hotspot areas. In may 2009, 9th working group meeting, all participants from each institues gathered to discuss the third year research (2009) plan was discussed and 8 hotspot areas were determined. 8 hotspot areas are big cities where to domestic wastewater and livestock and mining areas related serious heavy metal pollution.

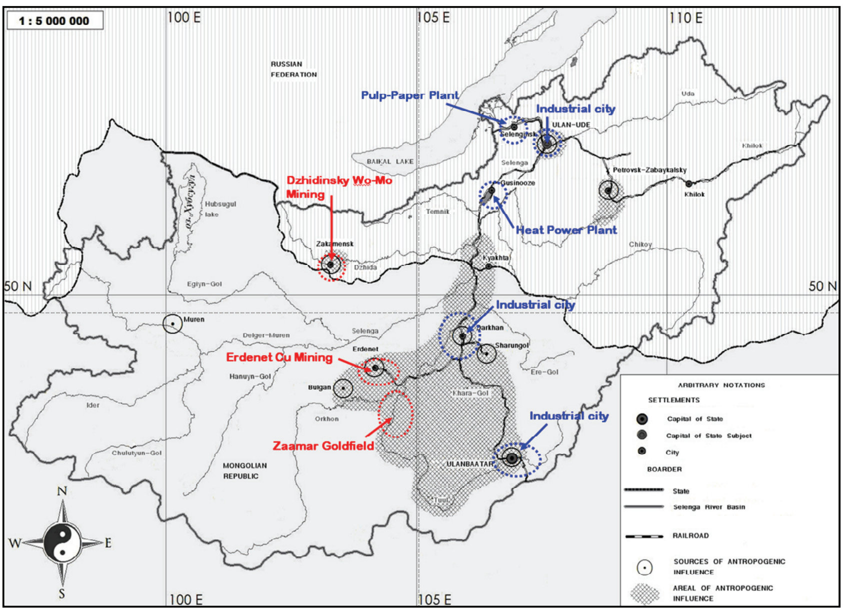


Figure 2-37. Selected Eight Hotspot Areas in Selenge Project

B. Hotspot Areas of Mongolia

Four sites in Mongolia are considered hotspots for water quality and management. These are the city of Ulaanbaatar, the Aimag (province) of Darkhaan Uul, Erdenet and the mining soum (administrative district) of Zaamar.

Ulaanbaatar is the capital city of Mongolia and has a population of just over 1 million people. Around 40% of the country's population lives in Ulaanbaatar (2007), which is located in the Tuul River Basin.

Darkhan-Uul Aimag is located in north of Mongolia, and is surrounded by the Selenge Aimag. Darkhan-Uul contains four soums. Darkhan city was founded in 1961 and intended as a second industrial centre after capital city of Ulaanbaatar. It remains the second largest city in Mongolia in terms of population, but since 1990 the amount of industry in the area has contracted. The city is now dominated by small enterprises, of which the iron industry is the most important. Sharingol soum is the second most populated soum in Darkhan-Uul. Mining is the most important industry in this area, including significant amounts of open cast placer mining activity. Khongor and Orkhon soum are predominantly agricultural in nature and account for around 9% of the population of the Aimag and 92% of the land area.

The Zaamar Goldfield is the largest producer of gold in Mongolia, having produced more than 10,000 kg at gold from 1998-2003 with the highest gold output of 18.500 kg in 2004 (Boris et al., 2005). The mining area is located in both the Buregkhangai and Zaamar soums of Bulgan and Tuv Aimags. The populations of Buregkhangai and Zaamar soum were 2376 and 5481 respectively in 2007. The hotspot area chosen for this analysis is the Zaamar soum.

a. Ulaanbaatar

Drivers and Pressures for Ulaanbaatar

Water quality

Environmental degradation in Ulaanbaatar is strongly linked to the growth of the Ger area, where people live in traditional Mongolian homes (felt tents called gers) with poor infrastructure. The Ger area is not connected to the central water supply system and there is no treatment of waste from the area, causing severe water pollution. There are 126,400 pit latrines and same number of individual soak pits for disposing of grey water in the Ger areas. Waste water and wastes from the latrines and soak pits flow directly through the soil to the river basin.

The population of the Ulaanbaatar Ger area is currently growing at a rate of over 10% per year (Emerton, 2009). This growth is linked to the increased migration to Ulaanbaatar after 1990, which is largely due to the lack of infrastructure, services (e.g. health, education) and employment opportunities in remote areas. Harsh dzuds in the early years of the 21st century caused many herders to lose significant proportions of their livestock, and migrate to Ulaanbaatar.

Many of these migrants bring livestock with them from the countryside, causing further pressures on water quality. High levels of poverty and unemployment are associated with other harmful practices. For example air pollution from heating Gers impacts water quality through the hydrological cycle, while deforestation is also a continuing problem that impacts on water quality. The continued sprawl of the Ger area also means that the boundaries of Ulaanbaatar are constantly expanding and this change in land use also has associated negative impacts on water quality.

Air pollution more broadly also impacts water quality. As well as pollution resulting from heating Gers (with coal, wood and other materials such as old tires), the city's main source of electricity comes from three coal-fired power plants, which release large quantities of pollution into the atmosphere (CBD, 1996). The number of cars has also been increasing rapidly, both due to population growth and increasing affluence in parts of society. Many of these cars are imported second-hand, and badly maintained, which worsens their impact on the environment. High heavy-metal content of fuel has also been linked to toxic emissions (CBD, 1996)

The transition to a market economy has also seen Ulaanbaatar grow in importance as a hub for commerce and industry. It accounts for almost 70% of national production (Emerton, 2009), including almost 50% of the nation's industrial production. Many large companies based in Ulaanbaatar draw on the central water supply systems and cause soil and water pollution by discharge of impure water. Small enterprises often discharge water directly into rivers.

Waste water treatment throughout the city is inadequate, largely to due to funding constraints (Altansukh, 2008). For example, the efficiency of the Central Waste Water Treatment Plant has been estimated to be around 60-70%

due to poor maintenance, lack of spare parts, outdated equipment and frequent power shortages (Altansukh, 2008). Monitoring systems, moreover, are not sufficiently developed to police water pollution. Problems include the size of territory covered and the legislative and administrative environment.

Ulaanbaatar also currently lacks a solid waste (garbage) management system. Both collection and treatment of solid waste are insufficient and in some cases non-existent and this results in water pollution.

Water resources

The rapid growth of the population of Ulaanbaatar has resulted in a rapidly increasing demand for water. As discussed earlier, this population growth is linked largely to migration into the capital city, arising from a number of factors including the effects of transition to a market economy and several years of dzud.

However, the centralized water distribution network is more than 50 years old and caters to less than half of the city's population (Emerton *et al.*, 2009). Around 60% of the population lives in Ger areas, and rely on water kiosks for their water supply (see Figure 2-38).

Figure 2-38. Population drinking water distribution system in Ulaanbaatar

A large amount of water wastage in areas connected to the central water supply system is caused by leaking pipes, and the fact that many water users in Ulaanbaatar pay only for water supply, not usage. This includes both residential and industrial water users. Industrial water supply is entirely from fresh water resources. There is very little re-use of water in this sector due to limited economic incentives to do so. Because water charges are not linked to real water use there is no incentive to save water.

As discussed earlier, the importance of Ulaanbaatar as a commerce and industry hub is also an important driving force affecting water resources in the city. Again, factors such as GDP, economic and industrial production growth rates, have important influences on the way the city uses and manages its water. The number of businesses in Ulaanbaatar has increased by 26% in the past four years, and continued growth is projected (Emerton, 2009)

States and Impacts for Ulaanbaatar

Water quality

The Tuul River Basin is now considered the most polluted river basin in Mongolia (Emerton, 2009). Field work carried out in 2007 and 2008 for Phase I of this project found significant levels of pollution in parts of the Tuul River downstream of Ulaanbaatar. Samples were found to be polluted with Arsenic, and water downstream of the WWTP also had a foul smell, very low Dissolved Oxygen and high conductivity (Enkhtuya, 2009). Some of the impacts associated with rising air pollution include a rise in SO_2 content of snow, and an impact on the pH of rainfall (CBD, 1996).

Poor water quality has been linked to a range of human health problems in Ulaanbaatar. Of the 10,000 cases of diarrhea reported annually in Mongolia, 70% occur in Ulaanbaatar (Basandorj and Davaa, 2005). Dysentery and hepatitis stemming from a lack of access to safe drinking water and sanitation are also common in the city, while contamination with heavy metals such as Arsenic has the potential to be deadly. Of particular concern is that some Ger area residents use water from shallow wells, springs and other watercourses, which may not meet drinking water standards.

As previously discussed, decreases in water quality also have negative impacts on aquatic and related ecosystems.

Water resources

The Ulaanbaatar water supply system is currently working on average at around 70% of its capacity (see table 2-7) and recent estimates suggest that the city could be facing severe water shortfalls by 2020 (Emerton et al, 2009). Seasonal water shortages between May and August have already been observed.

Water is supplied by the Ulaanbaatar Water Supply and Sewage Company (USAG) form deep wells in four water sources: at the confluence of the Terelj and Tuul rivers (“Upper”), and at three locations in the city (“Central”, ”Industrial” and “Meat-complex”). The three power plant wells account for around 25% of daily water use, on average.

Table 2-7. Water capacity in Ulaanbaatar, 2007*

Water source	Number of wells		Capacity (m^3/day)	
	Total	Operating	Design	Operating
Upper	56	19	72,000	47,307
Central	97	55	114,000	64,150
Industrial	16	11	40,000	22,200
Meat-complex	11	5	15,000	11,160
Power plant no.2	-	5	-	4,800
Power plant no.3	-	13	-	29,300
Power plant no.4	-	12	-	16,200
Private wells	-	297	-	3,000
Total	**-**	**417**	**294,300**	**198,117**

Source: Emerton et al, 2009

*Excludes water used for agriculture

In contrast, Ger area water users (around 60% of the population of Ulaanbaatar) account for only 2% of the annual water use (Emerton et al, 2009), or around 4% of household water use (see table 2-8). Apartment dwellers are the largest category of water users despite accounting for only around 40% of the city’s population. Thus, a key issue for Ulaanbaatar is the current inequitable supply of water resources.

Table 2-8. Water use by sector, Ulaanbaatar

Sector	Volume (106 m^3/year)	Volume (% Total)	Tariff (Tug/ m^3)
Industries	2.3	3%	
Business and commercial	8.29	11%	329.32
Other institutions	2.67	3%	
Power plants	18.36	24%	n/a
Irrigated farms	1.5	2%	3000
Livestock production	1.37	2%	n/a
Ger settlements	1.7	2%	909.09
Apartment dwellers	40.87	53%	167.27
Individual houses	0.22	0%	
Total	**77.28**	**100%**	

Source: Emerton et al, 2009

Water use in Ger areas is only 7-9L per person per day, which is far less than levels needed to meet basic health and hygiene requirements. Water is largely obtained from kiosks in Ger settlements (supplied by pipeline or tanker) and collecting water can entail long walks carrying water canisters. Some Ger area residents continue to use shallow wells and watercourses (springs, streams, rivers) to access water (Emerson *et. al*, 2009), despite the fact that water from these sources may not meet drinking water standards.

Water tariffs are low and inequitably distributed, with people in Ger settlements paying more than those in apartments, despite generally having lower incomes (see Table 2-8). Only around 20,000 (<5%) of apartments have water use meters installed, meaning there is little incentive to save water. Recent data indicate that apartments with water meters use on average 60L/person less than those without water meters (Emerton *et al.*, 2009). Water meters also make it easier to identifier leakages in the water supply system. Current estimates suggest that up to 30% of Ulaanbaatar's water use is unaccounted for (Emerton *et al.*, 2009).

b. Darkhan

Drivers and Pressures for Darkhan Uul

Water quality

Waste water treatment is the main issue affecting water quality in the Darkhan soum. Land-use in this area is primarily urban and industrial (dominated by small enterprises and the iron industry). According to the chief engineer of the Darkhan waste water treatment authority (pers. comm., July 2009) the main issue facing the agency is a lack of funding. The agency is a self-funded government agency, and although they report a high level of profitability (cost of waste water treatment: 35T/m3; price of treated water: 1000T/m3) they have insufficient funding to carry out any improvement works. For example, they report that around 40-50% of their profits are spent on electricity due to inefficient water pumps.

Mining is the main cause of water pollution in the Sharingol soum. An open pit coal mine was established in the area in 1965 and now covers an area of around 580 hectares, employing around 1000 people (World Bank, 2006). Since 1990, gold mining has also been carried out in the area. A key issue is the inadequate enforcement of mining license conditions. In particular, many companies with exploration licenses have commenced extraction without appropriate approval. Moreover, very little mine area rehabilitation occurs after extraction, and this is associated with many negative environmental impacts. For example, the World Bank (2006) has identified a risk of Acid Mine Drainage associated with the large, untreated waste rock piles from coal mining.

Artisan (ninja) gold miners also operate in these areas. These individuals undertake illegal activities to extract gold from residues left behind by larger mining companies. They use dangerous practices, such as washing gold with mercury, which are associated with negative environmental and human health impacts. Moreover, significant social problems are associated with communities of artisan miners, including alcoholism, prostitution and vulnerability to exploitation. A significant problem is the reluctance of these artisan miners to move to alternative forms of income generation, even when other employment opportunities are provided.

In the predominantly agricultural Orkhon soum, migration of herders into the area is a major driving force for a range of problems. A major concern is the increasing number of livestock, which are the main non-point source of water pollution. Despite having some of the most fertile agricultural land in Mongolia, severe land degradation is occurring due to overgrazing.

Lack of solid waste (garbage) management (e.g. treatment and disposal) is another significant source of water pollution throughout the Aimag, as in much of Mongolia.

Water resources

There are reports of much water wastage in Darkhan soum due to leakages in the central water supply system. This can be attributed to old equipment and the high cost of maintenance.

In Sharingol soum, mining activities have also had a negative impact on water resources, both in terms of quantity (e.g. use of ground and river water for mining, and modifying stream flows) and quality (see section 1.2). The mining production rate can be seen as a driving force for the area of land used for mining, which leads to many of these impacts. Major issues are similar as identified in section 1.2: inadequate enforcement of mining conditions, limited mine area rehabilitation, and the impacts associated with Artisan miners.

The predominantly agricultural Orkhon soum has inadequate water supply despite having two rivers. Families in the soum centre rely on their own shallow wells for water supply, which often do not satisfy drinking water quality guidelines. Outside of the soum centre, the decreasing water level of the Sharingol River makes irrigation difficult for farmers[1]. For herders, wintertime brings severe water shortages because there are not enough wells.

The high levels of migration into the area mentioned in section 1.2 is a major driving force of increasing pressure on this inadequate water supply infrastructure. Again, the relatively low levels of income available for many, and lack of alternative employment opportunities to agriculture, also create pressures on the environment, including water resources. For example, illegal harvesting of forest resources causes deforestation, which is linked to land and water degradation.

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[1] It is necessary to consider whether the level of the river decreasing is due to climate change or too much diversion.

States and impacts for Darkhan Uul

Water quality

Waste water quality results for Darkhan city provided by the chief engineer (Purevdorj.B) of the Darkhan city Waste Water Treatment Plant suggests that the water discharged meets all required water quality parameters. However, these results may be biased as the analysis is carried out by the waste water treatment authority rather than by an independent auditor. The major impact associated with funding shortfalls identified by the chief engineer is that the agency is unable to upgrade its equipment, resulting in large energy wastages in pumping water.

Sharingol soum suffers from severe environmental degradation due to mining activities. Heavy metal pollution has also been suspected in Khongor soum. Repeated reports of both human and animal deaths recently resulted in a World Health Organisation (WHO) investigation of water quality in the area. Although WHO did not find any evidence of water pollution, it is suspected that gold washing by artisan miners was responsible for causing the reported deaths in the area.

The poor quality of water supplied by the shallow family wells in the Orkhon soum centre has also been linked to water-related diseases. Water quality has decreased due to livestock overstocking, with livestock being the main non-point source of pollution in the area. Additionally, the water in some existing wells is becoming polluted as the well becomes older and is over-used, due to infiltration of unclean water (for example from animal waste) into the well. This is one of the impacts of large levels of in-migration into the area, particularly by herders.

Inadequate disposal of solid waste (garbage) causes water quality issues throughout Darkhan-Uul.

Water resources

Leakage rates of around 55% have been reported from the central water supply system in Darkhan city.

River flows have reduced in several parts of Darkhan Uul, and this is making crop irrigation difficult in agricultural parts of the Aimag. This makes it difficult for farmers to utilize the full potential of some of the most fertile soils in Mongolia. Although higher than in other parts of Mongolia, the local food production rates remain below the levels that could otherwise be expected.

Indeed, although the area has naturally high soil quality, it is suffering from land degradation, largely because of high levels of in-migration and overgrazing of pasture. Some reports suggest that grazing land availability has been reduced by 2.0 times in Darkhan-Uul (Schneider and Ankers, 2005), and this has been linked to land and ultimately water resource degradation. Pasture overgrazing is particularly evident around wells and other watering points, and desertification is increasing.

Local officials in Orkhon soum also report that there is a lack of enterprises in the area due to a lack of water infrastructure, particularly as the soum centre has no central water supply system. There are therefore insufficient employment alternatives to agriculture for this rapidly growing population.

Changes in river flows and river bed morphology also affect in-stream ecosystems. For example, decreases in the amount of overbank flows reduce lateral linkages with floodplains, which are particularly important in the breeding cycles of some insects.

c. Erdenet

Drivers and Pressures for Erdenet

Drivers

The Erdenetyn-Ovoo copper ore deposit is located close to the town of Erde net. Orkhon aimag is located in the north of Mongolia, in the territory of Bulgan aimag, approximately 400 kilometers northwest of Ulaanbaatar. The deposit was discovered and explored between 1960 and 1972. In 19 73, the Government of Mongolia, together with the former Soviet Union, set up the Erdenet Mining Corporation.

When Erdenet city (Bayan-Ondor soum) was first build the population was just over 7800. There were around 2500 head of livestock and 7 percent of total population was working in the industrial sector. During the last 30 years, the population has increased 10-fold, the head of livestock has increased by 55 times, and 33.8 thousand people work in over 1200 establishments.

The population of Bayan-Ondor soum is 78 thousand and 92.5% of the total population of Orkhon aimag. The Bayan-Ondor soum has over 10 ethnic groups. About 90% are khalkh, 2.4% are dorvod, 1.7% are bayad and 4% are kazak, urianhai, buriad, hoton and zahchin. About 30% of the total population is native born citizens and others are migrants. Over 40% of migrants are from Bulgan, Khovsgol, Selenge and Zavkhan aimags (Figure 2-39, 40).

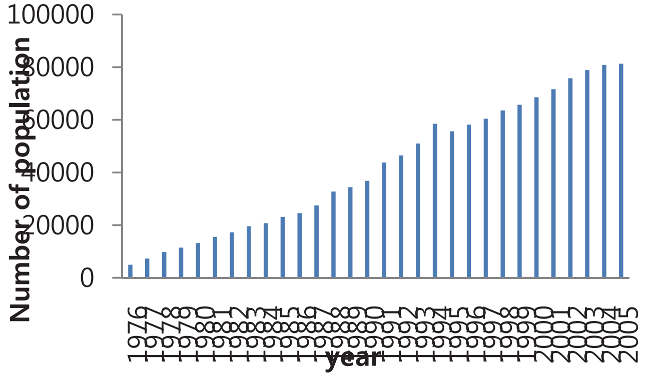


Figure 2-39. Population of Bayan-Ondor soum

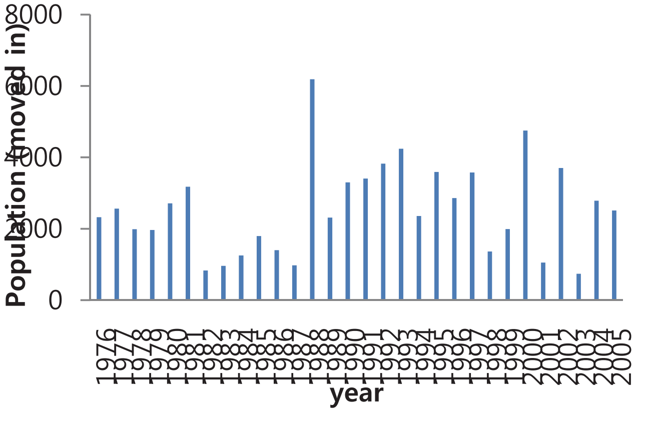


Figure 2-40. Migration into Bayan-Ondor soum

Over 80% of total production in the Bayan-Ondor soum is included in the metal sector, over 4% in the wool and wool fabric industry, about 4% in the electricity and fuel sector, 3% in the construction sector, and about 2% is included in the food sector.

The total number of livestock is about 197,000 in Bayan-Ondor soum. Total livestock was increased in between 1994 and 2002, between 2002 and 2004 dropped due to "Dzud" and since 2004 has been increasing.

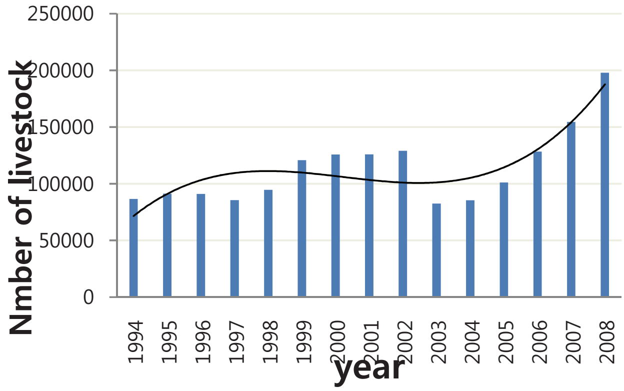


Figure 2-41. Number of livestock in Bayan-Ondor soum

The Erdenet porphyry Cu (-Mo) deposit is one of the largest mines in Mongolia and is operated by a joint Mongol-Russian company. The Erdenet mine has been operating since 1978 and annually yields approximately 20 million metric tons of Cu ore from which approximately 354,000 metric tons of copper concentrate and 3,500 tons of molybdenum concentrate are produced annually. More than 90% of the Cu and Mo produced is exported to Russia. The copper concentration from Erdenet contains 27-35% of copper with trace amounts of selenium (50-60 g/T), silver (50-70 g/T), tellurium (8-9 g/T), and gold (0.3-0.5 g/T). The molybdenum concentration from Erdenet typically contains 47-54% of molybdenum with trace amounts of rhenium (450 g/T), selenium (90 g/T), and tellurium (15 g/T). On average, 124,000 metric tons of copper and 1,672 metric tons of molybdenum are produced annually from the Erdenet mine (Figure-42, 43).

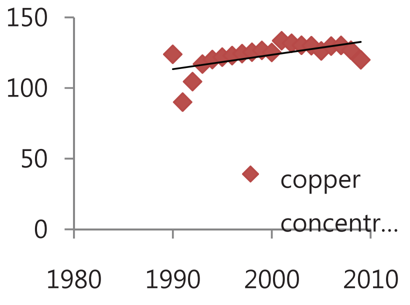


Figure 2-42. Annual copper Concentration, thousand ton

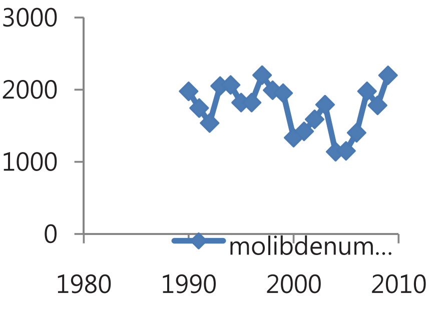


Figure 2-43. Annual molybdenum Concentration, ton

Heap (2004) reported that the Erdenet copper mine) is reportedly fined US$500,000 per year, and chalked it up as a cost of doing business rather than the more costly option of improving their processes. Enforcement of environmental standards is weak, and the nascent environmental elements of civil society are silent with few exceptions. In other words, a company can do pretty much what it likes.

Pressures

The waste from the ore processing is pumped to a Tailings Management Facility (TMF), which is located approximately 4 km away from the plant. The TMF is basically a 5 km-long tailing reservoir and Dam of standard design, of which 3 km are covered with water and 2 km are exposed tailing beaches. It contains 400 million tons of mine tailings, as well as 15 million m^3 of supernatant water. To make room for more tailings, the dyke has increased in lifts of 6 to 10 meters; current plans call for the dyke to reach its final height in 2010. There is a critical need to strengthen the routine maintenance and monitoring of the dyke's stability according to international standards to avoid and/or manage any seepage contamination problems resulting from the tailings turning acidic, as the ore contains copper-sulfide minerals and pyrite, which cannot entirely be removed in the beneficiation process.

To date, only some $30,000 is being spent to put topsoil on the tailings. Since a possible date for the decommissioning of the operation is still to be set, there is no plan for environmental remediation after the mining operations cease, nor have funds been set aside from operating income for this purpose. Blowing tailing dust is also one of the most serious environmental issues. With an open area of approximately 500 hectares of dry tailing beaches and a very fine-grained tailing material (80 percent < 0.74 μm), the wind has no trouble picking up dust. There is not much that can be done to mitigate the problem; stabilizing the surface with surfactants may help, but it is considered too costly since it has to be done on a regular basis due to new waste material continuously being pumped into the TMF.

States and impacts for Erdenet

States

From our field data in 2009, the dissolved Cu was 20.88 μg/l, 17.53 μg/l and 47.07 μg/l at sampling stations SM2 (Khangal River), SM4 (Erdenet River) and SM5 (reuse water from filtration), and the dissolved Zn was 32.365 μg/l at sampling station SM2 (Khangal River) respectively.

The water concentration taken from sampling station SM2 and SM7 (Khangal River near Ulaantolgoi) was included in the hydro carbonate class, calcium group, of the second category of Alekin's classification, medium level of mineralization (mineralization 724.3 to 599.3 mg/l) and hard (hardness 8.95 to 7.75 mg-eq/l). The SM2 site decreased in mineralization and hardness when compared with 2007 results (Phase I). The water concentration taken from SM4 was included in the hydro carbonate class, calcium group, of the third category of Alekin's classification, medium level of mineralization (mineralization 629.3 mg/l) and hard (hardness 8.40 mg-eq/l). The water was much polluted according to classification of the surface water.

The concentration of water taken from sampling station SM5 (reuse water from filtration) was included the sulphate class, calcium group, of the second category of Alekin's classification, medium level of mineralization (mineralization 703.0 mg/l), hard (hardness 8.85 mg-eq/l) and very polluted according to surface water classification.

The amount of total nitrogen at sampling station SM3 (Figure 2-44), amount of total phosphorus at SM3 and SM5 also was higher than the Waste Water standard MNS 4943:2000 (Figure 2-44).

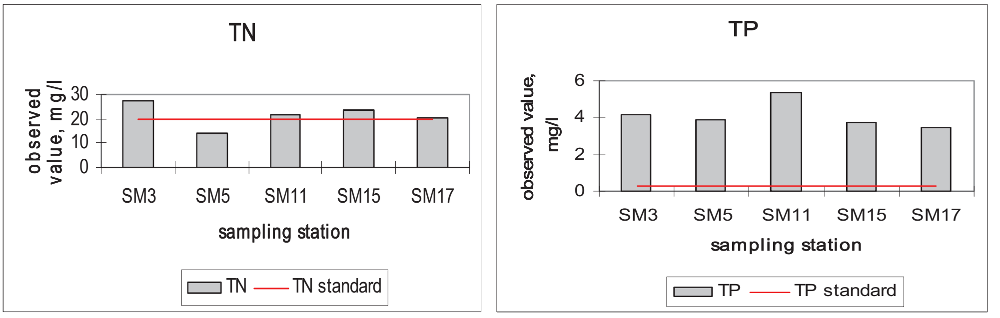


Figure 2-44. Spatial distribution of TN and total phosphorus in waste water

Institute of Geoecology of MAS(2009) reported that the concentrations of Mn, Cu, As, Mo, Cd, Li, Br, Co, Fe and U were from 0.37 to 25 times higher than standard in the surface water near the tailing pond and Erdenet city area.

KIE (2006) noted that the chemistry of surface water in the Khangal River is typically affected by the oxidation of sulfide minerals in relation to the mining of porphyry Cu(-Mo) ores.

Spatial variation of water quality is typical in the Khangal River where high concentrations of dissolved ions are caused by mining activity. Heavy metal contamination is generally negligible in the study area, possibly because heavy metals generated by mining are attenuated by dilution and adsorption onto suspended particles.

Pavlov and others (2004) noted that the bottom sediment in water bodies situated within the Selenge River basin can be classified as uncontaminated. Some exceptions were found to be local and associated with either the wastewater from the Erdenet MCC or the intense gold mining upstream of the sampled sites (the Bukhlyn and Eroo rivers).

Impacts

The state of the environment, of course, not only has an impact on biodiversity, but also on human health and on the long-term prospects of the economy (e.g. sustainability of economic growth) (Enkhtuya. 2009).

Impacts that can be identified are: water shortage (caused by human activities), decrease of river water resource for social case, population, damage area due to the limited water supply for economical case, quality of habitat and change in landscape for environmental case in the Selenge River Basin (Enkhtuya. 2009).

d. Zaamar

Drivers and Pressures for Zaamar

Water Quality

The Zaamar gold mining placer has major impacts on water quality in Zaamar soum, as do the activities of artisan (ninja) miners in the area. As reported for Shariin gol soum in Darkhan Uul Aimag, ninja miners use a variety of unsafe practices to extract gold from mining residues, and this is associated with a range of negative impacts on health and the environment.

Enviroplan Services (1999) reported that the lack of enforcement, poor mine planning and operations result in a lack of effective pollution control in the Zaamar gold mining area. Landscape destruction has affected more than 70,000 hectares (Enkhtuya, 2009).

Most of the smaller industrial mines in the Zaamar goldfields are open-cast operations using free digging shovels or hydraulic excavators and haul trucks that dump the ore near the wash plants (see Figure 2-45). The resulting effluent of high pressure water from the water cannon is directed to tailings ponds to settle out the coarsest material down to fine sand, and the still-turbid water is then recycled back to the wash plant or illegally discharged to the Tuul River.

The settling ponds are unusually large and vulnerable to uncontrolled discharge by overtopping or collapsing. At least two mines discharge all effluent directly onto the floodplain, with frequent discharge of dirty water into the Tuul River. Moreover, large-scale placer mining is done by dredging, which seems to be a major source of sediment contaminating the river and also changes the river channel morphology.

Figure 2-45. Mining operation using dredging, Tuul River, Zaamar region

Water reources

Water resource issues on the Tuul River near the Zaamar gold mining placer relate largely to mining in the area. Hence, factors such as the amount of gold produced annually are particularly important driving forces.

The water cannons used in Zaamar consume large amounts of water and are often left running even when the wash plant is idle, making water use is very inefficient. Thus, the lack of sufficient incentives to minimize water use during mining (for example, water use regulations that are enforced, or pricing water use according to consumption) can be seen as a driving force leading to high use of river water.

Mining also generates high volumes of effluent that have become more and more difficult to manage. Again, there are insufficient incentives or policed regulations to ensure that waste water is treated and re-used where possible. Significant changes to river channel morphology are also caused by large-scale dredging.

States and Impacts for Zaamar

Water quality

Field data (Phase I report; Enkhtuya, 2009) shows a high turbidity around the Zaamar placer, with suspended solids ranging from 86.5mg/L-194.67mg/L. Other researchers have also noted that the water quality in Tuul River has a turbidity problem, largely due to illegal mining without any protection measures (Lee et al., 2006). The dissolved As values ranged from 9.547-10.416 μg/l, and were higher than Ambient Water Quality Standard in Tuul River of Zaamar Gold mining placer. Also, the suspended matter in the gold wash wastewater is 1-110 times larger than the maximum level allowed to be discharged to surface water sources according to water quality standards and water quality of the Tuul River. These are included in the categories 'pure' to 'slightly polluted' as per amount of oxidation of permanganate recorded. The ammonium ion concentration is comparatively high or 1 - 4 times larger than that of the 'Pure' category (Tsengelmaa et al., 2007).

Tsengelmaa et al. (2007) also reported that organic pollution has been increasing in this region. In September 2004, an indicator organism of organic enrichment, Trichoptera, Hydrosyche Sp. was dominant in all the sample points. This was particularly the case in sample points 2 and 6-8, where Hydrosyche Sp made up 65 – 73% of organisms in each sample. As a result of the collected macroinvertebrate samples, it can be concluded that the Tuul River has been polluted by organic matter and periphyton-attached algae. She classified the river using the Hilsenhoff water quality classification method as 37.5% in 'excellent', 29.1% 'good', 25% 'good-fair' and 8.3% 'poor' in this region.

The impacts arising from this water pollution are significant. Tuul River water no longer passes drinking water standards in Zaamar soum, and this has negative human health impacts. The increases in suspended solids loads has also reduced and modified invertebrate populations, an import source of food in the riparian ecosystems of the Tuul River. Habitat loss due to landscape damage, siltation and over fishing from the large influx of people into the Zaamar area are also impacting Taimen populations.

Water reources

Water resources in Zaamar soum are being inefficiently used by mining companies in the area. As a result, the amount of available water is decreasing.

Impacts include increased water shortages due to human activities (i.e. water shortages beyond those caused by the natural scarcity), decreased river water resources and, in some cases, drought damaged property. A number of people and land are affected by these limited water supplies can also be considered as an impact.

Changes to river flows and river bed morphology also affect in-stream ecosystems. For example, reductions in the amount of overbank flows reduce lateral linkages with floodplains, which are particularly important in the breeding cycles of some insects.

C. Hotspot Areas of Russia

a. Ulan Ude

Ulan-Ude is the largest city - the capital of Buryatia, with a population of 3,733,000 people (2009) located on the right bank of Selenge river at the confluence of the river. Uda currently occupies territory with an approximate area of 380 square km. This is a largest industrial, transport and cultural center of the republic. The city is an important hub of roads and railways. The Trans-Siberian Railway and the railway Ulan-Ude - Naushki - Ulan Bator lie through the city of Ulan-Ude, where a river port is available. The largest share in the city's economy took engineering industry, light and food industries. Specialized sectors in the engineering industries of the city are aerospace, electrical engineering, and repairing of rolling stock.

The decisive factor in the continuing decrease in population size of SRB (the Republic of Buryatia) is the migration outflow of the population. The highest rates of migration outflows observed among the urban population and, above all, from the Ulan-Ude. The working-age population, aged 20-49 years, representing a decrease of labor potential of the territory, dominates at the structure of the migration outflow.

Analysis of employment and labor market shows the typical characteristics of the following problems: low efficiency of labor and wages, high wage differentiation, loss of labor potential of skilled and qualified personnel as a result of their exclusion and under exploitation of their working time, and a difficult situation with the employment of youth and women. In general, the present situation on studied labor market remains difficult and is unlikely to expect significant positive structural change.

The volume of gross regional product (GRP) production in a Selenge river basin estimated in 2007 was 94.6 billion rubles. - See table 2-9. Over the period 2004-2007 GRP dynamics tended growth of the economy SRB territory in 2007, its share in the Republic of Buryatia was 92.42%. The greatest contribution to the production of GRP was made by Ulan-Ude (65,4%), and by Nizhneselenginsky industrial hub - 5,9% and by Gusinoozersky - 4,5%.

Table 2-9. Gross regional product by areas of the SRB

Unit: mln, rbl

Selenge river basin	2004		2005		2006		2007	
	GRP	%	GRP	%	GRP	%	GRP	%
	53443,6	100	63585,5	100	75931,6	100	94587,2	100
Republic of Buryatia	50237,7	94.0	60006,7	94.4	70793,7	93.2	87419,0	92.4
Zakamensk industrial hub	789,7	1.48	966,6	1.52	1120,2	1.48	1401,7	1.48
Nizhneselenginsky industrial hub	2657,0	4.97	3341,7	5.26	4332,8	5.71	5661,7	5.99
Gusinoozersky industrial hub	3026,7	5.66	3168,3	4.98	3132,3	4.13	4253,8	4.50
Ulan-Ude	34636,8	64.81	41286,8	64.93	49769,4	65.55	61866,5	65.41

2004 - 2007 years

The city of Ulan-Ude does not have a single, centralized water supply system. Municipal water supply system has infiltration water withdrawals on the two islands of the Selenge river - Spassky - 168 thous.m3/day and Bogorodskoe - 51 thous.m3/day. Water withdrawals are made from 60 wells with submersible pumps 160-250 m3/h capacity. In 2009, the total pumped water was 56.68 million m3 (Table 2-10).

Table 2-10. Indicators of water use in Ulan-Ude, 2008

Unit: mln. m3

water withdrawal		Discharge water to surface water	Losses due to transport -tation	Used water	Reusing water	sum payment for the sewage
surface water	Under-ground water					
2,91	53,77	34,29	8,96	47,72	42,86	0,38

Length of water mains in Ulan-Ude is 184.8 km. Due to the dilapidated state of networks, which is more than 50%, 45 major accidents appear each year, losses during transportation amounted to 8,96 m 3 (see table 2-10). Besides the city water withdrawal, there are more than 10 institutional providing individual enterprises (heat station -1, aircraft factory, LVRZ (repairing of rolling stock plant) etc.). The population of microdistrict are not covered by the centralized water supply, water is pumped from 13 individual wells and 30 water-filled towers.

In case of the development of the south-west, south-east and the left-bank parts of the city, as well as a centralized water supply of its suburbs, it became necessary to increase the production capacity withdrawals up to 330 thous.m3/sut and correspondingly increasing the length of water networks.

Drinking water supply of the city is fully provided from underground sources, but sanitary protection zones are missing or are in poor condition.

The water consumption for service-drinking needs was 137.45 m3/year, or 370 liters per day per inhabitant

The selected largest enterprises of the city's water supply is implemented as follows:

Heat station-1 has two water supply systems: for drinking service and for industrial service. The Selenge river sub-riverbed waters act as industrial water supply sources, for the purposes of drinking service use city plumbing.

Repairing of rolling stock plant, residential- exploitation office (K.E.CH.), "Elektromashina”, meat-packing plant, aircraft factory, distillery, selkombinat have their own system of drinking and industrial water supply, which provides the water needs of industrial enterprises and the adjacent residential area.

“Gormolkombinat”, brewery, confectionery factory, “Teplopribor” plant, distillery “Baikalfarm” use water from municipal water supply for drinking and industrial needs; East-Siberia railway road draws water from the municipal plumbering for drinking goals, for production needs using departmental plumbering from the Selenge River and Uda River water withdrawal.

Table 2- 11. Ulan-Ude waste water discharge, in 2008

Ulan-Ude heat station 1	0,12
municipal enterprise Vodokanal Ulan-Ude	34,03
Total:	34,15
Total in SRB	479.16

States and Impacts

On the territory of Ulan-Ude industrial junction located factory (aviation, locomotive factory, instrument making, etc.), the fuel power (TPC-1, TPC-2), centrals and central food, textile and wood industry, small furniture production, tank farms and many gas stations. Virtually all objects were covered by the monitored control. There was underground water pollution with oil products - from the moderately hazardous (1-5 MPC) to highly hazardous (10-100 MPC) concentrations. In the zones of influence of oil storage facilities was located in v. Steklozavod, fuel storage areas at an aircraft factory and Locomotive factory on the surface water, formed by the lens of liquid petroleum products up to 3 m or more. Widespread pollutants are ammonia and nitrate concentrations or above the MPS. Oil spills and nitrogen-containing compounds are usually accompanied by increasing oxidation of underground water within - 5-10 mgO/dm3. The most dangerous hotbeds from the geological environment are identified on aircraft factory and Locomotive factory, in which underground water is contaminated with sulfates, chlorides at concentrations of 1.5 MPC and more.

There is a thermal and chemical pollution of underground waters in Ulan-Ude which is ecologically dangerous. The wide spectrum of polluting substances is characteristic for sites of aircraft factory placing and sediment tank of LRP (Figure 2-46). Characteristic polluting substances are phenols, oil products, manganese, fluorine, and ammonium. The question about liquidation of the sediment tank creating danger of occurrence of extreme situations has not been answered. At the same time, pollution of underground waters by highly toxic substances is progressing every year. The polluted underground waters are discharged into downstream sediment tank of HES-1, and also into a stream flowing on territory which further migrate with surface and underground waters, and flow into the Uda River.

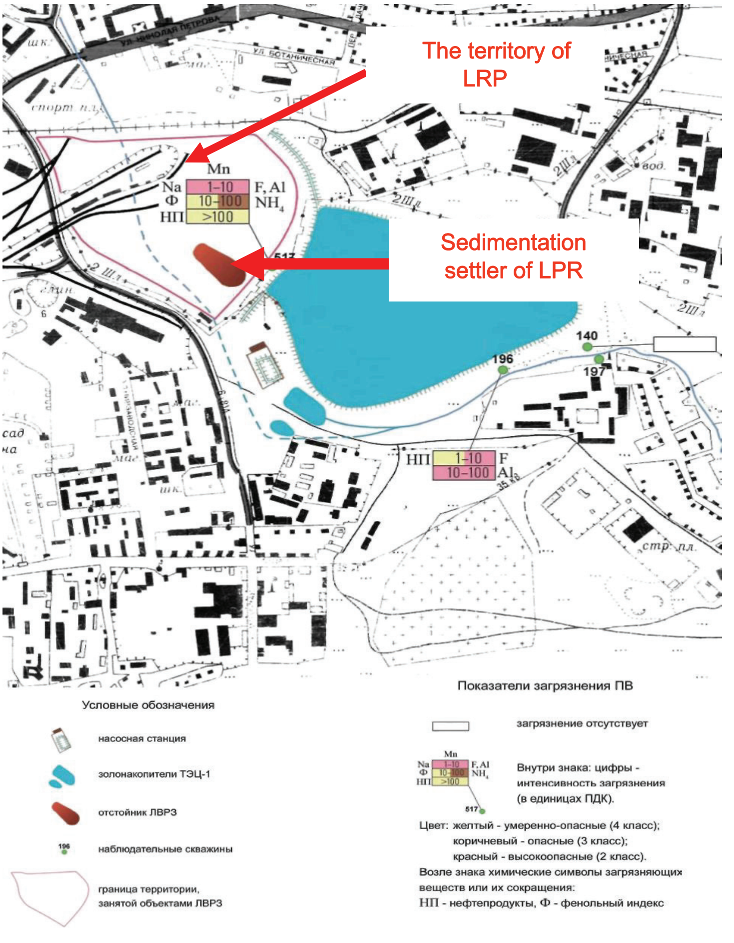


Figure 2-46. Pollution of underground waters in the territory of Lokomotiv repair plant (LPR)

The mineralization (dry residue) of its reach is 1,5-3,4 g/dm3. Near the Locomotive factory underground water were contaminated with an extremely dangerous concentration of phenols, fluorine, and oxidation of more than 240.0 mgO/dm3, the pH value reaches 9.6 junctions. According to the geo-environmental surveys in the territory of Ulan-Ude industrial junction of soils and sediments were contaminated by Cu, Ni, As, Pb, Zn, and Cd concentrations of 10-100 MPC.

The left bank of the Uda riveris the location of ash disposal areas of HES-2. The observant network is presented by 4 chinks with a depth of 7.6-15.0 m. In underground waters the raised content of oil products, manganese, cadmium which is concentration in 2008 has reached 1200 MPC is periodically marked. The scheme (Figure 2-47) of underground water spread near ash disposal areas in HES-2.

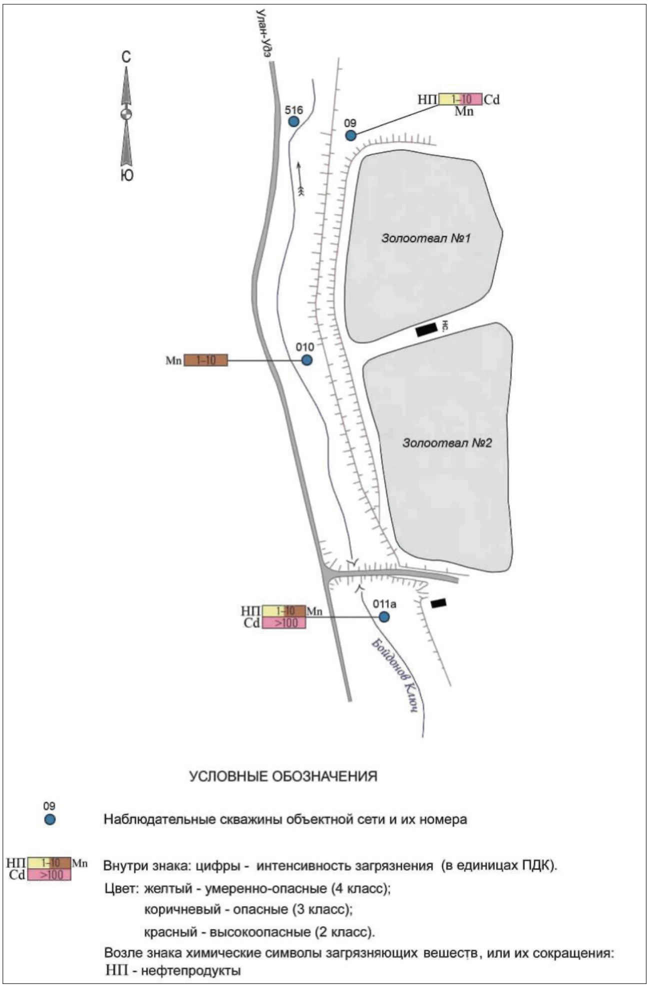
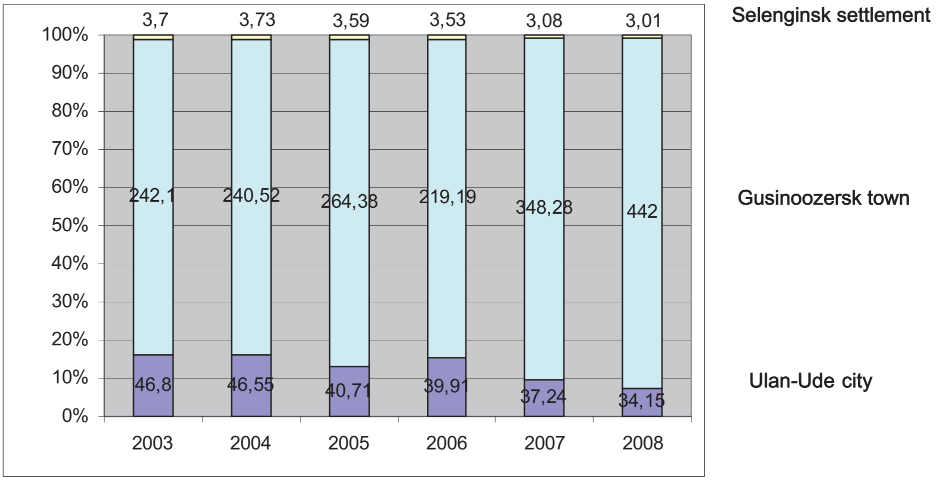


Figure 2-47. Underground water spread near ash disposal areas in HES-2

Pollution of surface waters

Sewage waters fall in the category of "insufficiently treated". The main polluting substances arriving with sewage waters - the organic substances, the suspended substances, compounds of nitrogen, phosphorus, copper, iron, and also phenols, oil products in the liquid form (in a zone of influence of tank farms of Steklozavod district) which are unloaded in the Uda and SelengeRivers.



Unit: mln. m3

Figure 2-48. Discharging into surface water objects

b. Selengzinsk

Driving forces and pressures

Nizhneselenginsky diversified industrial center is located in the western part of Kabansk district and adjacent to the Central ecological zone of Selenge river basin (SRB), along the left bank of the Selenge river with location area of pulp and paper industry, industry of construction materials and machinery. Centers of the hub are towns Selenginsk, Kabansk, Kamensk, where located key enterprises – otkrytoe aktsyonernoe obsestvo (OAO) "Selenginsky pulp and paper plant (PPP)", obsestvo s ogranychenoy otvetstvenostiy (OOO) "Selenginsky plant of reinforced concrete", OOO "Selenginsky Agromash", OOO "Timlyuysky Cement Plant", OAO "Timlyuysky cement plant, asbestos cement products plant", Kabansky fishery plant, OOO "Oymur – furniture".

Figure 2-49. Selenginsky PPP

The core of Nizhneselenginsky industrial hub is Selenginsky PPP, which is the enterprise forming company town for t. Selenginsk and budget forming for Kabansk region. The plant was put into operation in 1973. Due to the fact that it is located in the central ecological zone of Baikal natural territory Selenginsky PPP is limited by capacity to produce goods. Based on environmental requirements, the capacity of producing cellulose is defined within 171.0 thousand tons per year, a production of corrugated packaging, knobble gaskets, coated paperboard, fiberboard, production of sacking paper and manufacture of sack paper bags for packing of bulk products.

A distinctive feature of the plant is that it does not have emissions of waste water. 20 years ago for the first time in the world practice on Selenge PPP a system of closed water and full utilization of industrial wastes has been introduced. Suffice to note that in 1994 the project was awarded the State Prize of Russia.


Figure 2-50. Cleaning facilities of Seleginsk PPP

Despite the measures taken to limit the volume of production and the introduction of a closed water circulation for the period of exisiting of Selenginsky PPP repeatedly proposed to close it[2].

Currently, the company develops moderately. Since 2002 OAO "Selenginsky PPP" became a part of the holding company “FC Continental-Management” Co, ltd, in this case the structure of production is changed: the production of containerboard increased by 13,1%, cellulose decreased by 12,6%, production of sack paper decreased by 29%, goffered production decreased by 22%.

At the moment, production volume and structure of production PPP are as follows (Table 2-12).

Table 2-12. Structure of production in the Selenginsky PPP

Production	2009 г.	By % to 2008
Rosin, tons	735	26,1
Turpentine, tons	466	135,1
Cardboard, thousand tons	93,5	95
Pulp, thousand tons	100,1	96,1
Paper, thousand tons	5,3	88
Paper bags, mln. items	14,7	86,2
Boxes made of cardboard, mln. square	38,1	100,4

2 Proposal of TerKSOP (Territorial complex scheme of protection of nature), developed by Giprogor (State institute of city projecting in 1984).

On the territory of the hub the main source of water consumption for household and drinking needs are the underground water (67,8%), from surface water diverted 32.2% for the needs of fish-breeding, agriculture and cement production. According to the Department of Water Resources of Lake Baikal in the present volume of water withdrawal of Nizhneselenginsky industrial hub is 8,79 million м3 (Table 2-13).

Table 2-13. Water Withdrawal of Nizhneselenginsky Industrial junction

2008, mln. м3

Industry	From surface sources	From underground	total
Total	2,83	5,96	8,79
Tanhoi	0,01	-	0,01
Branch of OAO "Energetic company-14 Timlyusky heat electropower station	-	0,01	0,01
OAO"Selenginsky PPP"	-	3,71	3,71
Office of housing and communal services of t. Selenginsk	-	1,08	1,08
OOO UK "Novii Dom"	-	0,20	0,20
Municipal company "Kamenskzhilcomservice"	-	0,14	0,14
OOO "Timluysky cement plant"	1,51	-	1,51
SPK "Kabansky fishery plant"	-	0,02	0,02
Bolsherechensky fishery plant	1,22		1,22
SPK "Kabansky fishery plant" Oymur disrict	-	0,01	0,01
Kabansky GOS	0,08		0,08
SPK "Tvorogovsky"	-	0,04	0,04
Municipal company "ZHILCOMHOZ" t. Babushkin	-	0,30	0,30
Others	0,01	0,45	0,46

A major water consumer is Selenginsk, in which water withdrawals are made from ground water OAO "Selenginsky PPP "(3,71 mln. м3) and "Municipal enterprice of housing and communal services" (1,08 mln. м3). Surface water sources are used by Bolsherechensky fishery plant (1.22 mln.

м3). The specific water consumption per capita was 130.06 м3 /per year or 356 liters per year.

States and Impacts

The main pollutant of surface waters is Municipal Unitary Enterprises (MUE) Housing Communal Economy (HCE) Selenginsk. 1, 58 million m3, or 39.4% of the total discharge of household wastewater was localized in the water protection zone of 21.5 km. above village Kabansk were accounted the share of cleansing engineering of MUE (see Table 2-14).

Table 2-14. Discharge of wastewater, 2008, million m3

	to surface water	in storage, depression, field filtration Total	Total
Total	5,52	0,92	4,01
station Mysovaya	4,01	0.03	0.03
branch of Opened Joint-stock Company (OJSC) “Heat Generation Company-14 (HGC) Timluysk Thermal Power Central (TPC)”	-	0,04	0,04
MUE Municipal Engineering (ME) village Selenginsk	-	-	1,58
Limited Liability Company (LLC) Management Company (MC) “Noviy Dom”	0,14	-	0,14
MUE “Kamenskzhilcomservis”	-	0,69	0,69
Bolsherechensky fish-breeding factory	1,22	-	1,22
Kabanskaya Government Irrigation System (GIS)	-	-	-
Agricultural Production Cooperative “Tvorogovskiy”	-	0,02	0,02
MUE “Zhilcomxoz” city Babushkn	0,15	-	0,15
MUE “Baikal Service”	-	0,14	0,14

Sources of underground water pollution are the TPC, sewage engineering, waste storage and liquid waste, owned by OJSC "Selenginsk Pulp and Paper Plant" (SPPP).

The intensity of underground water pollution is high due to the production of primary products of SPPP – sulphate cellulose and packing cardboard. The production process is accompanied by the release of subsidiary products - sulfate soaps and sulfate turpentine, of which, in turn, are tall oil and pure turpentine. As a result, the production of sulphate cellulose was formed using shlam lignin and tall oil.

Since 1984, the state monitoring conducted a network of wells on the territory of the SPPP. In different years, results of underground water monitoring were showed the persistent pollution sulfates at concentrations ranging from 50 -100 to 1400 mg / dm 3. Sulfate pollution is accompanied by higher contents of chloride, sodium and other components with increasing salinity of 2 g/dm3 and more. Lignin and tall oil are also found in the underground water, oil pollution, due to infiltration of sewage containing petroleum products in concentrations up to 14 mg / dm 3.

In recent years, despite the of the continuing severe underground water pollution has been a trend of losing control and monitoring system. For example, the number of hydro watched wells on the rivers has decreased by 3 fold. At the moment there are only 6 hydro watched wells on the rivers, which allows making appropriate measurements for underground water pollution.

Harmful substances, accompanying the technological processes of production, are to found not only in underground water, but also in the air.

Thus, in according to the data of State report on Lake Baikal, in settlement Selenginsk emissions into the atmosphere from stationary sources are increasing and in 2008 amounted to - 3, 996 tons (see Table 2-15).

Table 2-15. Emissions of harmful substances of settlement Selenginsk, 2008

Unit: Thous. tons

	2006	2007	2008
In total, from stationary sources	3.245	3.666	3.996
including: solids	1.3	1.655	1.614
Sulfur dioxide	0,9	0.917	1.205
CO	0,8	0,84	0,92
nitrogen oxides	0,2	0.195	0,207

The growth in emissions S. Selenginsk was associated with increases in output. The most of the emissions are the result not only from the production of the company, and the work of TPC, which provides heat and hot water, but the CCC, and even the whole village. TPC uses brown coal; ash is very high, which causes high rates of emission of solid substances.

Dust and gas emissions include dust, sulfur dioxide, hydrogen sulfide, nitrogen dioxide, chlorine, phenol, and methylmercaptan. The waiver of precipitation containing a large amount of oxides of sulfur and nitrogen may cause acidification of soil at a distance of more than 20 km from emission sources.

The territory of Nizhneselenginsky industrial junction was mainly as a result of the pulp and paper industry which were generated an enormous amount of solid waste, which is also the major source of pollution of the soil. For example, 103.456 tons of waste production and consumption (in 2007 - 164.96 tons of waste in 2006, -160.243 tones), of which utilized 0,9 thousand tons, placed on the landfill 0.155 thousand tons were formed in 2008. In general, at the end of 2008 the enterprises of s. Selenginsk were accumulated 1,846.546 tons of waste, about 70% of which belonged to the Selenge CCC.

Wastes, generated in the results of production of cellulose, are bark, sawdust, ash, slag, etc.

c. Gusinoozersk

Driving forces and pressures

The Gusinoozersky industrial hub is located on Lake Gusinoe one of the largest lakes in the basin of Selenge river. The lake area is 163 km2 and the maximum depth is 25 m. The volume of water mass at the average depth of 15 m is 2,4 км3. The maximum amplitude level is 95 cm.

Gusinoozersky industrial hub has always been second after the Ulan-Ude hub economic ally, the volume and scale of impact on the environment in the basin Selenge. Besides Gusinoozersky hydrostation (GRES) in the area of the Gusinooozersk town located coal mining objects (Holbodzhinsky cut, mine "Gusinoozersk"), a deposit of fresh water "Elnik", clay sandpit, brick factory, and militar.

Figure 2-51. Gusinoozersky GRES

Lake Gusinoe basin presented by basin depression, where on the shore of it located T. Gusinoozersk, T. Gusinoe ozero and the largest consumer in the Selenge basin Gusinoozersky GRES.

Development of water supply in the basin is based on the surface waters of the lake Gusinoe. Up to 80% of fresh water from surface water subjects in the Selenge basin is suited at the basin of Lake Gusinoe.

The main water consumers are: OAO "Gusinoozersky GRES", "Gusinoozersky Gorvodocanal" (2.7 mln. м3), municipal enterprise KKPiV t. Gusinoozersk (2,6 mln. м3), municipal housing enterprise station Gusinoe Ozero (0.3 mln. м3), Zagustayskaya Somon administration (0.3 mln. м3) and state irrigation systems - Zagustayskaya (1,3 mln. м3), Tsagaan-Golskaya (5.6mln. м3).

Wastewater from water users in the Lake Gusinoe is discharged in the amount of 242.2 mln. м3. Irrevocable water consumption concerning the surface water body is 14,5 mln. м3 or 5.6% of fresh water withdrawal from the lake. Specific water consumption at service drinking needs of the urban population in the basin of the lake Gusinoe amounted to 229 liter/day, the rural population – 58 l/day.

Town Gusinoozersk for service drinking purposes using surface water in large volumes. Water withdrawal from the lake Gusinoe is carried out by two pumping stations: the first water withdrawal capacity of 25-26 ths.м3/day operated since 1974, and the productivity of the second withdrawal is 7,2 thousand м3/day. The waters of Lake Gusinoye are characterized by hydrocarbonate calcium-sodium composition and mineralization of 0.3 g/l and by the presence of organic substances which are not suitable for drinking purposes without prior water preparation.

The problem of the city's water supply of drinking water quality may be solved by using groundwater. Organizations of Ministry of Natural Resources MNR of Russia have taken a series of exploration on the western shore of lake Gusinoe in the immediate vicinity (1 km) from the existing water withdrawal - 2. After the affirmation of operational reserves of underground waters for industrial categories, town water supply will be transferred to underground sources, and the first withdrawal after a capital improvement (in operation since 1947) will supply population with industrial water (irrigation of plantations, roads, etc.). The water consumption per inhabitant amounted to 89.28 м3/year, or 244.6 liters per day.

These anthropogenic pressures on the lake Gusinoe is considerable: the biggest in territory of Gusinoozersky GRES (branch of OAO "OGK-3"), increasing the production of electricity capacity, and consumes 90% of the total surface waters of the Republic of Buryatia. Accordingly, the volume of discharge to Lake Gusinoe of technological waters is increasing. In 2008, the warm regulatory clean wastewater dumping without treating after cooling of equipment amounted to 442.0 mln. м3 (2007 - 346.0 mln. м3, in 2006 -284 mln. м3, in 2005 - 261.1 mln. м3, in 2004 - 237 mln. м3).

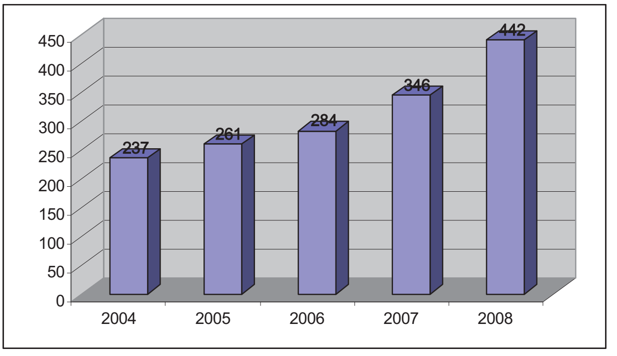


Figure 2-52. Warm technological water dumping to lake Gusinoe

Figure 2-53. Space photo of T.Gusinoozersk

The increase of sewage water dumping is due to the increase in electricity generated by Gusinoozersky GRES.

On the shores of the lake located other sources of anthropogenic impact were located: Gusinoozersk town, railway station and the township lake Gusinoe, inactive coal mines and the open-cast with worked mount excavation and mount rocks dumps.

Besides warm power plant discharges into the lake regulatory purified industrial storm water from industrial area of OAO "Gusinoozersky GRES", as well as waste water of municipal enterprise Vodokanal of town Gusinoozersk - a branch of the "Baikal pribor-1" and OOO "ZHEU lake Gusinoe" (the latter drains through the river Tsagaan Gol fall into the lake) are dropped in the amount of 3,05 mln. м3. The volume of pollutants discharged into the lake Gusinoe in 2008, amounted to 1,864.0 t (2007 - 1520.3 t). In the composition of pollutants such as sulphates, chlorides, oils, etc.

Table 2-16. Wastewater dumping, 2008

Unit: mln. м3

Industry	insufficient purification	standard-purification
OOO ZHEU Lake Gusinoe	0,04	0
OAO "OGK-3" "Gusinoozersky GRES"	0	442,02
Branch of Vodokanal of t.Gusinoozersk	3,01	0

Water consumption in the re-circulating water supply systems consistent of 191.5 mln. м3 or 118.1% compared to 2007. Fresh water savings through the use of recycling systems is 30%.

Dynamics of water use in electricity in 2002-2008 is presented in table

Table 2-17. Dynamics of water use in electricity in 2002-2008

Unit: mln. м3

Indicators	2002	2003	2004	2005	2006	2007	2008
water withdrawal from water objects: total	489	237	237	264	284	346	442
including: from underground sources источников	0,44	0,055	0,04	0,02	0,11	0,03	0,034
Discharged wastewater, mine-ore and drainage water into surface water objects: total	481	236	237	261	216	345	442

Indicators	2002	2003	2004	2005	2006	2007	2008
including: regulatory pure	0,15	-	-	-	-	-	
Consumption in recycled and re-supply water systems	49	114	114	145	202	162	192
Total expenditure on water supply	538	351	351	409	486	508	634
Capacity of wastewater treatment	2,22	1,87	1,87	1,87	1,87	1,87	1,87

States and Impacts

Water-quality monitoring was conducted at the Lake Goose station. During the year, the salinity of the lake water was varied from low (98.9 mg / dm 3) to medium (405 mg / dm 3). The water was slightly alkaline reaction (7,58-8,37 PH). Contents of dissolved oxygen was at -7,32-12,0 mg / L, and data for carbon dioxide is insignificant (0-4,4 mg / l).

During the year, increasing the Maximum Permissible Concentration (MPC) was recorded on six indicators of water quality. The maximum concentration of copper was 4.8 MPC, iron - 26 MPC, zinc -2,7 MPC, oil - 1,4 MPC, phenols - 2 MPC, and the organic matter in magnitude Chemical Oxygen Demand (COD) - 4 MPC.

A comprehensive assessment of water quality was observed common characteristics includes iron pollution, copper, zinc, organic substances but the value of COD average. For phenols and oil products unstable pollution, pollution level - low-medium was observed.

Specific combined index of water pollution (SCIWP) value in 2008 was increased to 3.19 compared to 2007 G. (2,53), the water of the lake is very polluted, 3 B class.

Status of underground water

Monitoring of underground water in 2008 was carried out only in the zone of influence at Gusinoozersky power central, where the range of contaminants included chloride, sodium, sulfate, nitrogen compounds, petroleum products, metals. According to observations in Gusinoozersky power central nitrite, oxidation, manganese in the most significant underground water pollution (maximum permissible concentration of 2,6 - 3,7 times) was observed.

There is contaminated underground water at the placement of distribution of ash dump, industrial junctions and farms.

Air pollution

In the city of Gusinoozyorsk the level of atmospheric pollution observed by Buryat Center of Hydrometeor Station (CHMS) in 2008 were exceeded the MPC in terms of suspended solids (1,1 MPC). However, in the atmosphere, the average content of sulfur dioxide, carbon monoxide, nitrogen dioxide, nitrogen oxide, theirs MPC, sanitary standards are not exceeded.

In 2008, industrial enterprises of the Gusinoozersk received the greatest amount of emissions, the degree of capture of pollutants is high - 98.60% (2007 -97.05%).

The atmosphere from stationary sources in 2008 released 32.489 tons of harmful substances, an increase in comparison to 2007 (27.781 thousand tons in 2006, -24.536 tons), partially falling into the lake, increased human pressure on the reservoir. In the structure of solids emissions are - 11.709 million tons (in 2007 -8.499 tons) of sulfur dioxide - 12.637 million tons (in 2007 - 10.169 tons), carbon monoxide - 0,993 tons (in 2007 year - 0.782 tons) and nitrogen oxides - 6.165 million tons (in 2007 - 7.147 tons).

The main contribution to the emissions of these substances in the atmosphere makes "Gusinoozersk GRES - 97.39%.

The increase in emissions of pollutants in industrial enterprises is due to increase in the number of fuel, which is used throught a mixture of different coals. Reduce emissions of pollutants on centrals for the extraction of coal by 0,143 tons due to reduced production.

Over the past five years (2004-2008.) emissions from stationary sources increased by 6.913 thousand tons (22,3%), and motor vehicles rose - to 11.086 thousand tons (41,7%). Total emissions have increased by 17.999 thousand tons (31,2%).

Soil pollution

The enterprises located in Gusinoozersky industrial junction, in 2008 were formed 5,905.87 tons of waste production and consumption (in 2007 - 6039.33 thousand tones of waste in 2006 - 4787.51 thousand tones), of which utilized 2.274 million tons (in 2007 - 0.96 tones of waste). At the end of 2008 the enterprises accumulated 21,571.039 tons of waste (in 2007 - 26766.4 thousand tons of waste). 445.179 million tones of landfill waste, mostly from companies for the extraction of fuel and energy minerals were posted.

d. Zakamensk

Driving forces and pressures

Zakamensk town is the administrative center of the eponymous district of the Republic of Buryatia, located 245 km from the nearest railway station Dzhyda, in the Modonkul river valley, which flows into the river Dzhyda in 4 km away from the city. The town is crossed a road of national importance Tsakir-Zakamensk-Dalahay. The basis of the city economy is industry. The largest town's enterprise is the Dzhida plant, which employs about 60% of the working population of the city. The degree of city improvement is low, with only 32-35% of the housing equipped with plumber, adequate and central heating.

Zakamensky problematic area was formed for the period of the Zakamensk industrial unit development on the basis of the mining of mineral resource deposits from Dzhida ore region. Its core and basic enterprise was Dzhida tungsten-molybdenum plant, founded in 1934. In 1996 the company closed, but its abandoned buildings (piles of rocks, drain ore waters, tailings warehouse) continued to pose high man-made pressures on the environment. Currently, the industry of the town presented by OOO "Zakamensk", which accounts for more than 50% of industrial output. The main activity is the mining of gold, tungsten, lumbering and processing of timber. The second largest is metallurgical enterprise OOO "Lyteishik" which it manufactures steel cast, iron cast and bronze cast. The annual volume of casting production is 450-500 tons. The company operates stably. OOO "Lyteishik" manufactures products for the branches of gold industry and agriculture.

The Zakamensk town has an infiltration water withdrawal from 8 wells on Modonkul river. It provides a centralized water supply for 78,5% of the population. The rest of the population supplied from single wells, dug wells and opened ponds. The water is unfit for drinking purposes in the mine pits due to the elevated concentrations of heavy metals. The city is in an extremely difficult position to supply the population with quality drinking water. Water supply system is an emergency condition, it needs extension of existing water withdrawals, and the construction of pressurized tank. Specific water consumption per capita was 109.64 m3/year or 300 liters/day.

Table 2-18. The distribution of water withdrawal for urban places in SRB

Unit: mln. м3

Urban settlements in SRB	Water withdrawal			discharge	population in 2009 (Thous.)	Water consumptio n per capita, m^3 / pers
	total	surface	ground water			
Ulan-Ude	67295,2	10	67285,15	44877	347,8	137,45
Gusinoozers k	551162	550730	432	547899	25	89,28
Zakamensk	1436,3	0	1436,3	1300	13,1	109,64
Selenginsk	6290	0	6290	1575	15,8	130,06

States and Impacts

The Dzhida mining company has accumulated more than 40 million tons of waste. They are concentrated in the storage of stale sulfide products and dumping the tailings of molybdenum and tungsten sulfide ores, in waste processing centrals, waste MPC in the off-balance ore and overburden, in the slag repository of Bayangolsky TPC. The total area was occupied by,700 hectares of waste.

Figure 2-54. Removal of man-made sand during heavy rain

Figure 2-55. Wells cerebral water intake. River Modonkul at the time of the flood

Repository final tailings former Pershamaiskaya molybdenum and tungsten Holtosonskoy factories are man-made deposits of sand, which is situated near industrial junctions concentrators and is immediately adjacent to the city of Zakamensk in Dzhida.

Figure 2-56. Final tailings deposits of Dzhida technogenic sands

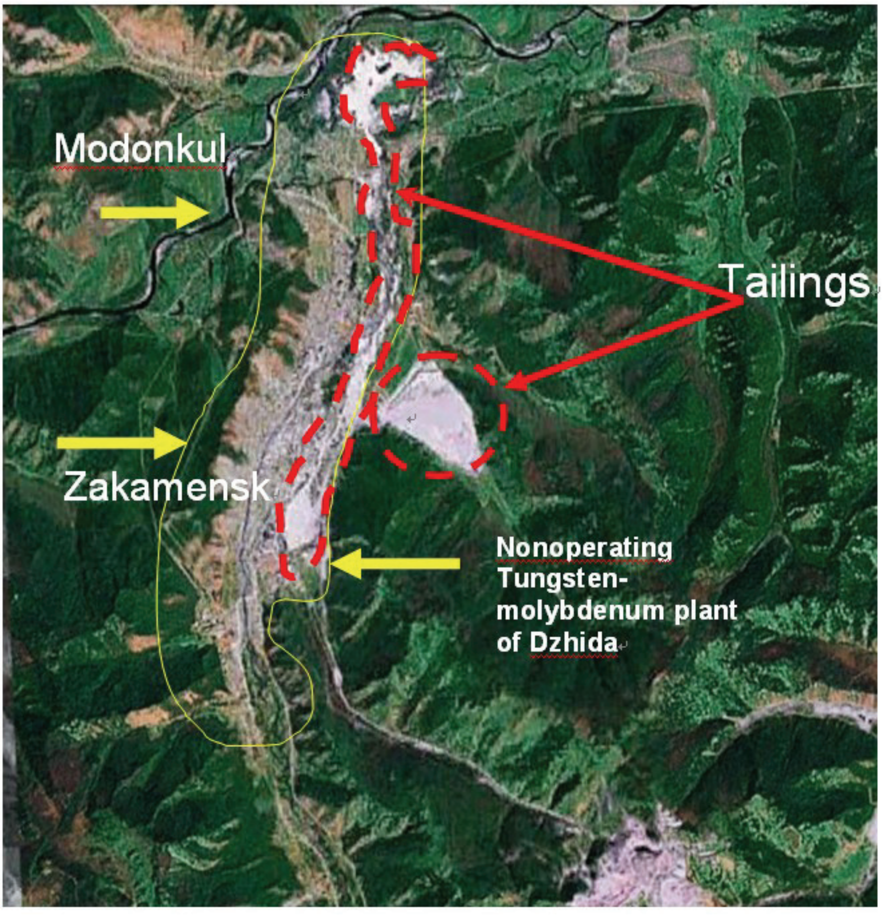


Figure 2-57. Space photo of Zakamensk. Google, 2009

On the surface of the tailings no land is covered. The surface of the tailings was exposed to intense planar and linear erosion, especially with frequent torrential rainfall, as indicated by crumbling, shedding steep slopes of ravines, flush, for liquefied soil

Planar erosion material from the surface of the tailings under the influence of the slope runoff of rainwater and melt water is directed to the channel region. Modonkul in the western and north-westerly direction were in transit across the territory of Zakamensk. The zone of soil pollution environmentally high dangerous elements captures more than half the square of Zakamensk.

Areas of strong and very strong pollution included Dzhida field and Modonkulskoe reservoir.

Pollution of surface water

Zakamensk industrial junction in the southwestern part of the territory of the Republic of Buryatia is currently not covered by the monitoring control, yet within it formed intense man-made pressures in the area previously was developed by the deposit tungsten and molybdenum ores (Dzhida mining company). Sources of pollution are the mine waters of Holtoson (although mine is closed, the discharge of mine water continues without engineering in the district. Modonkul), which accumulated over many years products Mining and other objects have encouraged harmful changes to the components of the natural environment at an alarming scale. The river water is polluted in the high-and extremely dangerous concentrations of aluminum (17 MPC), cadmium (170 MPC), manganese (40 MPC) and other metals; mineralization reaches 1.2 g/dm3, sulfate concentration exceeds 700 mg / dm 3, Fluorine - 6 mg / dm 3, oil - 2 mg / dm 3. The sediments contain heavy and toxic metals in the transcendent concentrations, pollution is apparent in the river valley. Natural hydrocarbon geochemical character of underground water changed to bicarbonate-sulfate and chloride, the concentration of fluoride in them up to 7 mg / dm 3, Fe - 3 mg/dm3.

Dirty water in the river Modonkul, incurable streams, Zun-Naryn and Barun-Naryn.

The complex of pollutants and intensity of surface water pollution of the river Gudzhirka (left tributary of the river. Myrgenshena) in the influence zone of the mine Pervomayskaya were determined by the following indicators: the sulfate ion, sodium ion, lead, fluoride - to 6 MPC (by SanPiN 2.1.4.1074-01), zinc, cobalt, nickel - up to 20 MPC; copper - up to 60 MPC, manganese and cadmium - up to 500 MPC and more. The reaction of water, acidic (pH 4,5-5,4). The main suppliers of pollutants are piles of rocks.

Surface water are in the estuary. Incurable (a tributary river. Modonkul), which is runoff water from the mine tunnels "Western" acidic (pH 5.4) to contain ¬ cobalt, copper, lead at the MPC, cadmium, and chromium - up to 3-5 MPC .

Every year, through engineering centrals CBM HCS PM Zakamensk in river

Modonkul reset 1,7 - 1,9 million m3 of inadequately treated water, which contains about 3000 tons of pollutants. Of the total volume of wastewater constitute 11% of waste water industries.

Pollution of soil and underground water

Abandoned Objects of Dzhida Company are a powerful contaminant soil. Within a radius of 2-3 km from the central content in the soils of lead, zinc, tin, copper, nickel, molybdenum, and cadmium, tungsten, manganese, chromium exceeds the background by 2-3 times.

Accordingly, the underground water in the city Zakamensk are contaminated with iron, fluorine, cadmium, manganese, etc. Their concentration is 10 times that concentration, lead is found at MCL, elevated concentrations of sulfate ions (300-330 mg / dm 3) and calcium ion (100-120 mg / dm 3). Because the tailings are filtered water fluoride concentration of about 20 mg / dm 3, and iron - more than 8 mg / dm 3 containing metals (Cd, Mo, Li, Pb) in amounts 1-5 times concentration, contaminating surface and ground water in the estuary. Modonkul.

Results of sampling the snow cover reflect air pollution, especially of waste processing centrals.

Pollution of the surrounding area continues. The total leakage flux of contaminants from a surface reservoir Dzhida averages about 2300 tons per year per 1 km2. The region has dramatically exacerbated the problem of irreversible chemical changes in the environment with remote and catastrophic consequences.

In 2008, according to statements 2-TP "Vodhoz, dumping mine water without using tunes mine Dzhida" JSC Dzhida Company amounted to 2.75 thousand m3/day.

By using observations GU "Buryat CHMS" Transbaykal UGMS Roshydromet in paragraph observations, the Zakamensk - p. Modonkul (2 alignment) in 2008, reported 9 cases of high pollution of surface waters.

D. Summary

Mongolian Part

Ulaanbaatar: Iindustrial activity & big populated city

Basically, the Central WWTP is functioning with all required regulation with some exceptions of conventional pollution. The water quality problems are occurring due to undeveloped upper stream area and centralized runoff drainage system. All storm waters are flowing directly into the river. As well the agricultural activity located nearly to the city is affecting by conventional pollutants. Along with that, there is noted regular insufficient amount of water for use in summer time. It means that water use is not rational and effective there needed to improve water supply system.

As result shows the conventional pollutions are occurring with high rate at downstream of CWWTP Songino village and near to agricultural areas.

Zaamar: Mining activity

Due to intensification and expansion of mining operation at Zaamar area (small reach of sub-watershed) by many mining operators there is impairing the local environment occurred as irreversible process. Where needed the observance of rules in mining technological procedures for whole period operation. Methods of extraction of deposit minerals and treatment facilities of wastes are outdated and ineffective. In order to mitigate the water quality issues need to conduct the advanced and effective management measures. As well as EIA and land use planning are required.

As result of measurement and analyses shows the heavy metals are occurring with high rate at mining area and downstream the mining area as sequence of its activities. As well as natural (geological) background has additional influence on water quality state.

Erdenet: Mining activity & Industries

Due to prolong intensive mining operation for mine deposit extraction in Erdenet copper mining the degradation of local environment is occurred. The local environment is becoming more sensitive for external pressure. Some issues related to water quality are particularly similar with Zaamar mining are (for instance: outdated and infective technology, failures to comply with rules).

As result of measurement and analyses shows the similar pattern for Zaamar gold mining areas. Water quality state at Zaamar mining area in comparison with Erdenet Copper mining area is showing much high rate of pollution. As gold extraction is the main stimulus for mining operation. As well as natural (geological) background has additional influence on water quality state.

Darkhan: big populated city & various heavy industries.

Darkhan city was found in Soviet time for growing industrial capacity of Mongolia with active cooperation of USSR. The similar situation is occurring in Darkhan city as well as in mentioned above for Ulaanbaatar case. In Darkhan city, there is no problem such as in Ulaanbaatar with water shortage. The result of measurements and analyses shows the conventional pollutions are occurring with high rate at downstream of WWTP and near to agricultural areas.

Russian Part

Zakamensk: Mining activity–not-operated mining area affecting on water quality of Modonkul stream by non-point sources.

Due to stopping operation of Dzhidinski Wo-Mo mining enterprise without sufficient land restoration, the tailing dumps/pits were become the main stressor for local environments such as water, air and land (soil).

For nowadays, there is no any company who is responsible for occurred situation. So it is become as one big problem for taking restoration actions.

During rain storm events the surface runoff is polluting the Modongkul stream much and bringing the distress for local environment (animals, fishes and plants).

As result of measurement and analyses shows clearly the heavy metals are occurring with very high rate at mining area and downstream the mining area as sequence of its influence. As well as natural (geological) background has additional influence on water quality state.

Ulaan-Ude: Iindustrial activity & big populated city

Basically, the WWTP is in good condition with all required norms. The occurrence of water pollution is due to undeveloped upper stream area and weak centralized drainage system. As well many companies and enterprises are not satisfying the requesting of control unit.

The results of measurement and analyses have showed that impact of Ulan-Ude city on water quality condition is not significant. But there have some potential problems especially in season variation (in low flow or high flow periods - flooding events).

Gusinoozerskr: Iindustrial activity & big populated city–near to Goose Lake located "Heat Power" plant (HPP).

Basically, the results of measurements and analyses have showed that impact from Heat Power Plant on water quality condition is not significant, except only for temperature parameter. Due to dumping of "Warm/Hot water" from "Cooling system" of HPP into Goose Lake, the local environment is under continuous anthropogenic pressure and has undergoing changes in ecosystem.

In any event, there needed to maintain the nature-conservative and management measures.

Selenginsk: Iindustrial activity & big populated city–near located "Pulp-and-Paper" plant (PPP).

Selenginski PPP is located very near to Baikal Lake; it was founded in Soviet time as strategical enterprise for supplying of cord fabric products. And it is presenting for Baikal Lake as potential threat in case of accident-related water discharge. Baikal Lake is considered to be sacred lake and unique water body which has very clean water composition with luxuriant biodiversities in world wide.

Actually, the results of measurements and analyses have showed that impact from Selenginsk is not significant because the PPP is using recycled (closed) water supply system. There was noted the diluting process for parameters along the downstream.

In any event, there needed to maintain the nature-conservative and management measures.

3. Water Resource State of SRB

A. Rainfall Characteristics of SRB

The annual precipitation in the upper reaches of the Selenge River Basin in the Khangai, Khentii and Khovsgol mountains is 350-400mm. The precipitation in the area of mountain branches is 300-350mm and the precipitation in the Orkhon, Selenge and Kharaa River valleys is just 250-300 mm (Figure 2-58). Moreover, during the summer season 90% of annual precipitation occurs intensively so that lots of damage is caused by frequent flooding.

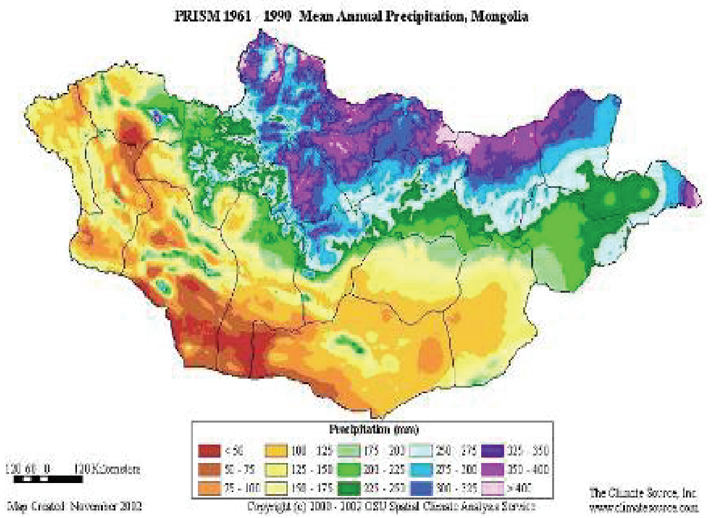


Figure 2-58. Mean annual precipitation, Mongolia

Rivers in the Selenge River Basin experience mudflows and flooding. Snowmelt flows generally occur during spring, but their duration is fairly short (a few days at the end of April and the beginning of May).

B. Surface water Characteristics of SRB

The first comprehensive water resources evaluation was recognized by the National Water Master Plan of 1975 by the Ministry of Water Economy (Design, Survey, and Research Institute of Water Economy with Hungarian assistance and Mongolian institutes). Subsequently, six Regional Water sub plans were prepared between 1978 and 1991 and published by the Institute mentioned above (now the Institute of Geoecology.MAS). The product was awarded the parliament prize for scientific work in the 20th century. The flow records used at that time were the registers of 36 hydrometric stations. In 2006, the evaluation was updated with records from 90 stations. The majority of the stations used in the later exercise have records for 15 and 45 years of observation.

The total water resources are estimated at 38.8 km3 and potentially accessible water resources are estimated at 34.29 km3. Each percentage of the water resouces distribution is as below.

5.8% of the total surface water resources (i.e., 3,600 m^3/year) are in rivers and 2.1% in the base flow. 3.7% is in the direct runoff from rainfall and snow. This is measured by the method of Flow Separation Analysis. Note that the amount of 34,600 m^3/year consists of the river runoff formed within Mongolia (30,600 m^3) and water inflow from Russia and China (4, 000 m^3/year).

C. Ground Water Characteristics of SRB

The groundwater resources of Mongolia were evaluated during the preparation for the National Water Master Plan of 1975 and six regional plans of the subbasins 1990. The evaluation was based on the model developed by Ivanov A. T. To estimate the annual recharge to aquifers, the model used precipitation and geological formations. The country is divided into eight principal hydro geological regions, subdivided into 20 sub-regions and then into about 50 areas.

The recharge estimation was cross-checked, in an iterative process, with the base flow derived from hydrograms analysis. The estimated groundwater potential resource was 6,100m^3/year.

Despite the small amount, surface and ground water resources play vital roles in the country's economy, especially in agriculture, livestock production, industry, and domestic water supply. For example, 31% and 25% of the total population of Mongolia receive water as tap water or as tank distribution, in which mostly 90% come from ground water; 36% directly from ground water wells and 10% from rivers.

Mongolia receives very limited precipitation, with an annual mean value ranging from 50mm to 400mm. In addition 70-90% of the precipitated water evaporates back into the atmosphere.

Groundwater is one of the most important mineral resources of the Selenge River Basin within Mongolia. The hydrogeology of the Selenge River Basin is varied and consists of a combination of alluvial deposits, Cambrian and Precambrian limestone, granite of varying age, sedimentary deposits (including sandstone, siltstone and conglomerate), and metamorphic rocks.

There are a wide variety of deposits and hard rocks distributed throughout the basin of the Selenge River which contain groundwater. Conversely, there are zones in the basin where groundwater is not present, and these include some loamy areas, hard rock plate areas, and steep, rocky mountain slopes, as well as some permafrost areas. Unconfined groundwater is generally present in zones near hard rock outcrops at the ground surface or at depths of approximately 10m below the surface. Conversely, confined groundwater is generally distributed along inter-mountain depressions.

Alluvial aquifers tend to contain groundwater at the shallowest depths. The ease of access to these resources, coupled with their often high quality, means they are widely used as sources for urban and industrial centers and for agricultural purposes.

For the major cities of Ulaanbaatar, Erdenet, Darkhan, Murun, Sukhbaatar, Tsetserleg, and Zuunkharaa the main water sources are the alluvial deposits along river basins. The depth to the groundwater table, although largely undetermined in many regions, commonly ranges from 0-2m along the major drainage lines (rivers, streams etc) to greater than 20m. The depth of groundwater generally increases with increasing distance from the major drainage lines.

D. Dam Development Plan for Mongolia

In the Mongolian Water innovation government program which was elaborated and adopted in 2004 and National program on Water 2009, there are issues included which refer to the need to make equal surface and ground water utilization. The utilization of water storage by the method of water regulation is embedded in the Water National program, Water program and policy acts of ministries. The issue has been discussed in the previous studies of researchers. In 1960, the Institute of Hydroproject of the Russia elaborated on the technical and economic feasibility study to build 7 sites in the Selenge and Eg River, 8 sites in the Orkhon River, 1 in the Tuul River and 4 in the Yeroo River as part of a complex system of multipurpose dams. Matveev. E.S and Damba. E recommended that 11 sites could be built in the Selenge River Basin for hydro constructions. By "Mongolian hydropower energy" project, Institute of Water Policy, 1994, was recommended 64 sites for hydropower plants including a station for Eg river, and 4 stations for Selenge River. Recently, Eg river Urumgut site's hydropower plant was designed by foreign companies and has planned capacity of 220 MW.

The second biggest river in the SRB is Orkhon and has many sites for dam, 3 of them along the Orkhon river are Kharkhorin, Khishigundur and Orkhon Ulaan Khunkh, which more important, on one of the sites conducting some researches recently(Table 2-19).

A project with 100MW installed capacity, in the Orkhon River (site Ulaan Khunkh) was developed in 1991 by Chubu Electric power Co., Ltd. JETRO, Japan. The project has been delayed because of difficulties in financing.

The Khishigundur dam site is situated 300 km west of the capital UlaanBaatar and 30 km South-West of the provincial capital of Bulgan Aimag. The site (Figure-555, photo-555) elevation is approximately 1105 m. The height of the dam has been foreseen as 60-70 m during the preliminary studies (Institute of Water Economy,1986) for reference list "Subregional schema for the complex utilization and Conservation of Water resources in the r. Selenge" 1986, I tom, Prestige engineering 2006). The total capacity of the reservoir will exceed 600 million m3. The system would include a 20 MW hydro-electric power plant and would pump 2500l/sec from reservoir through a 740 km pipeline to Gobi region and the site is more important for Gobi region mining industry water supply, development a fruit farming and 2000 ha irrigated area for cereals.

Figure 2-59. Main Dam site, Orkhon River

Figure 2-60. Khishigundur multipurpose Dam site, r. Orkhon

Table 2-19. Sites information of Ulaan khunkh dam site, Khishig-undor Dam site, and Kharkhorin dam site

Specification	Ulaan khunkh dam site	Khishig-undor Dam site	Kharkhorin dam site
Location	104026′00″ 48044′00″	103018′00″ 48033′00″	103018′00″ 48033′00″
Water source	Orkhon r.	Orkhon r.	Orkhon r.
Height of dam , m	90	70	40
Irrigation area, ha	-	28000.0	10,000.0

The study on the development of irrigation and pasture land in the Selenge river basin by IGMAS (2008) reported that the irrigation field could be expended up to 33,093.6ha by developing an irrigation system in the Selenge river basin,

Figure 2-61. Irrigational facility in Selenge river basin

Selenge River could irrigate 31,798ha of agricultural field in the Bulgan, Selenge, and Khovsgol aimags (Figure 2-62) with 10 soums, and Selenge River could add irrigation field of 5,150ha and in total 36,948ha by constructing new reservoir.

According to the hydrologic study, of irrigation water could be extracted from up-stream (staring point) 0.15%, 0.4% from middle stream, and 0.32% of mean annual flow from down stream, which does not affect the in-stream flow for aqua-ecosystem in Selenge River.

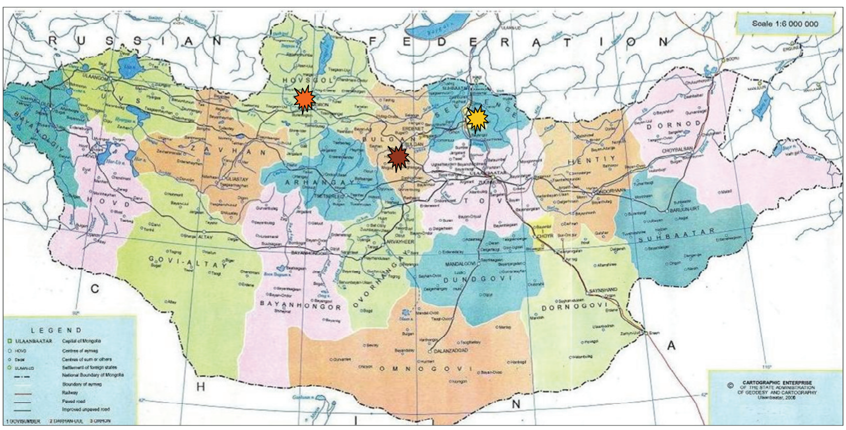


Figure 2-62. Administration map of Mongolia

The development of the irrigational reservoir calls for an investment of enormous sum of money, hence it is recommended to build multi-purpose dam which can be used for hydro-power generation, tourism, water sport, in-reservoir farming, flood control, and irrigational purposes.

Table 2-20. Specification of potential dam reservoir development

Specification	Shuren	Khyalganat	Urumgut
Loaction	104^0 57′ 20′′~ 49^0 44′ 10′′	1040 18′ 21′′ ~ 490 28′ 40′′	1030 37′ 35′′ ~ 490 24′ 13′′
Water sources	Selenge river	Selenge river	Eg river

Specification	Shuren	Khyalganat	Urumgut
Reservoir type	rock, earth	rock, earth	rock, earth
Height, m	44	32	15
Length, m	1,710	1,400	560
Surface area, km²	89	12.5	53
Storage volume, 1,000 m³	1,192,600	1,209,500	1,868,780
Storage time to full water level, day	173	15	245
Irrigation area, ha	2,550	5,831	3,980

Shuren

The Shuren reservoir could supply irrigation water of 2,550ha area including the paddy field in both sides of Tsuuts, and Shar manhaltai River. The irrigation field consists of a paddy field in southeast of Uvgun Sant mountaion (350ha), Shingenet agricultural area of Bayan nuga (200ha), and 2000ha in Orgikh basin. The Shuren dam was planned by the Soviet Union but it was not executed.

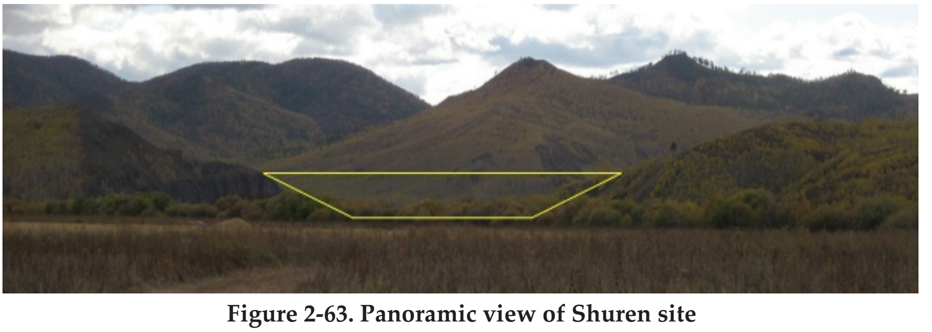


Figure 2-63. Panoramic view of Shuren site

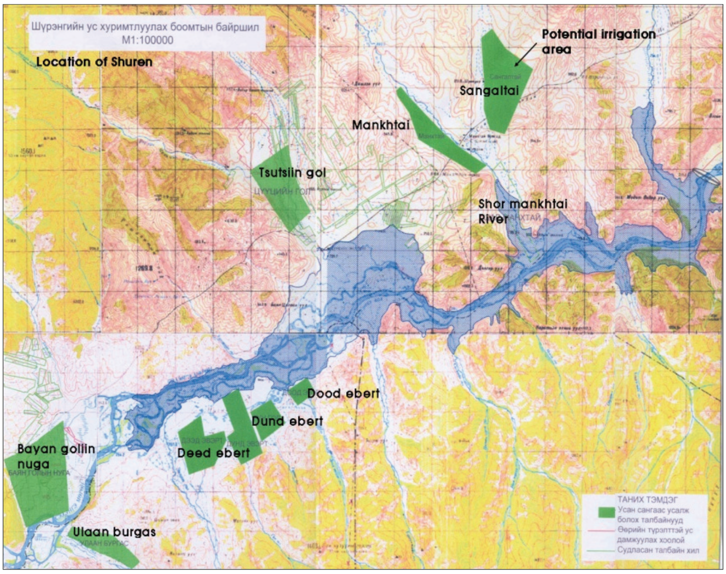


Figure 2-64. Location of Shuren site and potential irrigation area

Khyalganat

The potential dam construction area of Khyalganat is located at the western part of the bridge which connects Zuunburen and Tsagaan nuur sum to Selenge Aimag. This reservoir could irrigate the area of 1800ha in Shar tal, grassland in Khyalganat, and the Tsulkhar area.

Figure 2-65. Upstream view of Khyalganat site

Figure 2-66. Downstream view of Khyalganat site

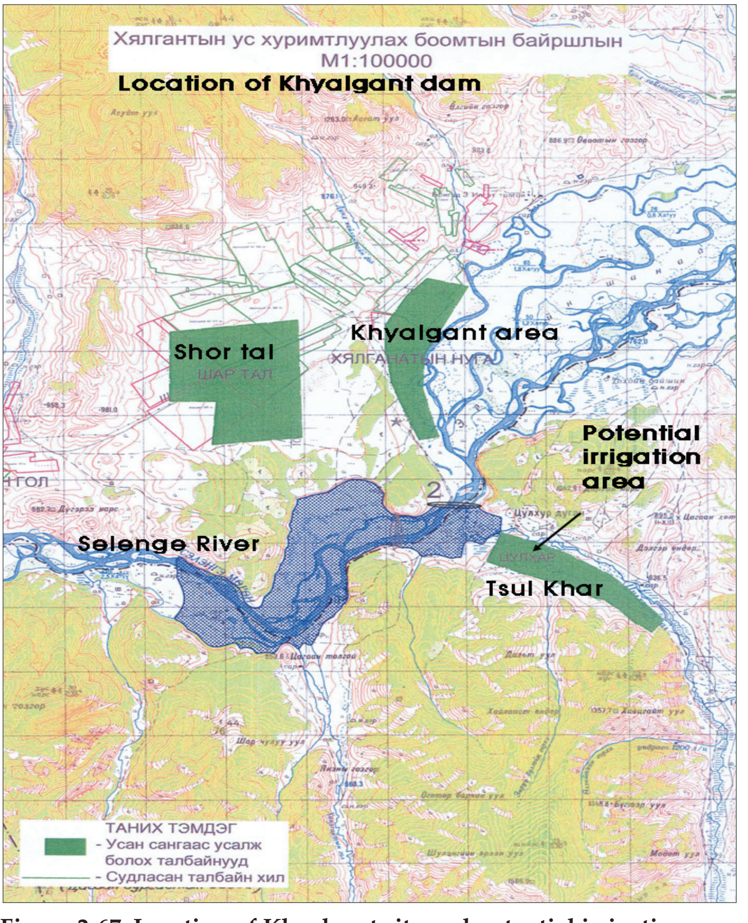


Figure 2-67. Location of Khyalgant site and potential irrigation area

Urumgut

The potential irrigation and powerstation Dam, reservoir of Urumgut is located at Eg river which is fed stable water from Khovsgol Lake. The Eg reservoir could supply water to western part 800ha by pumping which covers in Khujir, Tsagaan tokhoi area.

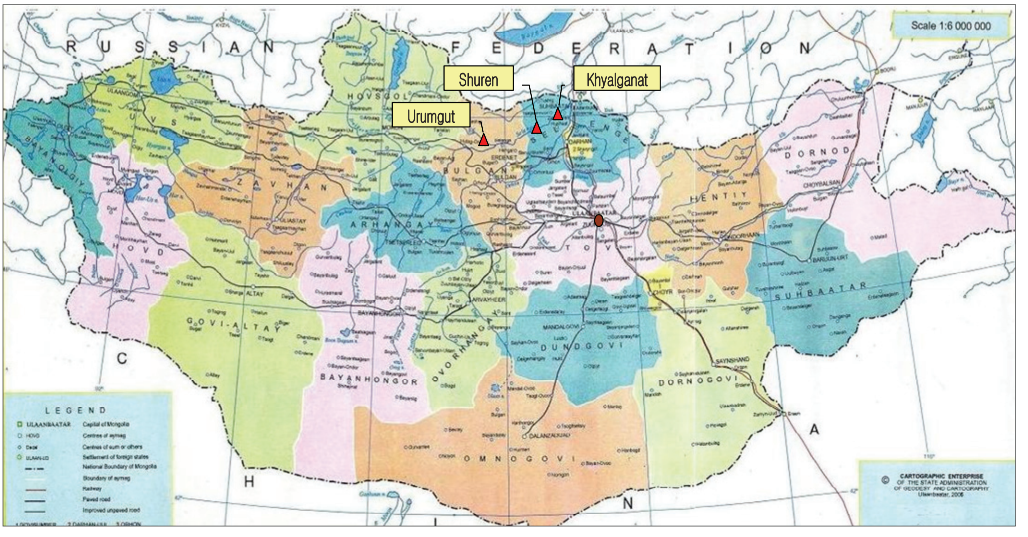


Figure 2-68. Location of potential dam reservoir construction sites

Table 2-21. Irrigation area in Selenge river basin

Unit: ha

Aimag	Sum	Region	Area	farmland, ha				
				potato	vegetable	feed grains	fruit	grain
Selenge	Zuun buren	1.Bongiin tohoi	3000	26.70	20.80	388.45	3.50	3492.55
		2. Sumiin bulan	500					
		3. Orkhon in Selenge	300					
		4. Mogoi zuu	132					
	Tsagaan nuur	5. Tiireg	6000	15.40	12.00	685.16	6.17	6160.27
		6. Sogooch	500					
		7. Jargalant	379					

Aimag	Sum	Region	Area	farmland, ha				
				potato	vegetable	feed grains	fruit	grain
Sub total			10811	42.10	32.80	1073.61	9.66	9652.83
Khovsgol	Rashaant	8. Khyalganat	500	40.10	31.30	72.86	0.66	655.83
		9. Ar teel	300					
	Tarialan	10. Nogoon tokhoi	400	22.90	17.90	95.92	0.86	862.42
		11. Erkhuud	600					
	Toson tsengel	12. Teeliin am	144	26.10	20.40	9.75	0.09	87.66
Sub total			1944	89.10	69.60	178.53	1.61	1605.16
Bulgan	Bayan agt	13. Khavtsgait	2560	19.40	15.20	252.54	2.27	2270.59
	Bugat	14. Maanit	600	13.00	10.20	82.68	0.74	743.59
		15. Bugat	250					
	Selenge	16. Khujirt	300	29.30	22.80	818.09	7.36	7355.45
		17. Khar ereg	340					
		18. Alag morit	500					
		19.Tsagaan tokhoi	500					
		20.Inget tal	3200					
		21. Inget goliin adag	270					
		22. Kharlag	400					
		23. Khartsain gol	300					
		24. Tariakhtiin zuun bulag	500					
		25. Shar tal	600					
		26. Khyalganatiin nuga	250					
		27. Bayan goliin nuga	600					
		28. Shar khundii	123					
		29. Shar mankhtai	350					
	Khatgal	30. Gun gol	200	28.00	21.80	175.02	1.58	1573.60
		31. upper Evert	300					
		32. middle Evert	400					
		33. Ulaan burgas	300					
		34. Tsagaan tavilan	100					

Aimag	Sum	Region	Area	farmland, ha				
				potato	vegetable	feed grains	fruit	grain
		35. Irgeliin ar khushuut	500					
	Khutag undur	36. end of Teel river	2500	22.10	17.30	556.06	5.00	4999.54
		37. inner part of Namnan	1500					
		38. side of Khangai	600					
		39. Dalkhiin tokhoi	200					
		40. Ikh tulbur	800					
Sub total			19043	111.80	87.30	1884.39	16.96	169442.55
Total			31798					

Table 2-22. Irrigation water usage in Selenge river basin

Aimag		Kinds of cultivation					annual cultivation area, ha	annual water use, m^3
		potato	vegetable	feed grains	fruit	grain		
		mean irrigation volume, m^3/ha						
		3000	3200	2900	6000	2500		
		cultivation area, ha						
Khovsgol	1. Rashaant	40.10	31.30	72.86	0.66	655.08	800	2,073,414
	2. Tarialan	22.90	17.90	95.92	0.86	862.42	1000	2,565,358
	3. Toson tsengel	26.10	20.40	9.75	0.09	87.66	144	391,545
Sub total		upstream of Selenge river						5,030,317
Bulgan	4. Bayan agt	19.40	15.20	252.54	2.27	2270.59	2560	6,529,301
	5. Bugat	13.00	10.20	82.68	0.74	743.38	850	2,174,302
	6. Selenge	29.30	22.80	818.09	7.36	7355.45	8233	20,966,106
	7. Khangal	28.00	21.80	175.02	1.58	1573.60	1800	4,604,798
	8. Khutag undur	22.10	17.30	556.06	5.00	4999.54	5600	14,263,084
Sub total		middle stream of Selenge river						48,537,591
Selenge	9. Zuun buren	26.70	20.80	388.45	3.50	3492.55	3932	10,025,540
	10. Tsagaan nuur	15.40	12.00	685.16	6.17	6160.27	6879	17,509,259
Sub total		downstream of Selenge river						27,534,899
Total water use								81102807

E. Selenge River Networking

Mongolia Part

The SRB in the Mongolian part has a good river network compared to other regions in Mongolia. The main tributaries are the Orkhon, Tuul, Kharaa and Eroo Rivers. The average density of the river network in the SRB is 0.15 km/ km2. The Selenge River was formed and named by the confluence of the Ider-Chuluut and Delgermurun rivers.

The Ider River originated from southeast of the highest peak of the Khangai Mountain range. Within the Selenge River's watershed area of 425,245 km2, 282,050 km2 (Hydrometric control section near Sukhbaatar), or 66% of the catchment area is located in Mongolia. It runs 534 km before crossing the Mongolian border. The main tributaries are the Orkhon, Khanui, and Eg (refer Figure 2-69).

The largest tributary is the Orkhon River, which is Mongolia's longest river. Its total length is 922 km and its catchment area is 133,000 Km2, which represents about 47% of the Selenge's catchment area. The width of the river is between 50 and 150m. Its depth is up to 5m, with part of the chute between 1 and 1.5m. The velocity is 2.0-2.5 m/s and parts with a shallow depth are 0.5m and 1m/s.

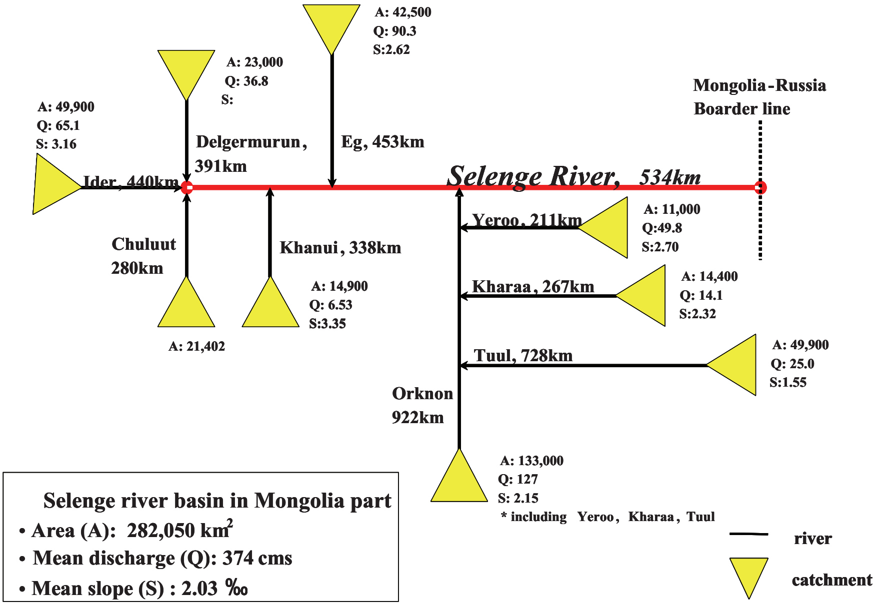


Figure 2-69. Schematic schema of Selenge River Watershed on Mongolia with major tributaries

The Selenge River Basin occupies 20% of the total land territory of Mongolia; hence it is a nationally significant region in terms of both natural ecology and economic productivity.

The water regime of the Selenge River Basin consists of mud flows, snow melts, and floods (refer Table 2-23). As rain feeds the Selenge River Basin, so the water level is more vacillate. Snowmelt flows generally occur during spring but their duration is fairly short (a few days at the end of April and the beginning of May).

Analysis of average monthly discharges indicate that about 50-70% of total annual discharge is concentrated in three months during the summer, and 20% is recorded in the spring. Hydrological results along the Selenge River in July 2007, show low precipitation and water.

Table 2-23. Hydrological characteristics of major tributaries of the SRB

River	**Catchment area**(Km2)	**Length** (km)	**Discharge cms** (appr.)	**Mean slope** (%)
Selenge**	282,349	534	374.0	2.03
Khanui	14,900	338	6.53	3.35
Eg	42,500	453	90.3	1.62
Chuluut	21,402	280	N/A	1.27
Orkhon	133,000	922	141.0	2.15
Tuul*	49,900	728	20.1	1.55
Kharaa*	14,400	267	14.1	2.32
Yeruu*	11,000	211	49.8	2.70

Note: * - The hydrological characteristics of Kharaa, Yeruu and Tuul rivers included in Orkhon River basin.

**- Hydrological characteristics of Zelter, Tsoh rivers not included

Table 2-24. Flow regime of the SRB

Unit: %

No.	River-Station	Average portion of flow regime		
		Ground water	Snow melt water	Rain water
1	Ider-Ider soum	20	25	55
2	Ider-Zurh(mountain)	30	25	45
3	Orkhon -Kharkhorin	37	16	47
4	Orkhon- Orkhon	39	11	50
5	Orkhon- Sukhbaatar	36	18	46
9	Delgermurun-Murun	30	17	53
10	Eg- Khantai	29	10	61
11	Terelj- Terelj	37	8	55
12	Kharaa-Baruunkharaa	43	15	42
13	Yeroo -Yeroo	43	15	42
14	Tuul- Ulaanbaatar	22.3	8.1	69.6

Note: * - Rivers originating from the Khangai Mountain: 1,2,3,4,5

- Rivers originating from the Khuvsugul Mountain: 9,10

Russia Part

There are more than 17,000 rivers in the Russian part of the Selenge River Basin. Their total length is about 70,000 km. Main tributaries include the Dzhida, Chikoi, Khilok, Uda, and Itantsa Rivers. The total watershed area of the entire Basin is 151,130 km2, with the Russian area taking up 134,130 km2, or 90% of the Selenge River Basin. The total average long-term water supply is 17.38 km3, which accounts for 58% of the Selenge River flow or 93% of the river flow formed in the Russian territory.

The average density of the river network is 0.47 km/ km2 .The highest density is 0.8–1 km/ Km2 (the upper flow of the Chikoi) and the lowest (0.1 km/ km2) is found in the area between the Chikoi and Khilok rivers. The density of the river network becomes higher depending on the altitude of the locality; the only exception is the Dzhida River basin, where the density coefficient increases at an altitude of 1,300-1,400 m. The higher the river, the lower its density. Rivers with a length less than 100 km accounts for 99% of the total number of rivers.

Information regarding the quantity and the total length of the rivers based on their gradation are given in Table 2-24. The main hydrographic parameters are given in Table 2-25.

Table 2-25. Quantity and length of water flows

Gradation of water flows	Length of Rivers	Number of units	%	Total length of Rivers , km	%
The smallest	<10	15,959	93	36,474	53
	10–25	1,018	6	15,748	23
Small	26–50	229	1	7,767	11
	51–100	47	0	3,268	5
Medium-size	101–200	12	0	1,660	2
	201–300	3	0	494	1
	301–500	3	0	973	1
Big	501-1,000	3	0	2,176	3
	>1,000	1	0	409	1
Sum total		17,275	100	68,969	100

source: Information bulletin, 2006

Table 2-26. Hydrographic characteristics of SRB in Buryatia

No	Rivers	Flows into	Distance from the outlet, km	Which bank of the river	Length of the river, km	Water-catchment area ㎢
1	Selenge	Lake Baikal	—	—	1024 409	447060 148060
2	Kyahtinka	Not clear	—	—	—	— 100
3	Dzhida	River Selenge	346	left	567	23500 18580
4	Tsakirka	River Dzhida	438	left	102	1250

No	Rivers	Flows into	Distance from the outlet, km	Which bank of the river	Length of the river, km	Water-catchment area ㎢
5	Modonkul	River Dzhida	383	right	38	175
6	Hamnei	River Dzhida	328	left	118	3360
7	Darhintui	River Hamnei	28	right	103	1050
8	Zheltura (Atszargain-gol,Tselteriin)	River Dzhida	158	right	202 15	5320 400
9	Temnik	Selenge	310	left	314	5480
10	Chikoi	Selenge	285	right	769	46200 34600
11	Chikokon	Chikoi	646	left	131	2110
12	Zhergei	Chikoi	594	right	87	1310
13	Asa (Atsa)	Chikoi	469	left	85	2150
14	Dolentui	Chikoi	398	right	18	57.7
15	Gremyachka	Chikoi	385	right	16	77.1
16	Menza (Minchzhi)	Chikoi	357	left	337 192	13800 7770
17	Burkal	Menza	83	right	128	2260
18	Khatantsa	Chikoi	267	left	94 63	3330 2320
19	Urluk	Chikoi	249	left	54	
20	Khilkhotoi	Khatantsa	7	right	90	1150
21	Khudara	Chikoi	155	right	83	1130
22	Khiran	Chikoi	114	left	67 20	— 1130
23	Khilok	Selenge	242	right	840	38500
24	Khila(Khola)	Khilok	711	right	73	1600
25	Bludnaya	Khilok	542	left	164	4480
26	Tarbagatai	Khilok	354	right	16	63,8
27	Balyaga	Khilok	340	right	74	1400
28	Ungo	Khilok	268	left	189	2320
29	Alentui	Khilok	258	right	15	59,0
30	Maleta	Khilok	250	left	67	774
31	Sokhotoi	Khilok	244	left	48	638
32	Bui	Khilok	190	right	98	4640
33	Bichura	Khilok	144	right	160	2770
34	Sukhara	Khilok	38	left	70	1950
35	Tugnuika)	Sukhara	7	left	42	454
36	Orongoi	Selenge	216	N/A	N/A	N/A
37	Gilbiri	Orongoi	20	N/A	N/A	N/A
38	Ubukun	Orongoi	20	right	94	865
39	Kuitunka	Selenge	208	right	65	1140
40	Ivolga	Selenge	165	left	40	730
41	Uda	Selenge	156	right	467	34800

No	Rivers	Flows into	Distance from the outlet, km	Which bank of the river	Length of the river, km	Water-catchment area ㎢
42	Ona	Uda	206	right	173	3700
43	Khudun	Uda	200	left	252	7820
44	Khizhingz	Khuddun	50	left	146	2170
45	Kurba (bigger one)	Uda	84	right	227	5530
46	Bryanka	Uda	48	left	128	4470
47	Ilka	Bryanka	44	right	118	2490
48	Itantsa	Selenge	119	right	85	2650
49	Angir	Itantsa	31	left	56	815
50	Bolshaya	Selenge	107	right	32	254
51	Talovka	Selenge	88	left	16	103
52	Viluika	Selenge	65	left	34	271
53	Kabanya	Selenge	54	left	46	369

source: Baikalvodresursy, 2002

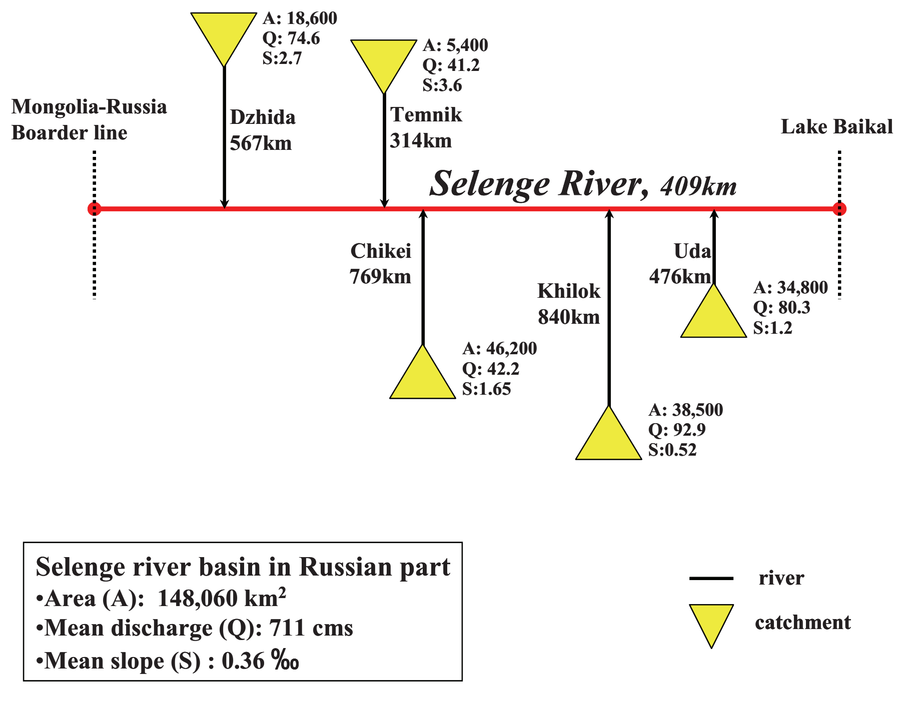


Figure 2-70. Schematic schema of Selenge River Watershed on the Russia side with major tributaries

F. Flooding on the Selenge River and their consequences

Maintenance and safety of an inhitant is a priority for the State. At the World conference on natural accidents, in May 1994 in the city of Iokogama (Japan), accepted the declaration in which is defined, that the struggle for reduction in damages from the natural accidents, based on forecasting and prevention should become an important point of new State strategy of all countries in sustainable development achievement.

The territory of the Selenge river basin (Republic of Buryatia) is characterized by wide development and display of some adverse and dangerous natural processes such as: flooding, earthquakes, forest fires, mud streams, ravine and river erosion, accumulation of deposits, flooding, bogging, icings, stone falls, collapses, avalanches, etc.

Flooding on repeatability, the areas of distribution, influence sizes are one of the most dangerous kinds of act of nature representing threat of ability to live and suffering the big economic damage to the Republic of Buryatia. According to statistics in the XX century it was registered a number (6) of catastrophic flooding (above 400 cm): 1908 - 408 cm, 1932 - 450 cm, 1936 - 464 cm, 1940 - 416 cm, 1971 - 410 cm, 1973 - 437 cm, and also a series of high (above 300 cm): 1927, 1938, 1942, 1962, 90th years (h. p. Selenge - Ulan-Ude). The sizes of the damages put to the Republic are enormous: in 1971 have made about 1, 4 billion rubles, in 1973 - 0,7 billion rubles., 1993 - 40 billion rubles (prices of the period of flooding passages).

During 1990-1998 repeatability of flooding has reached 70 %. The greatest damage has been noted in 1993, at which six areas of the Republic and city of Ulan-Ude have suffered, all part of the city on the left coast cities were flooded. More than 9000 summer residences, 8250 houses, 36 thousand hectares of agricultural lands, 60 farms, 250 km of roads, 58 bridges, 1800 km of communication lines, 2800 km of electric mains were in a flooding zone.

Thus, the historical review of archival and literary materials testifies, that on the territory of the Selenge river basin periodic flooding are marked. Small flooding was marked on this or that river almost annually. For 100 years four periods are traced: 1902-1908, 1932-1942, 1971-1973, 1990-1998 years, in these years the series of the highest flooding is observed. Duration of the given periods varies from 2-4 till 10-12 years in which some (2-3) big and outstanding flooding by periodicity 1-4 years are registered. Repeatability of the highest flooding averages 20-30 years.

Studying on water leves during flooding in the Selenge river basin was spent on the basis of the substantial analysis of the collected information and share materials long-term (1936-2008) supervisions on the 17 hydrological posts (h. p.).

The basic natural factors predetermining occurrence of flooding on the Selenge river are climatic features and territory relief: cyclonic activity of the second half of summer, caused loss of rains of incessant or storm (more than 3 mm/min) character; a considerable quantity of the snow deposits accumulated in mountains (100 cm and more) during the winter period; the considerable partition of territory with a difference of heights (to 900m) of watersheds and the bottoms of the hollows, defining the big biases of the rivers and high speed of a current, and also an arrangement upper parts of the rivers and their mountain inflows in the zone of a long-term frozen, which weakens filtration ability of grounds and strengthens speed of lifting water level. In 1971 the maximum intensity of lifting of a water level on the Dzhida river in its top-average current (h. p. Khamnei) was 4, 57 m/day and in bottom current - 2, 79 m/day (h. p. Dzhida).

Besides it is noticed, that historically developed tendency of development of territory and moving near the rivers, where the majority of haymaking and pastures, arable lands, settlements and also the part of the city of Ulan-Ude is on inundated sites potentially dangerous to flooding.

The reasons of occurrence of flooding can be connected with passage of very big expense of water in the period of spring-and-summer high water and summer rain high waters are caused by the big resistance of water in the channel at jams, icings, and by the geophysical reasons.

The repeated analysis on genesis confirms, that for the Selenge river basin flooding are characteristic (a water exit on inundated site), caused freshet, high-water-freshet, jams phenomena, that is shown on the fig. 2-66. Freshet flooding (60-90 %) prevails and insignificant (5-10 %) – high-water-freshet. The Uda River is an exception, in which flooding of the mixed drain makes 31 %.

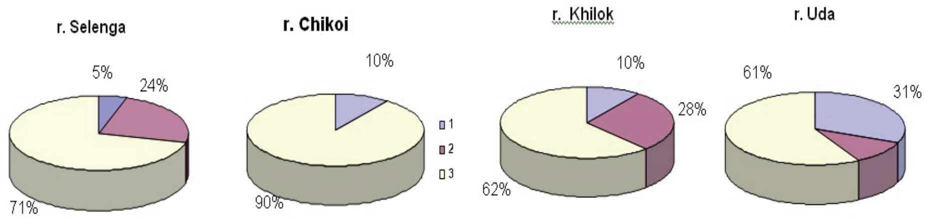


Figure 2-71. A share of flooding kinds on the rivers of the Selenge river basin
1) high-water-freshet 2) jams 3) freshet

It is necessary to highlight, that the highest and most catastrophic is the freshet flooding, sustaining enormous social and economic losses; flooding of the mixed drain are usually local for the separate rivers and seldom lead to considerable negative consequences for all basin. On the separate sites of the rivers clips, narrowings of rivers channels of natural and anthropogenous character periodically cause local jams flooding: Khilok (28 %), Selenge (0,24) and are the extremely rare jams. For example we will note flooding as a result of a powerful jam on the Selenge river at roadway travel the Mostovoi in 1974, where the water level made 614 cm (exit height on flood land is 74 cm), similar situations were noted in 1968 and 1977 years. In 1993 the opening of the Khilok river was accompanied by formation of ice jams and flooding of settlements, in which the water level registered to a mark of 280 cm.

Main danger parameters of flooding are their frequency of display, intensity and the distribution area.

Frequency of display or repeatability H (critical) (cases in a year) was defined as the relation of number of years with flooding to number of years of the considered period. Consideration of the calculated parameters testifies, that high repeatability 0,8-0,9 (a water exit on flood land) is characteristic for separate hydrological posts, on the average for basin makes 0,44 (0,2-0,9). The highest flooding with considerable flooding of economy objects and of some the settlements, located on flood lands, happen with frequency 0,05-0,12 and average-small, at which mainly agricultural lands and separate settlements - 0,15-0,34 are exposed.

Compared to the frequency of flooding display on the rivers of the basin, the greatest number is marked on the Dzhida river, the Chikoi river, directly on the Selenge river. In the middle current of Selenge the given parameters reach 0,8-0,9, and (of Ulan-Ude) decrease by almost in 2 times - 0,5 and in delta - only 0,1. Also it is high on the Dzhida river: in the middle current makes 0,9 and in lower decrease to 0,7. On the Uda river their frequency a little bit low - 0,2-0,44, however high flooding in its lower current occur more often (0,19), but are local for the river. Repeated flooding on the Chikoi river makes 0,5-0,6 and is more rare on the Hilok river - 0,2-0,3.

Intensity or size of flooding is very individual and is defined by hydrological conditions and valley morphology as a difference of the maximum lifting of a water level over level critical, i.e. a water exit on flood land. Data of calculations show, that the maximum values of water levels in the rivers of basin most typical for the period of summer high waters and excess over H (critical) makes from 30 to 437см. Exclusive lifting, height of water on flood land more than 200 cm, are characteristic for next h. p. Dzhida - Khamnei - 437 cm, Dzhida-Dzhida - 295 cm, Selenge-Novoselenginsk - 419 cm, Selenge-Ust-Kyakhta - 198 cm, Selenge-Ulan-Ude - 207 cm, Chikoi-Povorot - 267 cm, Uda-Ulan-Ude - 266 cm.

The comparative analysis of flooding size in dynamics of years on the rivers basin testifies to their essential distinctions on the separate sites. So, in the middle current of the Selenge river their height can reach more than 300-400см, in the lower current (h. p. Ulan-Ude) nearby 200см and in delta only reaches 30-40см. On the Uda river the development of flooding occurs a little differently. In the middle current level lifting over H (critical.) are rather insignificant: maximum 62см (h. p. Udinsk, 1991year.) and 127см (h. p. Pervomaevka, 1985year) and in the lower current (h. p. Ulan-Ude) can exceed 200см (266см, 1991year). In comparison to the rivers of the basin, the outstanding height of flooding is marked on the Dzhida river. So in 1973 year the level excess over H (кр.) has made 437см (h. p. Khamnei) and 295см (h. p. Dzhida). However for 70 years this unique flooding of such force, on the average the given indicator varies from 200 to 300см. In the lower current of Chikoi the maximum height of water in flood land in most cases does not exceed 200см and only on a site of its merge to

Selenge, where there is a valley narrowing, it can reach up to 267см (h. p. Povorot), on the average height of flooding - to 120-150см. On the Khilok river high lifting of level is less essential, excess over H (critical) to 155см and on the average to 100см. So, as a whole, on basin during catastrophic flooding height of water in flood land varies from 30-100см to 400см and above, middle-small - from 20 to 200см.

On the presented diagrams of dynamics of the water level, executed on the representative posts of the rivers of Selenge basin, usually reflect the repeatability and size of flooding are visually reflected (Figure 2-67).

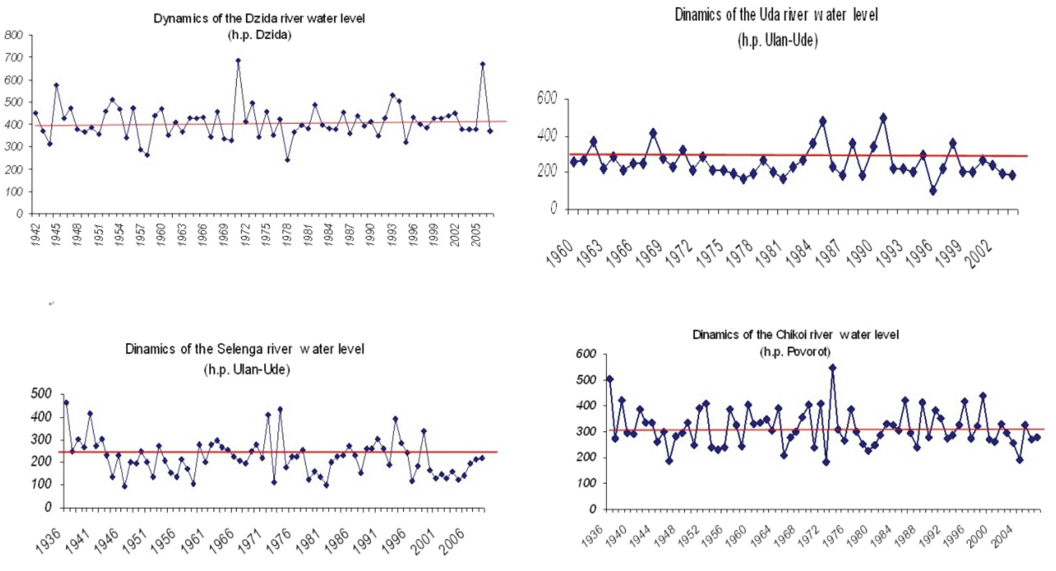


Figure 2-72. Dynamics of water level on the basic rivers of SRB - critical level of water exit in flood land

The areas of flooding

Revealing of probable borders of flooding is carried out on the basis of the calculated indicator of size of flooding on a topographical basis of scale 1:100000 by a remote sensing method, definition of the areas by means of GIS technologies in the program Arc GIS. At catastrophic flooding with a total area of possible zones of defeat reaches 3122, 6 км2, in which 236, 3 thousand hectares of the territory are agricultural lands, that makes 3, 4 % of territory of basin and 9,5 % of the area of agricultural land. More than 100 settlements, including the city of Ulan-Ude, are located in dangerous zones or adjacent to the threat of partial flooding but some protected by dams. Certainly, the value of the given indicator directly depends on flood land development, which is individual for each river and is various on all its extent. As a whole, for the rivers of basin the flood land in the upper reaches is insignificant, only in the middle and the lower current is rather developed, in places of mountain ridges crossing - minimum. The areas of the greatest possible flooding on the rivers of the basin make: directly on the Selenge river - 1332,6,3 км2, from which 625,1 км2 delta territory, on the Uda river - 739,1км2, on the Dzhida river- 330,5км2, on the Chikoi river- 468,3км2, on the Khilok river - 252,1км2.

Figure 2-70 shows the area of flooding on the rivers are presented: territories of the rivers directly of Selenge and Uda which exposed the most and make 69 % of the area of flooding of the basin, if to consider, that on the territory are considered only the lower current of the rivers Chikoi and Khilok, the flooding share on the Chikoi river is considerable - 15 % and a little bit less on the river Khilok.

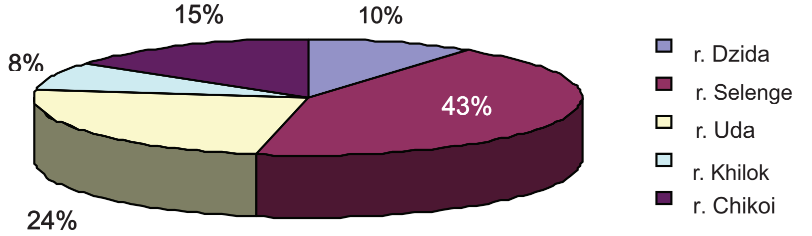


Figure 2-73. Share of flooding area on the rivers of Selenge basin

Thus, in the formation of high flooding on the Selenge river the defining influence have the Selenge river (upper reaches) and the Orkhon - on the territory of Mongolia, and also owing to essential carrying in waters by its basic inflows: Dzhida, Chikoi, more rare Temnik, Khilok; on the river Dzhida- the Khamnei river; on the Chikoi river- the Khuderiin-Gol river. Strong flooding on the Uda river basically occurs in its middle and lower current because of the Kurba, Kodun, rare Ona rivers, which are practically commensurable with it on water quantity.

The interfaced analysis of indicators of danger testifies to unequal course of flooding on the separate rivers, and also on their sites. It proves by significant, often repeating flooding in the middle-lower current of the Selenge river, the Dzhida river, in the lower current- the Chikoi river, the Uda river, however the most large-scale - in the Selenge river delta and in the middle current of the Uda river, where layer height on flood land is only 20-50см.

Objectively, the size of flooding assumes various variants of their passage with certain consequences. Thereupon, the ranging of territory with characteristic for them danger indicators was spent. For allocated sites are developed prognosis (I, II, III) scenarios of flooding development, there are defined: repeatability, areas of flooding of territory and agricultural grounds. The offered variants of scenarios form objective information base of the further estimated operations at definition of possible losses.

Chapter Ⅲ. Domestic Integrated Water Management Model on SRB

1. Introduction IWRM

A. Background of IWRM

Integrated Water Resources Management

During the last decades, there has been a continuous call for more integrated managementof rivers, lakes and groundwater, interrelating different social, economical and environmental aspects of water issues. People often refer to the idea of an integrated approach of water management as “integrated water management”, “integrated water resources management” or “integrated river basin management”. Thus, today it is generally accepted that water management should be “integrated”.

General idea on integrated management emerged from the Dublin principles, agreed at the International Conference on Water and the Environment (ICWE) in Dublin 1992 and the Agenda 21 chapter 18 on freshwater resources, adopted at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro 1992. The four Dublin principles state, in short, that fresh water is a finite resource, water management should be participatory, and water has an economic value in all its uses. In chapter 18 of Agenda 21, integrated water resources development and management is one of seven focus areas proposed for the freshwater sector. The ideas from these guiding policy documents are visible in what might be the most widely used and accepted definition of the concept Integrated Water Resources Management (IWRM). The Global Water Partnership (GWP) defines IWRM as:

a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems

Table 3-1 summarises main aspects to acknowledge in IWRM. As can be seen, IWRM requires consideration of a wide array of aspects. There are three overall criteria to respect: enuity, and economic efficiency in water use. Apart from the overall criterias, natural system aspects and human system aspects are needed to be considered.

By acknowledging IWRM as representing the most appropriate water management approach of today, it is implicitly evident that water quality and quantity problems are not only physical issue, easily solved by engineering techniques. Instead, water problems are indeed social issues, is tightly connected to economy and politics.

Table 3-1. Main aspects to consider in IWRM

Aspects of IWRM	Comment, explanation
Overall criteria	
- Environmental and ecological sustainability	For sustainable IWRM integration both within and between the natural and human system is needed. The time dimension has to be considered so that the resource is sustained over time, also available for future generations.
- Equity	Equity in IWRM encompasses the basic right for all people to have access to water of adequate quantity and quality.
- Economic efficiency in water use	Water resources should be used in the most efficient way due to its increasing scarcity and vulnerable nature.
Natural system aspects	
- Freshwater and coastal water management	Fresh water systems may strongly influence the state of coastal waters and therefore these two elements must be integrated.
- Surface water and groundwater management	Many people rely on groundwater for their water supply. However, the use of agro-chemicals and pollution from diffuse sources threaten the groundwater quality, and thus, IWRM needs to consider linkages between surface water and groundwater
- Quantity and quality of water	For IWRM thequantity of water available is important, but it needs to be considered in connection to the quality of the water.
- Land and water management	It is recognised that, e.g., land use changes influence the physical distribution and quality of water. Asa mean for integrating land and water, basin level management is important.
- Upstream and downstream water related interests	Factors such as land use changes and pollution loading upstream may cause problems, like flooding and degraded water qualitydownstream. Also, this element stresses the importance of basin level management.
- "Green" and "blue" watera	By "green water" is meant water used directly for biomass production and water "lost" in evapotranspiration, while "blue water" is the water of lakes, rivers and aquifers. Traditionally, water management has focused more on "blue water". By also considering "green water", increased water use efficiency can be obtained through, e.g., changes in the crops cultivated.

Aspects of IWRM	Comment, explanation
Human system aspects	
- Intersectoral approach between the: water sector; economic sector; and social sector	In policy development there is a need for integrating water resource policy with economic and social policies. IWRM should include cross-sectoral exchange of information and co-ordination procedures.
- Economic value of water	In IWRM the full economic value of water should be recognised and taken into account. This includes full cost of water provision, internalising external costs for water services, economic valuing of environmental services and removing of unsustainable subsides for, e.g., agriculture to be replaced by subsides to enable poor people access to water.
- Involvement of all stakeholders in the planning and decision process	The involvement of all stakeholders is a key element in IWRM. Therefore fora and mechanisms must be developed to ensure participation. Information should be communicated to all decision-makers and the public.
- Decision making at the lowest level possible	Subsidarity is essential for IWRM.
- Institutional legal framework	An institutional legal framework is a prerequisite for a successful IWRM. This framework should set the rules regarding allocation, development and protection of the water resource. Further, it should definethe roles of government and stakeholders at different levels of society.

Source: The Role and use of Information in Transboundary Water Management

2. Hotspot area Policy Alternatives by mDSS modeling

A. Background of mDSS modeling

The mDSS approach

The MDSS4 computer package (Fondazione, 2006) was used to evaluate different management options addressing water quality and water resource issues. The mDSS4, was originally developed in the context of the project MULINO (MULti-sectoral, INtegrated and Operational Decision Support System for Sustainable Use of Water Resources at the Catchment Scale) and further developed and applied with a contribution of several other projects.[3] mDSS modeling implements Mulit-Criteria Analysis (MCA) decision methods

[3] http://www.netsymod.eu/mdss/

within a conceptual and communication framework developed upon the DPSIR approach. MCA comprise a set of methods for identification, assessment and aggregation of preferences among alternative choices, widely used in operational research and decision making. DPSIR is a system for organising information that emphasises cause-effect relationships designed for environmental problem solving.

This research uses this methodological framework for decision-makers that summarises key information (indicators) from related water issues.

A mDSS modeling consists of three phase described below:

1) Conceptual Phase: Identification of the issues and problem exploration by identifying driving forces, pressures, state and impacts
2) Design Phase: Option definition by finding responses in terms of the DPSIR framework on the basis of the available indicators and making Analysis Matrix (AM) containing the indicator values of the alternative options for each decision criteria.
3) Choice Phase: Making Multi-criteria decision analysis.

B. Application of the mDSS Modeling to the Selenge project

In this project, through discussion of relevant experts on parameters related to water issues, the following 17 parameters were produced. Each index is classified through DPSI as follows:

Designation of cities impacting the water issues of the Selenge River Basin was performed via the field research results in this project, as well as through discussions among experts from Mongolia, Russia, and Korea.

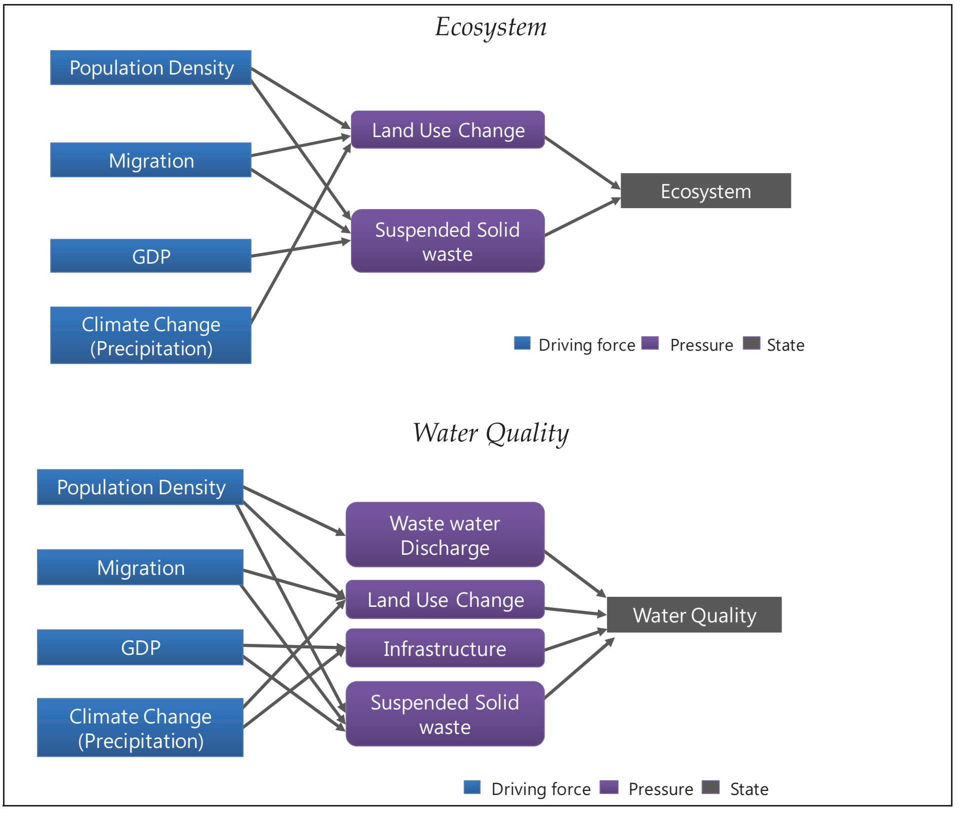
Table 3-2. Parameters related to water issues

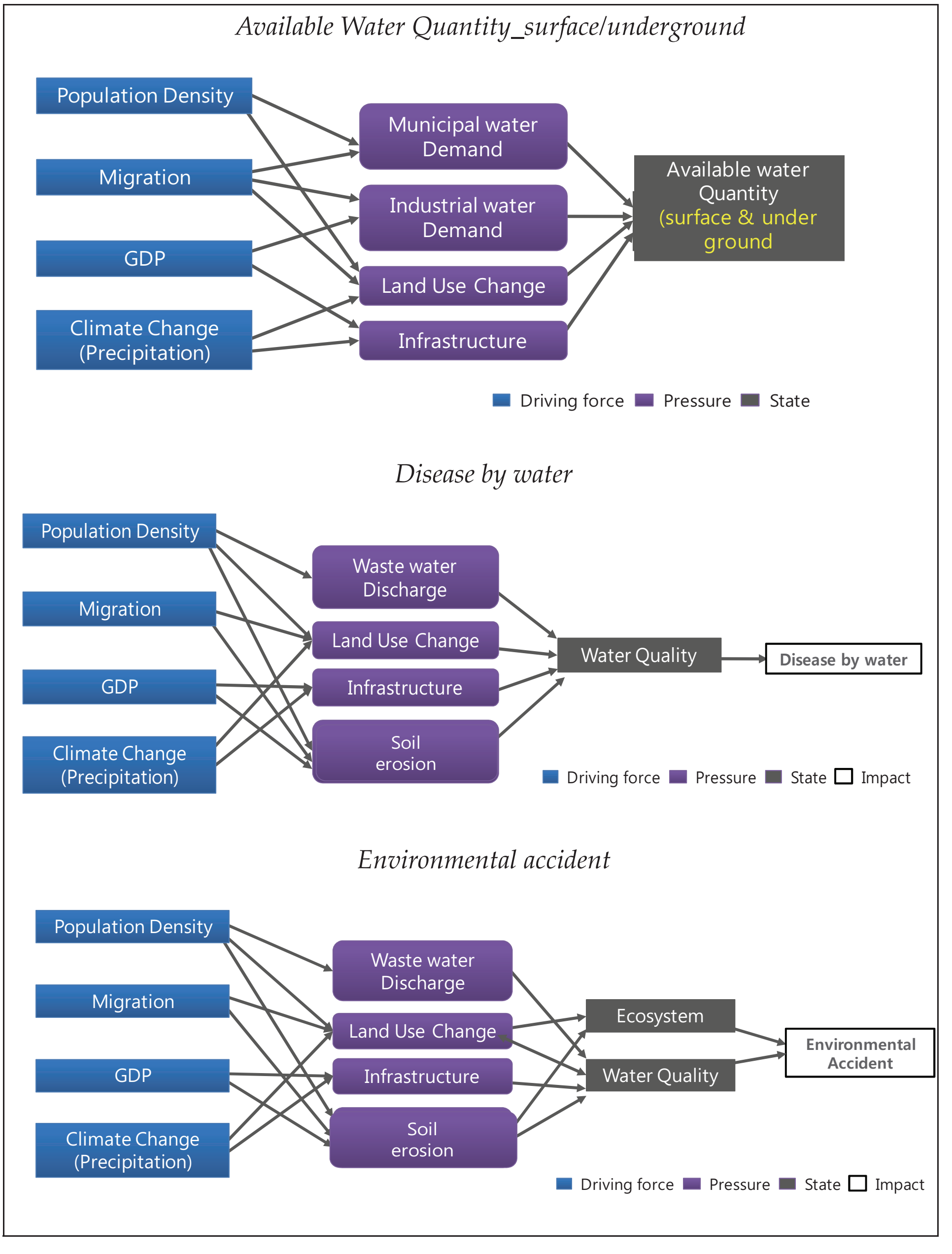
DPSI	Parameter
Driving Force	(1) Population Density (2) Migration (3) GDP per capita (4) Climate Change
Pressure	(5) Municipal water demand (6) Industrial water demand (7) Waste water discharge (8) Land use Change

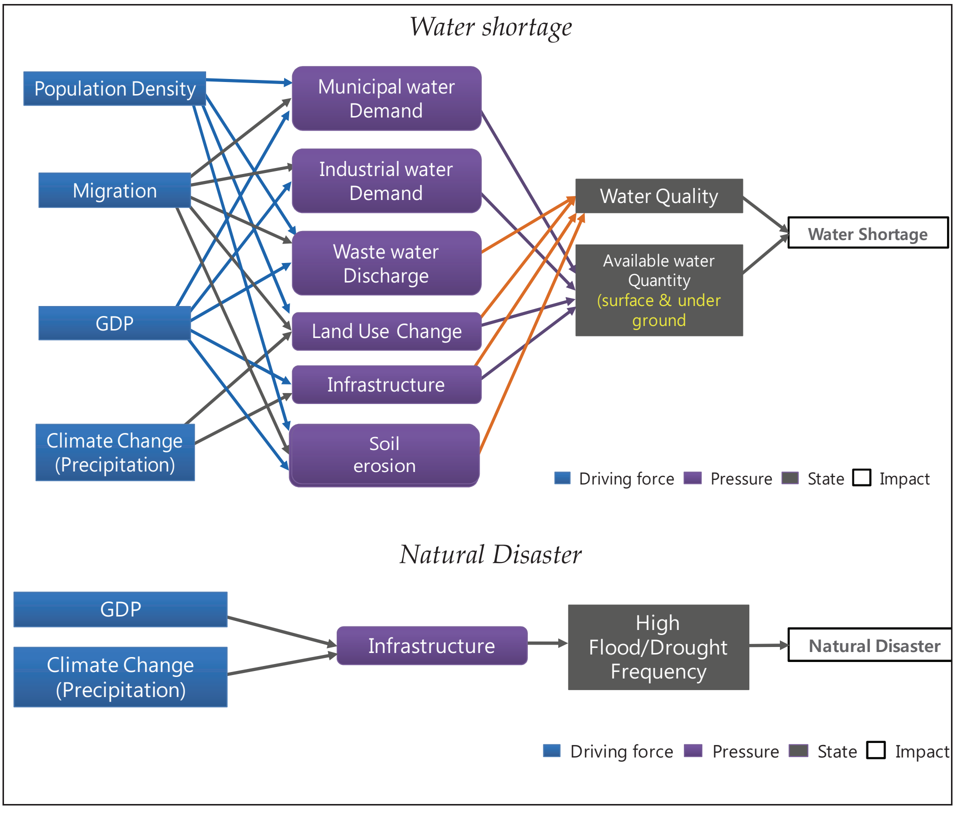
DPSI	Parameter
	(9) Infrastructure (10) Soil erosion
State	(11) Ecosystem (12) Water quality (13) Available Water Quantity (surface/ under ground)
Impact	(14) Disease by water (15) Environmental accident (16) Water shortage (17) Natural Disaster (High flood/drought)

The driving Force-Pressure parameters affect State-Impact parameters, and the relations are below:

Figure 3-1. DPSIR chain for conceptual analysis




Available Water Quantity_surface/underground
Population Density
Migration
GDP
Climate Change (Precipitation)
Municipal water Demand
Industrial water Demand
Land Use Change
Infrastructure
Available water Quantity (surface & under ground
Driving force
Pressure
State
Disease by water
Population Density
Migration
GDP
Climate Change (Precipitation)
Waste water Discharge
Land Use Change
Infrastructure
Soil erosion
Water Quality
Disease by water
Driving force
Pressure
State
Impact
Environmental accident
Population Density
Migration
GDP
Climate Change (Precipitation)
Waste water Discharge
Land Use Change
Infrastructure
Soil erosion
Ecosystem
Water Quality
Environmental Accident
Driving force
Pressure
State
Impact



Selection of Responses (alternatives)

On the Selenge River Basin, we have identified eight Hot Spot areas in two countries (Mongolia and Russia-Buryatia). The water quality related issues are presented by two origins: Mining and Urbanization. In order to improve the water quality conditions in the Selenge River Basin, we need to identify the exact locations of Hot Spot and then observe the existing management measures in the places. After that, there need to check the efficiency of the treatment operations for mitigation of pressure on water quality and improvement of local water quality condition.

The origins of water pollutions are different from place to place (mining and urbanized areas). The management options and approaches have to be properly defined and established according to management priorities.

Table 3-3. Selected hot spot areas for Mongolian site and Russian Site

Mongolian Site	Russian Site
Big Industrial cities	**Industrial cities**
▪ Ulaanbaatar (capital) ▪ Darkhan (industrial town)	▪ Ulan-Ude (capital) ▪ Gusinoozersk (Heat Power Plant) ▪ Selenginski (Palp and Paper Plant)
Mining activities	**Affected from not operated Mining area**
▪ Zaamar (Gold Placer Minig) ▪ Erdenet (Copper Mining)	▪ Zakamensk (not operating Wo-Mo Mining)

a) Big and industrial cities are supplied by Waste Water Treatment Plants. All cities in Mongolia (Ulaanbaatar, Darkhan) and Buryatia – Russia (Ulan-Ude) have chemical, mechanical and biological types of treatment. Gusinoozersk Heat Power Plant (HPP) is discharging only "warm" water, which is used for cooling processes of HPP plant. Selenginsky Palp and Paper Plant (PPP) have re-circulating water system. So, no discharge into the Selenge River from PPP plant. As well as, Water Source Protection, Land Use Planning, Charge user fee, Monitoring System, Improvement Water Supply System, EIA, Pollution Charge System, Solid Waste Management, Facility Permit System.

Mining areas are using following management measures, such as Water Protection System, Restoration of mining area, Land Use Planning, Facility Permit System, Build Sedimentation ponds, Environment Impact Assessment (EIA), Enforce mining license condition, Monitoring System, Solid Waste Management, Pollution Charge System, Development Water Source.

b) Performance of the management measures are considered to be outdated and ineffective in order to mitigate the pressure on environment. On the fieldwork of mining area in Mongolia, there were noticed some rough inobservance of rule, like discharging of waste mine water into the River, not proper land restoration and using dangerous and ineffective methods for extraction of minerals. In the Russian site (Buryatia), Zakamensk area, there is neglected Dzhidhinsky Wolfram-Molybdenum Mining area. The Mining operation had been stopped 18 years ago without sufficient land restoration. Since that time, the tailing dumps/pits from mining have been becoming the main stressor for local environment such as for water, air, and land.

c) There are different kind of recommendations for mining and urbaniz ed areas.

These policy responses to resolve the water issues of the hotspot areas are divided overall into "Institutional Alternatives," "Infrastructural Alternatives" , "Governance Alternatives," and are further divided into ten more detailed categories.

Table 3-4. Policy reponses for Institutional, Infrastructural and Governance Alternatives

R	Alternative-description	
Response	Institutional Alternative	**1) Charge User fee to All Water Users:** Measure water use, and charge accordingly. Payment should be related to how much water is used.
		2) Pollution Charge system: Checks of the accuracy of pollution reports and actual emissions. Payment should be related to how much water pollutant is discharged.
		3) Water Source Protection: Regulate the development of upper stream area and water resource protection area
		4) Facility Permit System: Permit and report system for the installation of discharging facility relating to the management of sites which discharge pollutant.
		5) Land Use Planning for pollutant control: Address the implications of development and plans upon the environment such as regulating migration of herders into agricultural areas.
		6) Enforce Environmental Impact Assessment: to ensure that decision makers consider the ensuing environmental impacts caused by proceeding with the project.
		7) Monitoring System: Build a control system under the inspection agency. The purpose is to record water quality & quantity to identify early signals of possible environmental change and to warn environmental accident.
		8) Solid Waste Mgt System: Decrease the amount of solid waste by establishing a Solid Waste Management System.

R		Alternative-description
		9) Enforce mining license conditions: Manage mining license for preventing illegal mining and make illegal mining industry close.
	Infrastructural Alternative	**10) Reusing Water:** Decrease the quantity of fresh water used by Wastewater Reclamation and Reusing System.
		11) Build local WWTPs: Build distributed Waste Water Treatment Plants at pollution sources.
		12) Build Sedimentation Pond: to allow for the setting of solids for cleaning the contaminated surface runoff.
		13) Restoration of Mining area: Identify the leaking and polluting runoff in this area, and conduct reclamation and reforestation for impacted land.
		14) Improvement Water Supply system (incl. **Irrigation):** Decrease leakage of pipes. Enhance the Water supply by pipes and sanitation services as well.
		15) Development Water Resource: Find alternative water resource. Build new wells in pasture areas
	Governance Alternative	**16) Participation & Capacity building:** Mobilize residents for participating of using water effectively. Educate local leadership and mobilize NGOs for protecting water resource as well.

Modelling Criteria Weights (AHP)

Analytic Hierarchy Process (AHP) was used to model criteria weights (satty, 1980). The method involves pairwise comparisons to create a ratio matrix through the normalisation of the pairwise comparison matrix the weights are determined. The method uses an underling scale with values, from 1 to 9.

1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Extreme importance
2,4,6,8	...may be used for interpolation between the

	C_1	C_2	C_3	C_4
C_1	1	4	7	5
C_2	1/4	1	1/3	9
C_3	1/7	3	1	5
C_4	1/5	1/9	1/5	1

Evaluation of relative weight by pair-wise comparison

For example, where water issues have occurred as a result of population increases, six responses are available, and relative significance between responses is assessed. When assessing significance between two responses, e.g. "charge all water users" and "charge for pollution, the assessment that due to water issues arising from population increases, "charge all water users" is more significant than "charge for pollution," is given a value of 3. Significance between the remaining responses can likewise assessed and inputted into the table.

Table 3-5. Example of the pair-wise comparison method

Population Growth	Charge All Water Users	Charge For Pollution	Decrease Leakage	Extend Water Supply	Reuse Industrial water	Build local WWTPs
Charge All Water Users	1	3	3	3	1/3	1/3
Charge For Pollution	1/3	1	2	1/2	4	3
Decrease Leakage	1/3	1/2	1	4	1/3	1/3
Extend Water Supply	1/3	2	1/4	1	1/3	1/3
Reuse Industrial water	3	1/4	3	3	1	1/3
Build local WWTPs	3	1/3	3	3	3	1

C. The Mongolian part

a. Urban & Industrial areas

In Mongolia, Ulaanbaatar, Darkhan and Erdnet are the representatives of urban and industrial areas. The main issues of those big cities are “Lack of water supply facilities due to population influx”, “Problem in sewage treatment system due to population influx”, “Water shortage due to population influx”, “Deteriorating water quality due to discharge of untreated industrial waste water, sewage and industrial waste water”, “Outworn water pipe or facility”, “Soil contamination due to industrial facilities in the city” and “Deteriorating water quality due to discharge of untreated sewage”. Considering those main issues regarding water management in SRB, the relative importance of the cities were calculated for each area; ecosystem, water quality, available water, disease by water, environmental accident and water shortage. Table 3-9 represents the normalized weights of Mongolian cities. The weights were reflected when conducting mDSS model.

Policy responses were selected by considering the environmental and socio-economical situation of those cities. Following tables show selected policy responses.

Table 3-6. Selected policy reponses for Ulaanbaatar

▪ Water Source Restoration; ▪ Land Use Planning; ▪ Charge User fee; ▪ Build Local WWTPs; ▪ Monitoring System; ▪ Reusing Water; ▪ Improvement Water Supply System;	▪ Participation and Capacity building; ▪ Development Water source; ▪ EIA; ▪ Pollution Charge System ▪ Solid Waste Mgt ▪ Facility Permit System

Table 3-7. Selected policy reponses for Darkhan

▪ Charge User fee; ▪ Water Source Protection; ▪ Land Use Planning; ▪ Monitoring System; ▪ Build Local WWTPs; ▪ Improvement Water Supply System; ▪ Pollution Charge System;	▪ Reusing water; ▪ EIA; ▪ Development Water Source; ▪ Enforce mining license conditions; ▪ Facility permit System; ▪ Solid Waste Mgt; Participation and Capacity building;

Table 3-8. Selected policy reponses for Erdenet

- Water Source Protection;
- Land use Planning;
- Build Local WWTPs;
- Monitoring System;
- Charge User fee;
- Participation and Capacity building;
- Reusing Water;
- Improvement Water Supply System;
- Development Water Source;
- Pollution Charge System;
- Facility Permit System;
- EIA;
- Enforce mining license conditions;
- Solid waste management;
- Restoration of mining areas;
- Building of sedimentation ponds;

Table 3-9. Normalized weights of Mongolian cities

Classification	Ulaanbaatar	Darkhan	Erdenet
Ecosystem	0.12	0.13	0.13
Water quality	0.18	0.20	0.20
Available water	0.29	0.27	0.27
Disease by water	0.06	0.07	0.07
Environmental accident	0.06	0.07	0.07
Water shortage	0.29	0.27	0.27

In this research, we pretreated the data for main issue priorities using expert survey analysis, weighting the issues priorities and normalized numbers of the weighted values, and fitted the data in the mDSS software. In the process of design of mDSS model, we transfered the database (DB) into analysis matrix (AM). Then we setted the ideal point method (TOPSIS). Aggregating the group members' preferences in the group decision, final solution rank were achieved by borda rule. Following table shows the reulsts of Ulaanbaatar, Darkhan and Erdent.

Table 3-10. Final solution rank of Mongolian cities by Borda Rule (Korean Experts)

Rank	Ulaanbaatar	Darkhan	Erdenet
1	Build local WWTPs	Water Source Protection	Water Source Protection
2	Solid Waste Management	Build local WWTPs	Land Use Planning
3	Water Source Protection	Improvement Water Supply system	Charge user fee
4	Monitoring System	Land Use Planning	Build local WWTPs
5	EIA	Development Water source	Monitoring System

Rank	Ulaanbaatar	Darkhan	Erdenet
6	Land Use Planning	Charge user fee	Improvement Water Supply system
7	Facility Permit System	Monitoring System	Development Water source
8	Pollution Charge system	Reusing Water	Enforce mining license conditions
9	Participation & Capacity building	Pollution Charge system	Participation & Capacity building
10	Development Water source	Participation & Capacity building	Facility Permit System
11	Improvement Water Supply system	Enforce mining license conditions	EIA
12	Charge user fee	Facility Permit System	Reusing Water
13	Reusing Water	EIA	Pollution Charge system
14		Restoration of Mining area	Restoration of Mining area
15		Solid Waste Management	Solid Waste Management
16		Build Sedimentation Pond	Build Sedimentation Pond

Table 3-11. Final solution rank of Mongolian cities by Borda Rule (Mongolian experts)

Rank	Mongolian Experts	Mongolian Experts	Mongolian Experts
1	Water Source Protection	Charge user fee	Water Source Protection
2	Land Use Planning	Water Source Protection	Land Use Planning
3	Charge user fee	Land Use Planning	Build local WWTPs
4	Build local WWTPs	Monitoring System	Monitoring System
5	Monitoring System	Build local WWTPs	Charge user fee
6	Reusing Water	Improvement Water Supply system	Participation & Capacity building
7	Improvement Water Supply system	Pollution Charge system	Reusing Water
8	Participation & Capacity building	Participation & Capacity building	Improvement Water Supply system
9	Development Water source	Reusing Water	Development Water source
10	EIA	EIA	Pollution Charge system
11	Pollution Charge system	Development Water source	Facility Permit System
12	Solid Waste Mgt	Enforce mining license conditions	EIA

Rank	Mongolian Experts	Mongolian Experts	Mongolian Experts
13	Facility Permit System	Facility Permit System	Enforce mining license conditions
14		Solid Waste Mgt	Solid Waste Mgt
15		Restoration of Mining area	Restoration of Mining area
16		Build Sedimentation Pond	Build Sedimentation Pond

b. Mining areas

Due to intensification of mining operation at Zaamar area (in one small sub-watershed) by many different mining operators and degradation of local environment occurred as irreversible process. Methods of extraction of deposit minerals and treatment facilities of wastes are outdated and ineffective. In order to mitigate the water quality issues need to conduct following order:

Table 3-12. Selected policy reponses for Zaamar

▪ Water Source Protection ▪ Land use Planning ▪ EIA ▪ Monitoring System ▪ Build local WWTPs ▪ Facility Permit System; ▪ Pollution Charge System; ▪ Solid waste Mgt; ▪ Participation and Capacity building;	▪ Enforce mining license condition; ▪ Restoration of Mining area; ▪ Building of sedimentation ponds; ▪ Charge user fee; ▪ Reusing water; ▪ Improvement Water Supply System; ▪ Development water source;

Table 3-13 Show the normalized values of Zaamar that is reflected relative importance by experts.

Table 3-13. Normalized values of Zaamar

Classification	Zaamar
Ecosystem	0.29
Water quality	0.36
Available water	0.14
Disease by water	0.07
Environmental accident	0.07
Water shortage	0.07

In this research, we pretreated the data for main issue priorities using expert survey analysis, weighting the issues priorities and normalized numbers of the weighted values, and fitted the data in the mDSS software. In the process of design of mDSS model, we transfered the database (DB) into analysis matrix (AM). Then we setted the ideal point method (TOPSIS). Aggregating the group members' preferences in the group decision, final solution rank were achieved by borda rule and extended borda rule. Following table shows the reulsts of Zaamar.

Table 3-14 . Final solution rank of Zaamar using "Borda Rule"

Rank	Korean Experts	Mongolian Experts
1	Enforce mining license conditions	Water Source Protection
2	Water Source Protection	Land Use Planning
3	Build local WWTPs	EIA
4	Land Use Planning	Monitoring System
5	Restoration of Mining area	Build local WWTPs
6	EIA	Facility Permit System
7	Pollution Charge system	Pollution Charge system
8	Facility Permit System	Solid Waste Mgt
9	Monitoring System	Participation & Capacity building
10	Solid Waste Mgt	Enforce mining license conditions
11	Participation & Capacity building	Restoration of Mining area
12	Build Sedimentation Pond	Build Sedimentation Pond
13	Development Water source	Charge user fee
14	Improvement Water Supply system	Reusing Water

Rank	Korean Experts	Mongolian Experts
15	Charge user fee	Improvement Water Supply system
16	Reusing Water	Development Water source

Table 3-15. Final solution rank of Zaamar using "Extended Borda rule" (Korean experts)

Total plurality mark	Options
3	Restoration of mining area
2	Build local WWTP
1	Water source protection
1	Land use planning

D. The Russian part

a. Urban & Industrial areas

In Russia-Buyatia, Ulan-Ude, Gusinoozersk and Selenginsk were selected as the representatives of urban and industrial areas. Following tables show the selected policy responses for those cities.

Table 3-16. Selected policy reponses for Ulan-Ude/ Gusinoozersk/ Selenginsk

- Water Source Protection;
- Solid Waste Mgt;
- Facility Permit System;
- Build Local WWTPs
- Monitoring System;
- Land Use Planning;
- EIA;
- Improvement Water Supply system;
- Pollution Charge system;
- Participation and Capacity building;
- Reusing Water;
- Charge user fee;
- Development Water Source.

Table 3-17 Shows the normalized values of Ulan-Ude / Selengzinsk / Gusinoozersk that is reflected relative importance by experts.

Table 3-17. Normalized weights of Russian cities

Classification	Ulan-Ude / Selengzinsk / Gusinoozersk
Ecosystem	0.33
Water quality	0.33
Available water	0.11

Classification	Ulan-Ude / Selengzinsk / Gusinoozersk
Disease by water	0.11
Environmental accident	0.11
Water shortage	0.00

In this research, we pretreated the data for main issue priorities using expert survey analysis, weighting the issues priorities and normalized numbers of the weighted values, and fitted the data in the mDSS software. In the process of design of mDSS model, we transfered the database (DB) into analysis matrix (AM). Then we setted the ideal point method (TOPSIS). Aggregating the group members' preferences in the group decision, final solution rank were achieved by borda rule. Following table shows the reulsts of Ulan-Ude, Selenzinsk and Gusinoozersk.

Table 3-18. Final solution rank of Russian cities using "Borda rule" (Korean experts)

Rank	Gusinoozersk	Selengzinsk	Ulan-Ude
1	Water Source Protection	Water Source Protection	Water Source Protection
2	Facility Permit System	Facility Permit System	Solid Waste Mgt
3	Solid Waste Mgt	Solid Waste Mgt	Facility Permit System
4	Monitoring System	Pollution Charge system	Build local WWTPs
5	EIA	Monitoring System	Monitoring System
6	Land Use Planning	Land Use Planning	Land Use Planning
7	Improvement Water Supply system	EIA	EIA
8	Pollution Charge system	Build local WWTPs	Improvement Water Supply system
9	Reusing Water	Reusing Water	Pollution Charge system
10	Build local WWTPs	Participation & Capacity building	Participation & Capacity building
11	Participation & Capacity building	Improvement Water Supply system	Reusing Water
12	Charge user fee	Charge user fee	Charge user fee
13	Development Water source	Development Water source	Development Water source

Table 3-19. Final solution rank of Russian cities using "Borda rule" (Russian experts)

Rank	Ulan-Ude / Selengzinsk / Gusinoozersk
1	Build local WWTPs
2	Solid Waste Mgt
3	Water Source Protection
4	Monitoring System
5	EIA
6	Land Use Planning
7	Facility Permit System
8	Pollution Charge system
9	Participation & Capacity building
10	Development Water source
11	Improvement Water Supply system
12	Charge user fee
13	Reusing Water

b. Mining areas

Due to stopping of operation of mining enterprise without sufficient land restoration, the tailing dumps/pits were become the main stressor for local environment (water, air, land). The priorities can be in different ordering as following for :

Table 3-20. Selected policy reponses for Zakamensk

▪ Water Source Protection; ▪ Restoration of abandoned mining areas (covering by native plants intensively); ▪ Facility Permit System; ▪ Build Sedimentation Pond; ▪ Enforce mining license conditions; ▪ Monitoring System; ▪ Solid Waste Mgt; ▪ Land Use Planning; ▪ Reusing Water; ▪ EIA; ▪	▪ Improvement Water Supply System; ▪ Pollution Charge System; ▪ Participation and Capacity building; ▪ Development Water Source; ▪ Build local WWTPs; ▪ Charge user fee. ▪ Finding of potential spots of water pollution sources and installing at outline the sedimentation ponds (capturing of storm waters);

Table 3-21 shows the normalized values of Zakamensk that is reflected relative importance by experts.

Table 3-21. Normalized weights of Russian mining areas, Zakamensk

Classification	Zakamensk
Ecosystem	0.30
Water quality	0.30
Available water	0.10
Disease by water	0.10
Environmental accident	0.20
Water shortage	0.00

In this research, we pretreated the data for main issue priorities using expert survey analysis, weighting the issues priorities and normalized numbers of the weighted values, and fitted the data in the mDSS software. In the process of design of mDSS model, we transfered the database (DB) into analysis matrix (AM). Then we setted the ideal point method (TOPSIS). Aggregating the group members' preferences in the group decision, final solution rank were achieved by borda rule and extended borda rule. Following table shows the reulsts of Zakamensk.

Table 3-22. Final solution rank of Zakamensk using "Borda rule"

Rank	Korean Experts	Russian experts
1	Build local WWTPs	Water Source Protection
2	Water Source Protection	Restoration of Mining area
3	Restoration of Mining area	Facility Permit System
4	Solid Waste Mgt	Build Sedimentation Pond
5	Monitoring System	Enforce mining license conditions
6	Land Use Planning	Monitoring System
7	EIA	Solid Waste Mgt
8	Facility Permit System	Land Use Planning
9	Pollution Charge system	Reusing Water
10	Participation & Capacity building	EIA
11	Enforce mining license conditions	Improvement Water Supply system
12	Build Sedimentation Pond	Pollution Charge system

Rank	Korean Experts	Russian experts
13	Development Water source	Participation & Capacity building
14	Improvement Water Supply system	Development Water source
15	Charge user fee	Build local WWTPs
16	Reusing Water	Charge user fee

Table 3-23. Final solution rank using of Zaamar Extended Borda rule

Total plurality mark	Options
3	Build local WWTP
3	Restoration of mining area
1	Reusing water

3. Expert Survey and Result

A. Background of expert survey

The overall objective of this project is to develop the IWMM for sustainability of the SRB in national level. Therefore, joint research team tries to identify the needs and expectations of major actors and stakeholders of Mongolia and Russia to develop potential domestic & transboundary water management system on the SRB in addressing common water environmental issues. The survey composed of three parts. The first part is to investigate the Recognition of the Domestic Water Isssues in the SRB, the second part is to investigate the Evaluation of the Current Water Management Policy of M/R on SRB and the third part is to investigate the Development of the water management system on SRB.

B. The results of expert survey

a. The Mongolian part

In the Mongolian part, 12 experts participated in the survey. The list of experts is included in the Appendix of this report.

In the first part, most of Mongolian experts agreed that there are several domestic water issues of the SRB that need to cope with by ingegrated water management system in Mongolia and Russia (hereinafter M&R).

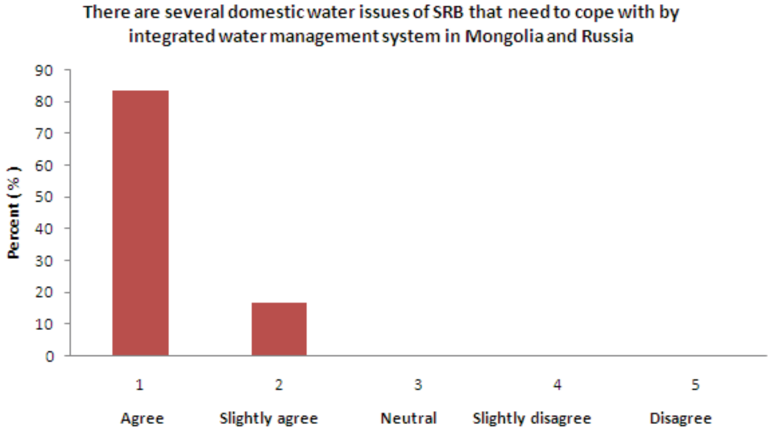


Figure 3-2. The results of question 1-1, Mongolian part

Also they agreed or slightly agreed that the domestic water issues of the SRB will be significant domestic issues of M&R. They chose the most significant, current domestic water issues of M/R in the SRB, in the first order 55% of experts chose "Water resources shortage" and 8% of experts chose "Water quality deterioration" and "Ecosystem deterioration/Biodiversity loss", 33% of experts chose "Development of river basin (Dam construction etc.)". In the second order, 25 % of experts chose "Development of river basin (Dam construction etc.)" and 17% of experts chose "Water resources shortage", "Water quality deterioration" and "Heavy metal pollution Improvement Water Supply system"

In the second part, 40% of experts agreed or slightly agreed that the domestic water management policies of M/R had been known well among major actors and stakeholders of relevant organizations in two countries. 15% of experts chose neutral, and 45% of expert disagreed or slightly disagreed.

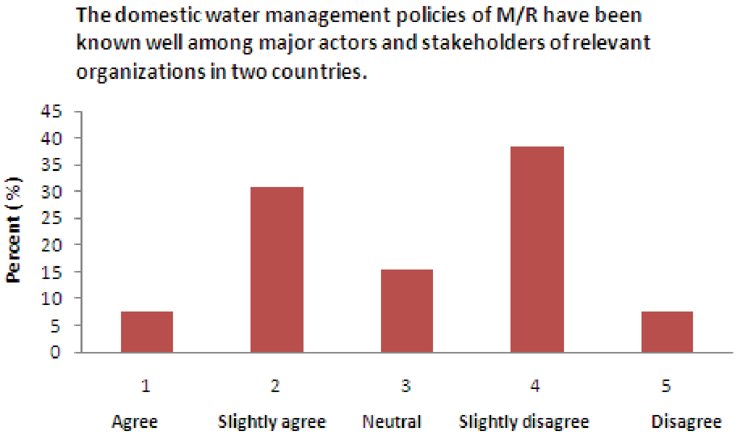


Figure 3-3. The results of question 2-1, Mongolian part

To the question of "The current water management policies of Mongolia/Russia produced positive outcomes in addressing rational use and protection of water of SRB", 18% of experts agreed, 55% of experts are neutral and 27% experts disagreed slightly.

They chose two of the most important domestic water management policies of M/R in current water management system in the first order, 29% of experts chose "Laws of water management" and 14% of experts chose "National water management plan (program)" 43% of experts chose "Water use fee and wastewater emission charge system" and 14% of experts chose "Water quality standard and pollutant emission standard". In the second order, 23% of experts chose "Environmental Impact Assessment system", 15% of experts chose "Environmental protection plan(program)", 7% of experts chose "National water management plan(program)" and 38% of experts chose "Regulations of water resources and river basin development".

They chose two of the most serious limitations or weak points in domestic water management policies of M/R in current water management system in the first order, 41% of experts chose "Insufficient recognition of the integrated management necessity of each government on water issues", 33% of experts chose "Different interests in water issues among relevant departments and stakeholders", 17% of experts chose "Lack of institutional arrangement and detail policy instruments", 8% of experts chose "Lack of coordination and harmony the differences and disputes among policies and interests". In the second order, 15% of experts chose "Insufficient recognition of water issues", "Insufficient recognition of the integrated management necessity of each government on water issues", "Different interests in water issues among relevant departments and stakeholders" and 23% of experts chose "Lack of institutional arrangement and detail policy instruments". "Lack of administrative and financial capacity" and 7% of experts chose "Lack of coordination and harmony the differences and disputes among policies and interests".

In the third part, 77% of experts agreed that water is public good that should be allocated fairly, and the cost and benefit involved in water management should be shared equitably in such a way that the users pay according to the quantity consumed and 23% of experts slightly agreed.

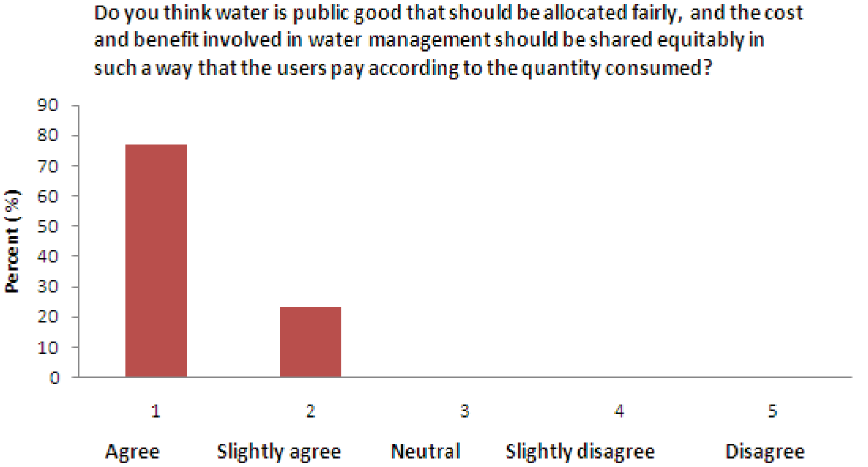


Figure 3-4. The results of question 3-1, Mongolian part

92% of experts agreed that the wastewater polluter should bear the cost of purification and 8% of experts agreed slightly. 85% of experts agreed that the water, as a public good, should be managed by the national government with the comprehensive framework on the national level and 15% of experts agreed slightly. 58% of experts agreed that the local administrative unit or public enterprise that charge of water management policy implementation need to improve the efficiency of water management, 17% of experts slightly agreed, 8% are neutral and 17% slightly disagreed. 69% of experts agreed that they think it is necessary to create a policy network in which the government agents, specialists, NGOs and community groups can cooperate, reflecting the global paradigm shift toward the environmentally sound and sustainable water management, and the 31% experts slightly agreed. 85% of experts agreed that integrated water management system on SRB should be established for SRB sustainability, and 15% of experts agreed slightly. The 62% of experts agreed that a couple of special policy alternatives such as special law or special management zone are needed for the efficient water management of Selenge River Basin, and 15% of experts slightly agreed, and other 15% are neutral and 8% of experts disagreed.

23% of experts chose the two most important issues in the water environment management as a first order "Limited water resources", 15% of experts chose "Quality of drinking water", 46% of experts chose "River ecosystem" and 8% of experts chose "Civil involvement in water resources management". As a second order, 15% of experts chose "Limited water resources" and "Quality of drinking water", 23% of experts chose "River ecosystem", 8% of experts chose "Social infrastructure for the flood/drought" and 38% of experts chose "Civil involvement in water resources management".

They chose the two most important issues related to the use of water resources. As a first order, 62% of experts chose "Limited water resources", 23% of experts chose "Quality of drinking water", 8% of experts chose "Social infrastructure for the flood/drought" and "Civil involvement in water resources management". As a second order, 23% of experts chose "Limited water resources" and "Social infrastructure for the flood/drought ", 15% of experts chose "Quality of drinking water" and 38% of experts chose "River ecosystem".

They chose the two most important policy related water resources consists of constructional approach in the non-constructural approaches. As a first order, 17% of experts chose "Effective management of existing facilities", "Demand control" and "Public relation and education emphasizing the economical use of water", 50% of experts chose "Developing a supplementary water resources". As a second order, 8% of experts chose "Effective management of existing facilities", 23% of experts chose "Developing supplementary water resources", 31% of experts chose "Demand control" and 38% of experts chose "Public relation and education emphasizing the economical use of water".

They chose the two most important special policy alternatives for the efficient water management of the Selenge River Basin. As a first order, 69% of experts chose "Water quality & ecosystem management", 23% of experts chose "Developing Water resource" and 8% of experts chose "Managing waterworks & Sewage". As a second order, 15% of experts chose "Water quality & ecosystem management", 62% of experts chose "Developing Water resource" and 23% of experts chose "Managing waterworks & Sewage".

They chose the two most important special policy alternatives for the efficient water management of the Selenge River Basin. As a first order, 15% of experts chose "Introduction of special law for water management on the SRB", 30% of experts chose "Establishment of special management zone on the SRB", 38% of experts chose "Establishing a comprehensive plan for the Selenge River Basin" and 8% of experts chose "strengthening the regulation related to the water management of the SRB" and "More civil involvement in the process of policy-making".As a second order, 15% of experts chose "Introduction of special law for water management on the SRB", 62% of experts chose "Establishment of special management zone on the SRB" and 23% of experts chose "Establishment of independent the SRB agency".

They chose the two most effective management measures for pollution source control. As a first order, 23% of experts chose "Designating control or protection area/zone", 54% of experts chose "Pollution source location control" and 15% of experts chose "Allowable discharge standard", 8% of experts chose “Enforcing EIA”. As a second order, 23% of experts chose “Designating control or protection area/zone”, 8% of experts chose “Pollution source location control”, 15% of experts chose “Allowable discharge standard”, 8% of experts chose “Regulation of total effluence” and 46% of experts chose “Enforcing Inspection system”.

They chose the two most rational policy options for promoting the water reuse. As a first order, 54% of experts chose “Realistic water fee”, 8% of experts chose “Tax benefit”, 23% of experts chose “Technological development” and 15% of experts chose “Investment aid”. As a second order, 23% of experts chose “Realistic water fee” and “Tax benefit”, 38% of experts chose “Technological development”, 15% of experts chose “Investment aid”.

They chose the two most important policy options for the systematic development and utilization of groundwater. As a first order, 33% of experts chose “Renewing the legislations and policies related to groundwater”, 17% of experts chose “Designation of water reserve”, 8% of experts chose “Investment aid” and 42% of experts chose “Data collecting and monitoring on the groundwater”. As a second order, 8% of experts chose “Renewing the legislations and policies related to groundwater”, 38% of experts chose “Designation of water reserve”, 23% of experts chose “Specialized governmental organization in charge of groundwater management” and 31% of experts chose “Data collecting and monitoring on the groundwater”.

They chose the two most important policy measures for flood/drought management. As a first order, 23% of experts chose “Establishing a comprehensive disaster management plan”, 38% of experts chose “System of acquiring and managing the information on the condition of river”, 23% of experts chose “Prediction and alarm system” and 15% of experts chose “Water resource development”. As a second order, 25% of experts chose “Establishing a comprehensive disaster management plan”, 8% of experts chose “System of acquiring and managing the information on the condition of river”, 17% of experts chose “Prediction and alarm system” and “Disaster restitution and community support”, and 33% of experts chose “Water resource development”.

b. The Russian part

In the Russina part, 18 experts participated in the survey. The list of experts is included in the Appendix of this report.

In the first part, most of Russian experts agreed that there are several domestic water issues of the SRB that need to cope with by ingegrated water management system in Mongolia and Russia (hereinafter M&R).

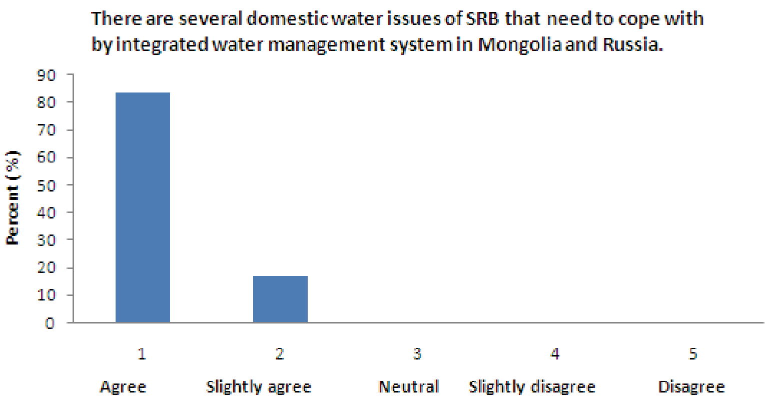


Figure 3-5. The results of question 1-1, Russian part

Also they agreed or slightly agreed that the domestic water issues of the SRB will be significant domestic issues of M&R. They chose the most significant, current domestic water issues of M/R in SRB, in the first order 50% of experts chose "Water quality deterioration", 28% of experts chose "Drinking Water quality issue", 5% of experts chose "Water resources shortage"and "Ecosystem deterioration/Biodiversity loss". In the second order, 22% of experts chose "Water resources shortage" and "Ecosystem deterioration/Biodiversity loss", 17% of experts chose "Water quality deterioration" and "Drinking Water quality issue", 6% of experts chose "Heavy metal pollution" and "Improvement Water Supply system".

They chose the most significant, future domestic water issues of M/R in the SRB, in the first order 21% of experts chose "Water resources shortage", 26% of experts chose "Water quality deterioration", 5% of experts chose "Heavy metal pollution", 37% of experts chose "Drinking Water quality issue" and 5% of experts chose "Improvement Water Supply system" and "Ecosystem deterioration/Biodiversity loss". In the second order, 6% of experts chose "Water resources shortage", 33% of experts chose "Water quality deterioration", 11% of experts chose "Heavy metal pollution", 17% of experts chose "Drinking Water quality issue", "Improvement Water Supply system" and "Ecosystem deterioration/Biodiversity loss".

In the second part, 80% of experts agreed or slightly agreed that the domestic water management policies of M/R had been known well among major actors and stakeholders of relevant organizations in two countries. 11% of experts chose neutral, and 11% of expert disagreed or slightly disagreed.

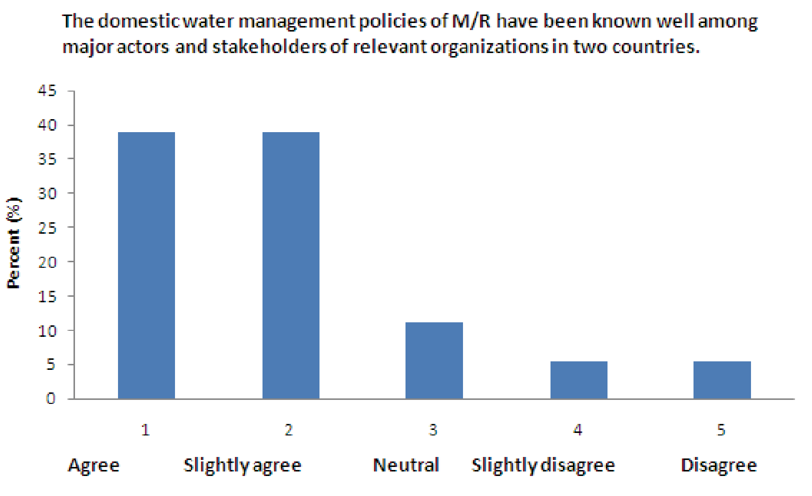


Figure 3-6. The results of question 2-1, Russian part

To the question of "The current water management policies of Mongolia/Russia produced positive outcomes in addressing rational use and protection of water of SRB", 74% of experts agreed or slightly agreed, 16% of experts are neutral and 11% experts disagreed or slightly disagreed.

They chose two of the most important domestic water management policies of M/R in current water management system in the first order, 89% of experts chose "Laws of water management", 6% of experts chose "Environmental protection plan(program)" and "National water management plan(program)". In the second order, 5% of experts chose "Laws of water management" and "Environmental Impact Assessment system", 16% of experts chose "Environmental protection plan(program)" and "Regulations of water resources and river basin development", 37% of experts chose "National water management plan(program)" and 21% of experts chose "Water use fee and wastewater emission charge system".

They chose two of the most serious limitations or weak points in domestic water management policies of M/R in current water management system in the first order, 16% of experts chose "Insufficient recognition of water issues", 32% of experts chose "Different interests in water issues among relevant departments and stakeholders", 21% of experts chose "Lack of institutional arrangement and detail policy instruments" and "Lack of administrative and financial capacity", 11% of experts chose "Lack of coordination and harmony the differences and disputes among policies and interests".

In the second order, 6% of experts chose "Insufficient recognition of water issues", "Lack of institutional arrangement and detail policy instruments" and "Lack of public awareness and participation", 22% of experts chose "Different interests in water issues among relevant departments and stakeholders", 11% of experts chose "Lack of coordination and harmony the differences and disputes among policies and interests" and "Lack of public awareness and participation", 39% of experts chose "Lack of administrative and financial capacity".

In the third part, 63% of experts agreed that water is public good that should be allocated fairly, and the cost and benefit involved in water management should be shared equitably in such a way that the users pay according to the quantity consumed, 32% of experts slightly agreed and 5% of experts slightly disagreed.

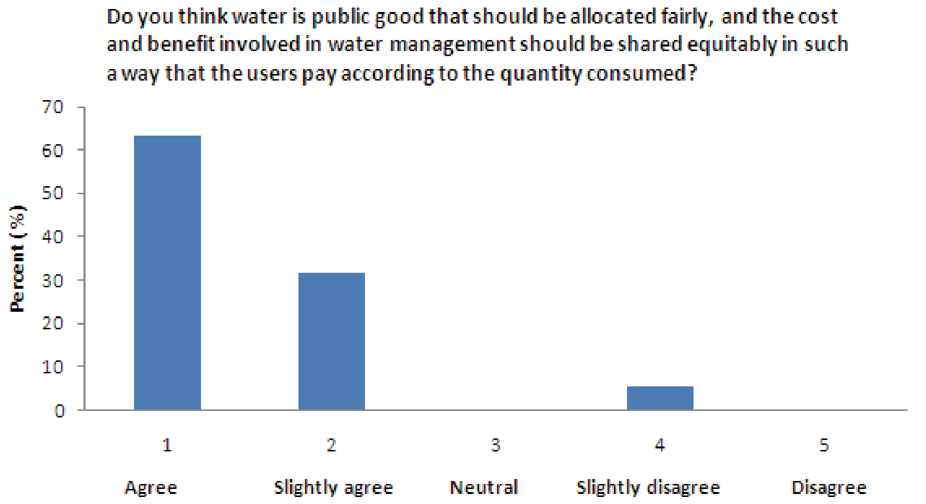


Figure 3-7. The results of question 3-1, Russian part

84% of experts agreed that the wastewater polluter should bear the cost of purification and 16% of experts agreed slightly. 95% of experts agreed that the water, as a public good, should be managed by the national government with the comprehensive framework on the national level and 5% of experts agreed slightly. 84% of experts agreed that the local administrative unit or public enterprise that charge of water management policy implementation need to improve the efficiency of water management, 16% of experts slightly agreed. 83% of experts agreed that they think it is necessary to create a policy network in which the government agents, specialists, NGOs and community groups can cooperate, reflecting the global paradigm shift toward the environmentally sound and sustainable water management, and the 11% experts slightly agreed, and 5% of experts were neutral. 84% of experts agreed that integrated water management system on the SRB should be established for the SRB sustainability, and 15% of experts agreed slightly. The 42% of experts agreed that a couple of special policy alternatives such as special law or special management zone are needed for the efficient water management of the Selenge River Basin, and 31% of experts slightly agreed and 25% of experts are neutral. 33% of experts chose the two most important issues in the water environment management as a first order “Limited water resources”, 44% of experts chose “Quality of drinking water” , 11% of experts chose “River ecosystem” and “Social infrastructure for the flood/drought”. As a second order, 6% of experts chose “Limited water resources” and “River ecosystem”, 17% of experts chose “Quality of drinking water”, 33% of experts chose “Social infrastructure for the flood/drought” and 39% of experts chose “Civil involvement in water resources management”.

They chose the two most important issue related to the use of water resources. As a first order, 39 % of experts chose “Increase in the demand for water for domestic use due to population growth and rising living standard”, 33 % of experts chose “Increase in industrial demand for water” and 27 % of experts chose “Water resources issues between the upstream and downstream within the river basin”. As a second order, 44 % of experts chose “Increase in industrial demand for water”, 17 % of experts chose “Increase in demand in the agricultural sector” and 39 % of experts chose “Water resources issues between the upstream and downstream within the river basin”.

They chose the two most important policy related water resources consists of constructional approach in the non-constructural approaches. As a first order, 75 % of experts chose “Effective management of existing facilities”, 6% of experts chose “Developing supplementary water resources” and “Demand control”, 13 % of experts chose “Public relation and education emphasizing the economical use of water”. As a second order, 13% of experts chose “Developing supplementary water resources” and the 25% of experts chose “Demand control” and the 63% of experts chose “Public relation and education emphasizing the economical use of water”.

They chose the two most important special policy alternatives for the efficient water management of Selenge River Basin. As a first order, the 78 % of experts chose “Water quality & ecosystem management” and the 22 % of experts chose “Developing Water resource”. As a second order, the 6 % of experts chose “Water quality & ecosystem management”, “Developing Water resource” and “Others”, the 61% of experts chose “Managing waterworks &

Sewage", and the 22% of experts chose "Disaster management".

They chose the two most important special policy alternatives for the efficient water management of Selenge River Basin. As a first order, the 31 % of experts chose "Introduction of special law for water management on the SRB", 6 % of experts chose "Establishment of special management zone on the SRB", 25 % of experts chose "Establishing a comprehensive plan for the Selenge River Basin", 13 % of experts chose "strengthening the regulation related to the water management of the SRB", 19% % of experts chose "Restructuring the system of management" and 6 % of experts chose "More civil involvement in the process of policy-making". As a second order, 13 % of experts chose "Establishment of special management zone on SRB", 6 % of experts chose "Establishment of independent the SRB agency" and "strengthening the regulation related to the water management of the SRB", 19 % of experts chose "Establishing a comprehensive plan for the Selenge River Basin", "Designating a target water quality level for the SRB", "Restructuring the system of management" and "More civil involvement in the process of policy-making".

They chose the two most effective management measures for pollution source control. As a first order, 17 % of experts chose "Designating control or protection area/zone", 61 % of experts chose "Pollution source location control", 6 % of experts chose "Allowable discharge standard", "Enforcing EIA", "Enforcing Inspection system" and "Others". As a second order, the 11% of experts chose "Designating control or protection area/zone", "Regulation of total effluence" and "Enforcing EIA", the 28% of experts chose "Pollution source location control", the 22% of experts chose "Allowable discharge standard" and the 17 % of experts chose "Enforcing Inspection system".

They chose the two most rational policy options for promoting the water reuse. As a first order, 11% experts chose " Realistic water fee", 28% of the experts chose "Tax benefit" and the 61% of experts chose "Technological development". As a second order, the 28% of experts chose "Realistic water fee", 11% of experts chose "Tax benefit"," Technological development", and the 50% of experts chose “Investment aid”.

They chose the two most important policy options for the systematic development and utilization of groundwater. As a first order, 22% of experts chose “Renewing the legislations and policies related to groundwater”, 17% of the experts chose “Designation of water reserve”, 6% of experts chose “Specialized governmental organization in charge of groundwater management” and “Data collecting and monitoring on the groundwater”, and the 22% of the experts chose “Investment aid”. In the second order, 28% of the experts chose “Designation of water reserve”, 6% of experts chose “Specialized governmental organization in charge of groundwater management”, 22% of the experts chose “Investment aid” and the 44% of the experts chose “Data collecting and monitoring on the groundwater”.

They chose the two most important policy measures for flood/drought management. As a first order, 35% of the experts chose “Establishing a comprehensive disaster management plan”, 12% of the experts chose “System of acquiring and managing the information on the condition of river” and “Water resource development”, 18% of the experts chose “Prediction and alarm system” and the 24% of the experts chose “Disaster restitution and community support”. As a second order, 22% of the experts choose “Establishing a comprehensive disaster management plan” and “System of acquiring and managing the information on the condition of river”, 11% of the experts chose “Prediction and alarm system”, 6% of the experts chose “Water resource development” and the 40% of the experts chose “Disaster restitution and community support”.

C. Summary

The questions that show similar opinions are following:

- There are several domestic water issues of the SRB that need to cope with by integrated water management system in Mongolia and Russia
- A integrated water management system on the SRB should be

established for the SRB sustainability.

The questions that show different opinions are following:

- About current domestic water issues, Mongolian experts chose "water shortage" and "Development of river basin (Dam construction etc.)" however Russian experts chose "Water quality deterioration" and "Drinking Water quality issue"
- About future domestic water issues, Mongolian experts chose "Water resources shortage of the SRB" and "Development of river basin (Dam construction etc.)", however Russian experts chose "Water quality deterioration" and " Ecosystem deterioration/Biodiversity loss"
- The question that asks whether the domestic water management policies of M/R have been known well among major actors and stakeholders of relevant organizations in two countries, most of Mongolian experts answered "not know well", Russian experts answered "understand well"
- About the most important issue related to the use of water resources, Mongolian experts answered "Increase in the demand for water for domestic use due to population growth" and "Rising living standard", however Russian experts answered "Increase in industrial demand for water" and "Water resources issues between the upstream and downstream within the river basin"
- About the policy priority related water resources in the non-constructural approaches Mongolian experts chose "Effective management of existing facilities", however, Russian experts did not answer one answer dominantly.

D. Feasibility analysis

The feasibility of policy options were investigated by Mongolian and Russian experts. Table 3-24 and 3-25 show the survey results that mean the possibility of policy options to be conducted in their countries. They had responded yes or no, and all the responses were gathered.

Table 3-24. Feasibility of Mongolia

R		Alternative	Feasibility		
			Technical feasibility (Yes/No)	Economical Feasibility (Yes/No)	Administrative Feasibility (Yes/No)
Response(Alternatives)	Institutional	Charge User fee to All Water Users	17/2	17/2	14/5
		Pollution Charge system	18/1	19/0	15/4
		Water Source Protection	13/6	12/7	15/4
		Facility Permit System	15/2	15/2	14/3
		Land Use Planning for pollutant control	14/0	13/1	11/3
		Enforce Environmental Impact Assessment	16/3	11/8	16/3
		Monitoring System	10/9	11/8	17/2
		Solid Waste Mgt System	14/5	13/6	16/3
		Enforce mining license conditions	7/4	7/4	5/6
	Infrastructural	Reusing Water	13/6	13/6	14/1
		Build local WWTPs	11/8	10/9	17/2
		Build Sedimentation Pond	6/5	7/4	9/2
		Restoration of Mining area	6/0	6/0	6/0
		Improvement Water Supply system	10/6	8/8	14/2
		Development Water Resource	12/6	7/7	13/1

R		Alternative	Feasibility		
			Technical feasibility (Yes/No)	Economical Feasibility (Yes/No)	Administrative Feasibility (Yes/No)
	Governance	Participation & Capacity building	14/1	10/5	14/1

Mongolian experts have reported that policy alternatives such as pollution charge system, land use planning for pollutant, facility permit system, and restoration of mining area have relatively high technical feasibility, economical feasibility, and administrative feasibility.

On the other hand, policies that reinforce EIA and monitoring system, and building local WWTPs, improving water supply system have lower economical feasibility.

Table 3-25. Feasibility of Russia

R		Alternative	Feasibility		
			Technical feasibility (Yes/No)	Economical Feasibility (Yes/No)	Administrative Feasibility (Yes/No)
Response(Alternatives)	Institutional	Charge User fee to All Water Users	13/0	13/0	13/0
		Pollution Charge system	5/8	13/0	11/2
		Water Source Protection	3/9	6/6	1/11
		Facility Permit System	5/8	4/9	11/2
		Land Use Planning for pollutant control	8/3	1/10	8/3
		Enforce Environmental Impact Assessment	11/2	4/9	12/1
		Monitoring System	5/8	3/10	13/0
		Solid Waste Mgt System	10/3	2/11	9/4
		Enforce mining license conditions	2/2	0/4	3/1

R		Alternative	Feasibility		
			Technical feasibility (Yes/No)	Economical Feasibility (Yes/No)	Administrative Feasibility (Yes/No)
	Infrastructural	Reusing Water	12/0	4/8	11/1
		Build local WWTPs	10/3	1/12	12/1
		Build Sedimentation Pond	4/1	1/4	5/0
		Restoration of Mining area	2/1	0/3	1/2
		Improvement Water Supply system	7/3	1/9	9/1
		Development Water Resource	10/1	2/9	9/2
	Governance	Participation & Capacity building	9/4	9/4	9/4

Russian experts have reported that charge user fee to all water users, pollution charge system have high economic and administrative feasibility. On the other hand land use planning for pollutant control was low in economical feasibility. The difficulty in regulating land use for development purposes may have been reflected in this.

Monitoring system was low in technical and economic feasibility, but high in administrative feasibility. Among other things, policy alternatives such as build local WWTPs, improvement water supply system, reusing water have high technical and administrative feasibility but low economic feasibility. On the whole Russian experts tended to assign low numbers to economic feasibility.

It particular, most policy alternatives have high administrative feasibility in both Mongolia and Russia. However for Mongolia, this feasibility result is not in line with the expert survey result number 2-1[4] on the understanding of water-related policies. Feasibility analysis may be reflecting the positive expectation for proper implementation of necessary policy alternatives.

[4] Q 2-1: The domestic water management policies of M/R have been known well among major actors and stakeholders of relevant organizations in two countries
A: More than 70% Mongolian expert answered “disagree”.

4. Policy Alternative on Domestic IWMM

A. Policy Implication of water state of SRB and survey results

The main policy implications of the water quality monitoring results and analysis are as follow:

First, we found out that water quality problems in the SRB are generated by two main origins, namely, mining and urbanization based on total 110 sample sites monitoring and analysis for three years. In order to improve and protect water quality conditions, policy need to regulate pollutants emited from mining, big cities and industrial facilities.

Second, considering spatial distribution of water pollution and pollution sources and population, the policies should focus on the hotspot areas, where most of the population and pollution sources are concentrated.

Third, from the point of view of major drivers and pressures influencing the water quality and the condition of water resources, there should be policies to cope with the influx of the population to cities, excessive grazing, and indiscriminate development of upstream regions.

Fourth, as has been confirmed by water quality of Mongolian wells, the policies and projects to guarantee the safety of drinking water in the SRB should be strengthened.

Fifth, in order to solve the deficiency and depletion of water sources, there should be policies and projects for the preservation and efficient use and development of water resources.

Sixth, policies and projects to improve water quality and develop/manage water resources should be adequately financed.

Evaluation of current water management systems of Mongolia and Russia yielded the following policy suggestions with regard to the IWMM.

For Mongolia, first, the rights concerning the water use, for example the ownership of wells in rural pastures, should be properly established through institutional improvement. Second, policies strengthening the coordination capacity of the water management organization and the role of local government should be introduced. Third, as a policy to establish the financial bases for the water management system, a law package should be developed, incorporating current laws on water management and other user charges of water, water resource preservation fee.

For Russia, first, introduction of rational and efficient water supply system is called for, in order to guarantee the drinking water safety and to promote economic use of water resources. Second, regulation policy needs to be strengthened in order to improve water quality and minimize the adverse effect of harmful materials. Third, there should be policies to improve the water management system, create financial resources and increase investment.

Policy implications from expert opinions on the IWMM policy alternative focusing on the hotspot areas, as expressed in the questionnaire results are as follows:

First, Mongolian metropolitan areas need to prioritize the policies and projects related to the water resource preservation, land use planning, and building wastewater treatment facilities. For the mining areas, policies related to the water resource management, land use planning, environmental impact assessment, building wastewater treatment facilities are among the top priorities. Korean experts chose the strengthening of regulation standards for mining as the top priority in the survery. Among the metropolitan hotspots of Russia, policies of water source protection, facility permit system, and solid waste management were most prioritized. For Russia's mining areas, protection of water sources, restoration of mining areas, building wastewater management facilities, building local WWTPs were selected.

The above result shows that water source protection was the most urgent policy issue in the IWMM in hotspot areas for both Mongolia and Russia. The policies regulating the land use, facilities location and permission for development, such as land use planning, facility permit system should be highly priorited. Also, establishing the environmental facilities such as local WWPTs has been also called for.

Policy implications from the expert opinions on the National Water management system, as expressed in the questionnaire results are as follows:

First, for Mongolia emphasis should be placed on solving water shortages and developing water resources, while Russia needs to concentrate more on improving water quality. Second, there is a pressing need to strengthening or introducing the water use fee and wastewater emission charge system. Third, organizational system to coordinate the interests between government branches or interested parties should be strengthened. Fourth, systematic arrangement of water management system and tangible policy means are called for. Fourth, a special policy package consisting of special legislation, specially administrated regions, comprehensive watershed management planning needs to be given serious consideration. Fifth, special policy package should include policy means for the protection of water quality and water ecosystem, and management of water demand as the major components. Sixth, detailed policies should be introduced such as direct regulation on the pollution sources, rationalization of user charge of water, building monitoring system for ground water, technological development, disaster management planning to combat flood/drought, building information system for river conditions.

Policy implications from the expert opinions on major policies and project means of IWMM, as expressed in the questionnaire results are as follows:

On the institutional level, user charge system had high propriety of introduction, but administrative support and substructure for implementation should be in place to guarantee its successful implementation. Policy of water source protection, which consists of regulations on development in upstream region or upstream reservoirs, is highly in demand, but its regulative nature necessitates administrative complementation. Policy means such as EIA, monitoring system, solid waste management system should be accompanied by technological, financial, as well as administrative supports. In general, project means related to the infrastructure, such as reusing water, building local WWTPs were not supported by adequate policy support in technological, financial, and administrative aspects. Especially, financial condition has been identified as the pivotal factor in the successful implementation of projects.

B. Design of IWMM on SRB

a. IWMM Framework on SRB

The basic directions of IWMM on SRB are as follows; first, management of SRB by special policy package, including special legislation. Second, establish a policy coordination body in charge of integrated basin management. Third, gradually improve the integrated river basin management system toward the long-term goal of independent basin management. Fourth, major target areas such as water source area and major pollution sources should be designated the special management zones. Fifth, the management of water quality and ecosystem, water resources, water supply and sewage management, disaster relief, which at present are managed by various government agencies, should be integrated. Sixth, policy means can be categorized into three policy spheres, namely, prevention, control, and financing.

Figure 3-5 indicates the major policy range, sphere and composition of the integrated management according to the basic directions of IWMM on SRB.

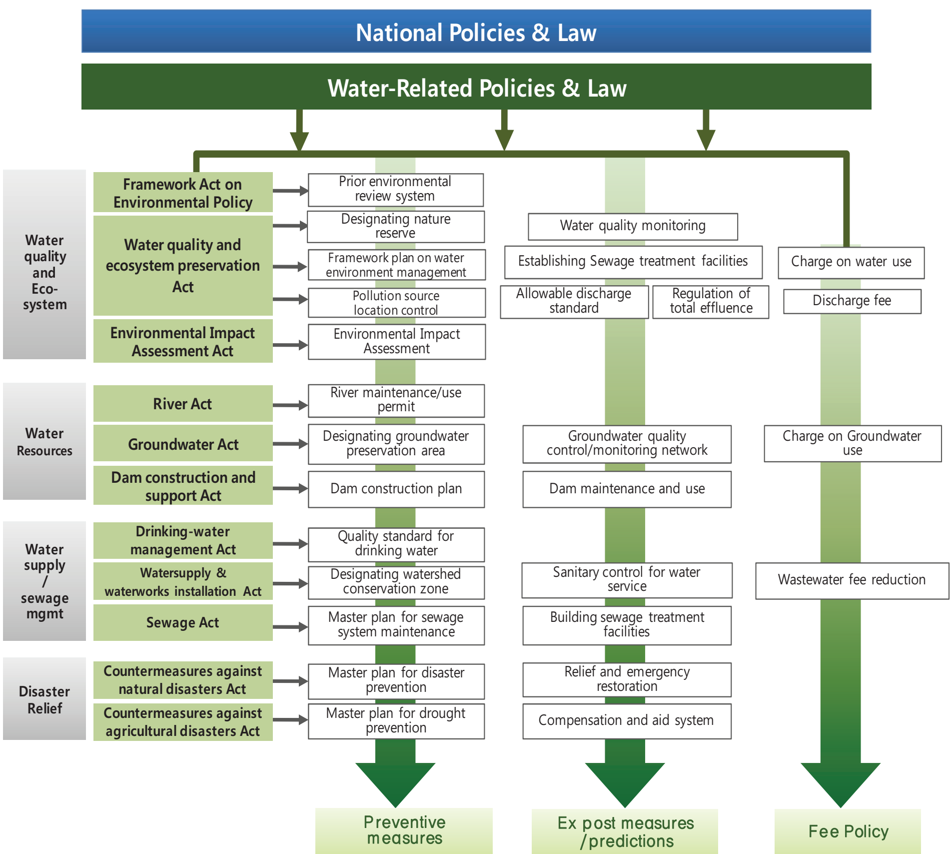


Figure 3-8. IWMM Policy Composition

In our study, we propose a special legislation for the SRB integrated management as part of our framework of IWMM on SRM. The model proposes a special act on SRB management on top of previous legal and policy schemes, as well as a long-term comprehensive planning for SRB management.

The organizational aspect of IWMM involves the long-term plan of establishing the SRB agency as an independent coordinating body, and the mid- and short-term plan of establishing the SRB water management policy coordination committee affiliated to the Office of Premier or the Office of the President.

The following figure is the conceptual framework of IWMM under special act on SRB management.

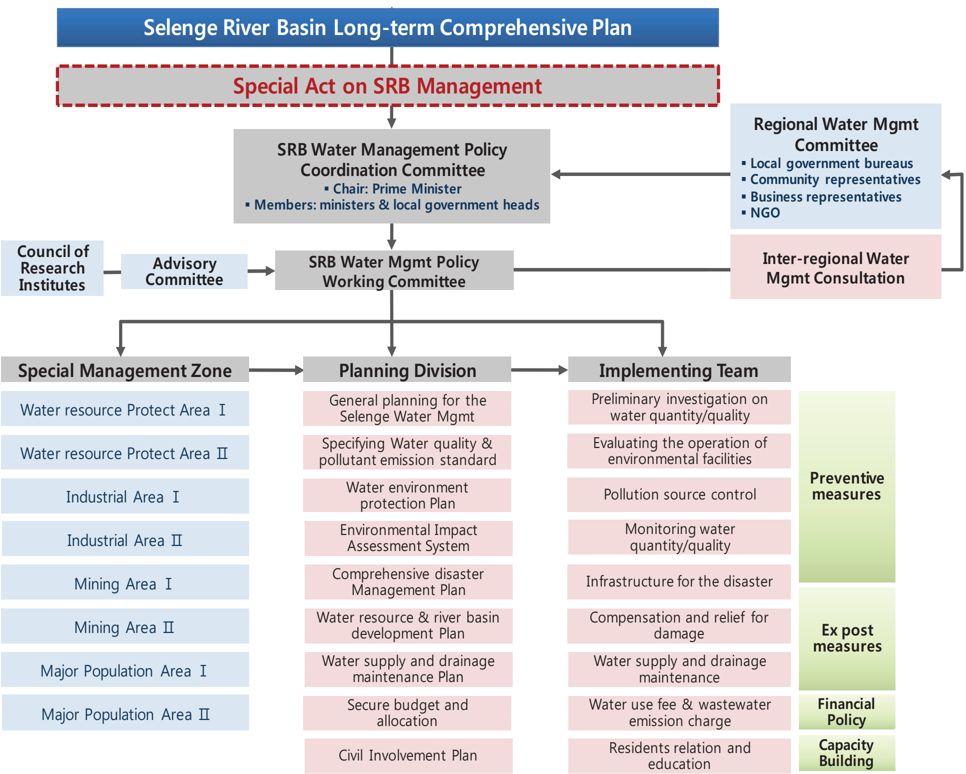


Figure 3-9. IWMM Framwork on SRB

For each country, integrated water management on SRB is a long term goal, but its introduction may not be readily available. Therefore it is recommended to gradually proceed with relevant domestic policies for each country.

At the primary stage, there should be efforts to improve recognition of policymakers and stakeholders and introduce the concept of integrated management in water use, flood control and river environment, while maintaining the current system. And in this stage, the comprehensive plan for the SRB needs to be estasblished.

At the second stage, the information system and the management system should be prepared, followed by the establishment of a SRB committee. The committee will play a central role in establishing the national water management plan for the SRB.

At the third stage, the SRB integrated management will be fully fledged, establishing a special management zone, building administrative branches in charge of making, implementing and monitoring the program tailored to the needs of each basin regions.

Table 3-26. Policy Proposal of Domestic Water Management by Stages

Stage	Domestic Water Management
1st	- Improvement of common understanding of the integrated management necessity of government on water issues - Improvement of different interests in water issues among relevant departments and stakeholders - Preliminary investigation on water quantity & quality - Improvement of lack of administrative and financial capacity - Establishing a comprehensive plan for the SRB
2nd	- Water use fee and wastewater emission charge system - Building Mornitoring System - Building SRB Water Management Policy Working Committee - National water management plan(program)
3rd	- Establishment of special management zone on SRB - Pollution source location control - Regulations of water resources and river basin development

b. Indicators for IWMM on SRB

In addition to the policy proposals, a sustained management of water-related indicators should be a part of the SRB integrated water management plan. This is due to the need for policy adaptation and evaluation based on objective indicators. The following table shows the selected indicators for each categories of IWMM.

Table 3-27. Indicator for IWMM on SRB

Category	Sub-category	Management Indicator
Climate	**Precipitation**	• Precipitation
	Temperature	• annual temperature change
Land	**Agriculture**	• agricultural land area ratio • agricultural production ratio • chemical fertilizer and pesticide usage • pasturage ratio • livestock increase and decrease
	Forest	• forest area ratio • degree of lumbering
	Urbanization	• Urbanization • Population concentration • Water service rate • Wastewater service rate
	Riverside	• Basin pollution rate • Waste dump • Swamp area increase and decrease
Freshwater	**Water quantity**	• Changes in river flow • Changes in water table • Rate of water intake • Daily water consumption per capita
	Water quality	• Water pollution rate of each basin area • water quality • waste water quality
Biodiversity	**ecosystem**	• reservation ratio • number of national biospecies • number of endangered species

Consumption/ Production	**Waste management**	• household and general waste generation • industrial waste generation • livestock excrement dumped into a river • reuse of waste
Disaster	**Disaster management**	• damage caused by natural disaster • Environmental Accident event

By tracing the changes in these indicators, we can evaluate the effects of a policy. The indicators can be policy guides on regional, local and national levels, enabling the systematic examination, implementation and evaluation of the integrated basin management.

Chapter Ⅳ. Transboundary Water Management System on SRB

1. Introduction Transboundary River

A. Transboundary river theory

Definition of Transboundary River

Spatial Range: Water flows through two or more countries on the boundary between the territories or continually of these countries.

Water Resource Range: In recent years, the recognition defines as the full coverage of rivers, lakes, subterranean water and their basins due to the mediation of water allocation and control of environmental Pollution.

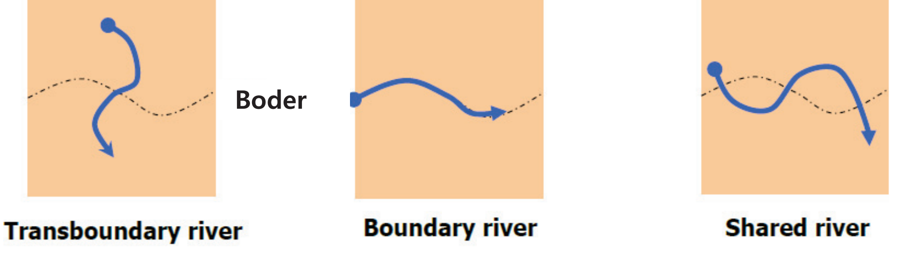


Figure 4-1. The concept of transboundary river, Boundary River, and Shared river

Transboundary River Basin in the World

More than 140 sovereign states share at least 263 international river basins in the world. It is Roughly 40 % of the world's population. Approximately one-half of the earth's surface area is covered with transboundary river basin. (Wolf et al. 1999) In other word, it estimated 60 % of global freshwater discharge.

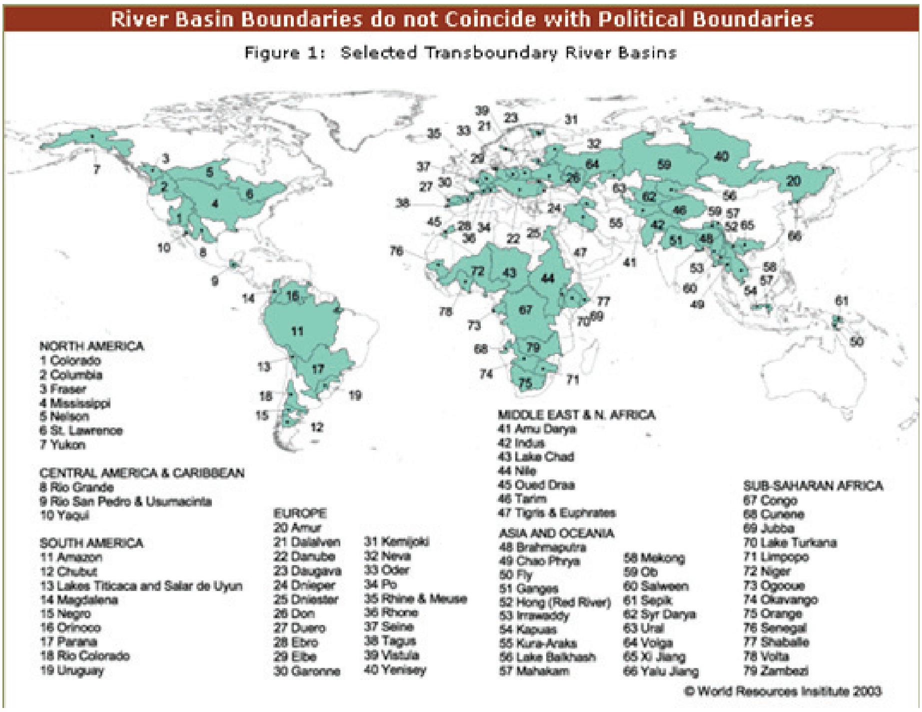


Figure 4-2. Selected Transboundary River Basin

Overview of International Water Management

Over the past century, freshwater resources and their management have increasingly captured the attention of the international community.

- ✓ Lack of access to safe drinking supplies
- ✓ Sanitation for the developing world's population
- ✓ Depleting groundwater resources
- ✓ Degrading water stocks worldwide

The pressures on water resources development lead to intense political pressures because water ignores political boundaries. These problems have lead greater international involvement in water management issues, particularly concerning the world's international basins.

Complexity of Management Transboundary River Basin

Managing international freshwater systems is complicated by the need for cooperation between nations. At present, approximately one-third of all international basins are shared by at least three countries. 19 basins contain five or more countries (ex: the Danube, involves 17 riparian states). Riparian countries have different needs and perspective for transboundary river use.

Overview Transboundary River Issues

Disparities (Differences) between riparian nations add further complications to water resources management Such as Economic Development, Infrastructural capacity and Political orientation. Characteristics of recent transboundary river issues are more serious and diversified because of important of environment and pressure of water development. Past time navigation was a main issue in Europe, and then water allocation conflicts were very common, currently combined problem to water quality and flood problem are expanded.

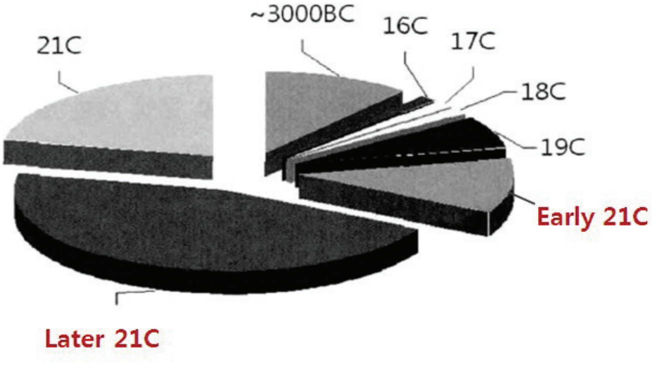


Figure 4-3. Chorological table of Int'l Water Disputes

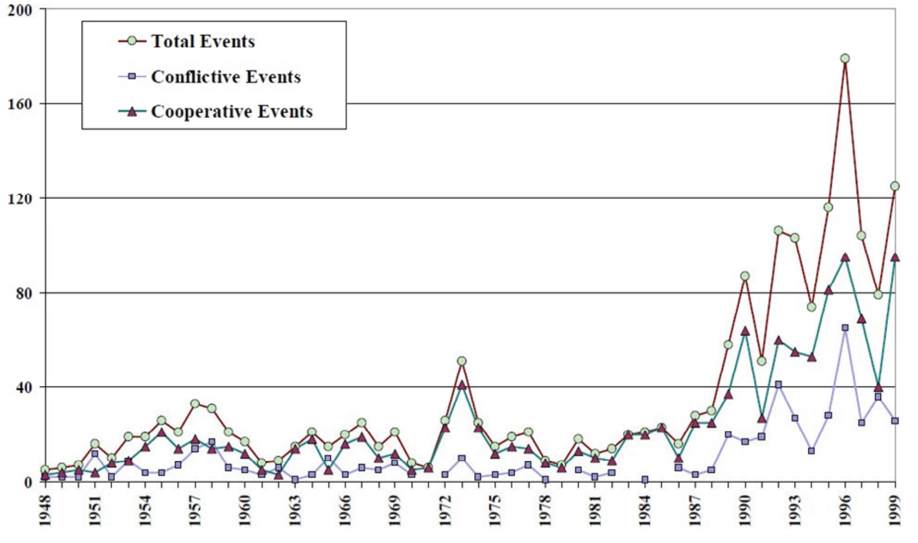
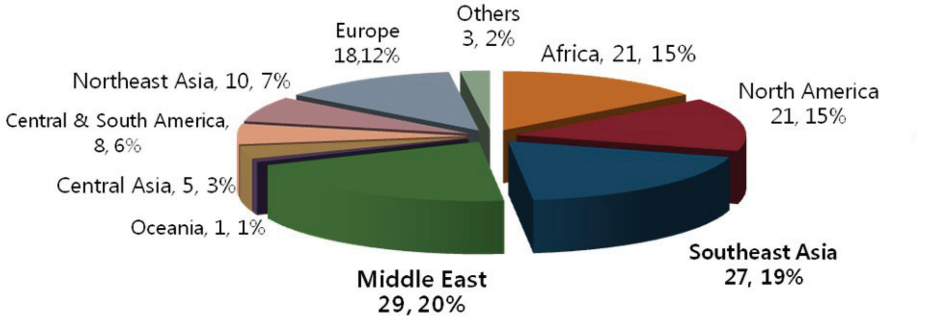


Figure 4-4. Distribution of Cooperative, Conflictive, and Total Events By Year

Above Figure shows the number of cooperative, conflictive, and total events by year.



*Regions, Mumbers of case, %

Figure 4-5. Water disputes caused by more than 2 countries after WW II

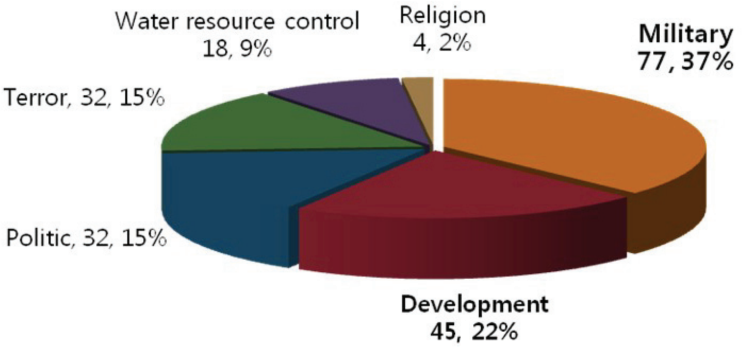


Figure 4-6. Causes of water dispute events

Theories of Transboundary River Use

The principle of the transboundary water use applies variously depends on circumstance of water and interests among countries. The Cooperation for resolving conflict and dispute is needed. Every country persists in the most profitable principle for safeguarding their national interests.

Table 4-1. Theories of Transboundary River Use

Types		Contents	Applied cases
Unilateral Principle	Absolute Sovereignty (Harmon's Doctrine)	Right to unlimited use of water in fatherland.	The Rio Grande (USA), The Euphrates River (Turkey)
	The principle of preoccupy	Preceded use action has legislative priority	The Colombia River (USA), The Nile (Egypt)
	Absolute territorial integrity	Prohibit development of damaging water amount and water quality at basin areas	The Indus (Pakistan), Committee of the Danube River conservation
Mutual Principle	The principle of mutual development	Development of River basins would implement with consent of all parties	Committee of the Mekong

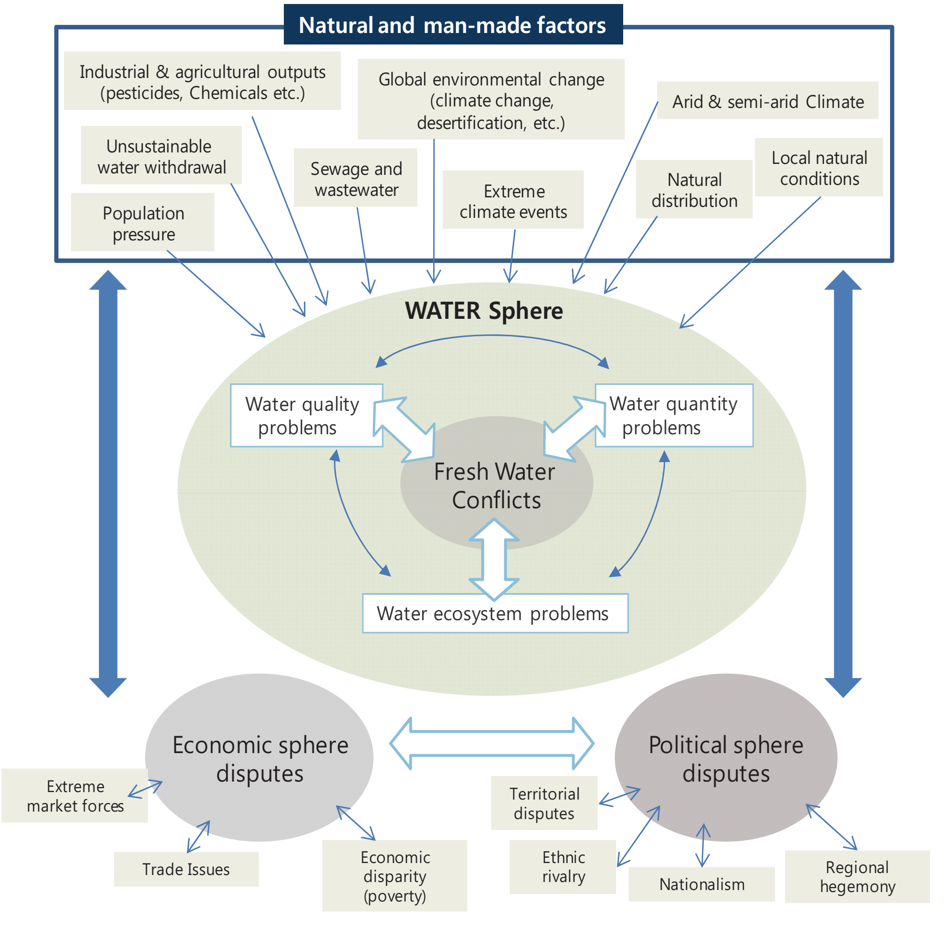
Types		Contents	Applied cases
	The principle of mutual use	The veto against agreement of International water use is available, if there is a case of inadequate compensations.	Upper Stream of the Rhine (Germany and Holland)
	The principle of linkage	Different types of issues might provide benefits to parties and transboundary water agreements have to be linked	Agreement between Israel and Jordan
	Helsinki Rules	Right of the water resource use	Countries in Upper stream of the Nile
etc	The principle of preventing serious damage	Countries have the proper duty of stoppage and prevention on use behaviors that might do harm to other countries	Europe (Eased principle of preventing serious damage)
	NEEDS based principal	Allocation water based on its NEEDS	Middle East area

Issue	Total		Cooperative		Neutral		Conflictive		Extreme Cooperative		Extreme Conflictive	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Water quantity	857	46	450	36	68	71	309	61	44	28	19	90
Infrastructure	351	19	203	17	19	20	129	25	4	3	2	10
Joint Management	225	12	208	17	4	4	13	3	21	13	0	0
Hydropower	175	10	163	13	3	3	9	2	46	29	0	0
Water quality	102	6	78	6	0	0	24	5	18	11	0	0
Technical Cooperation	42	2	41	3	0	0	1	0	0	0	0	0
Flood Control/Relief	38	2	31	3	1	1	6	1	8	5	0	0
Irrigation	30	2	24	2	1	1	5	1	1	1	0	0
Border Issues	25	1	14	1	0	0	11	2	4	3	0	0
Economic Development	9	0	9	1	0	0	0	0	7	4	0	0
Navigation	7	0	7	1	0	0	0	0	4	3	0	0

Figure 4-7. Int'l River Basin Events regarding cooperation/conflict level and Issue

B. Issues of Transboundary river management

a. Issues to Cooperation within Shared Rivers Basins



b. Important Functions of International River Basin Organizations

- Reconciling and harmonizing the interests of riparian countries
- Technical cooperation
- Standardization of data collection
- Exchanges of hydrologic and other information
- Monitoring water quantity and quality

-Submission for examination and approval of proposed activities, schemes or plans which could modify the quantity and quality of the waters
-Development of concerted action programs
-Enforcing agreements
-Dispute resolution

c. Identifying Cooperative Benefits

Table 4-2. Summary of *Cooperative Benefits*

Cooperative Management	Benefits
Benefits to the River	Reducing the potential detrimental effects on the socio-economic well being of a riparian state by fostering a healthy ecosystem. (*Cooperative Environmental Management*)
Benefits from the River	Good water management practices can effectively increase the available water resources in a system, allowing for increased benefits. (*Cooperative Development*)
Reduction of costs because of the River	Tension and disputes that arise because of the shared resource may reach the point where they color the geo-political relationships between states within a basin and become obstacles to growth by constraining the regional political economy and diverting resources from economic development and social well being. (*Diminishing the Costs of Non-Cooperation*)
Benefits Beyond the River	Cooperation in the management and development in transboundary basins may contribute to, or even result in, political processes and institutional capacities that themselves open the door to other collective actions. (*Broader Opportunities Catalyzed by Cooperative Management of the River*)

Source : (Sadoff & Grey 2002)

d. Stages towards Cooperation

Table 4-3. Developing a shared Vision

Developing a Shared Vision	
Initiating Process	'Bringing the Parties to the Table'- The stage when stakeholders are identified, parties convene, shared visions are considered, conflicts are diagnosed and the benefits of cooperation are assessed.
Institutional Management	The 'Agreement' – Solidifying a legal framework based on an established shared vision, building capacity for institutional management, ensuring accountability, participation at all levels, good governance, and stakeholder consultation, etc. are part of the institutional management.
Implementing the Shared Vision	
Programme Implementation	'Seeing the Benefits'-Where parties implement the shared vision, perform ongoing monitoring to develop uncontested databases, perform joint research projects.
Investment in Water Management Works	'Realizing the Vision'- Joint-development of water-related infrastructure.

Source : (Sadoff & Grey 2002)

e. Potential Services to Improve Water Cooperation

Table 4-4. Potential Services to Improve Water Cooperation

Direct Assistance
▪ Assisting in convening parties; ▪ Design of dispute management systems; ▪ Facilitating joint fact-finding arbitration; ▪ Basin-wide access to knowledge and tools; ▪ Assess dispute situations and needs; ▪ Mediation/Facilitating;

Direct Assistance
▪ Arbitration; ▪ Impartial third party advice; ▪ Enforcing agreements; ▪ Diagnosing conflict; ▪ Assistance in accessing financial resources; ▪ Implementation of agreements; ▪ Participation and stakeholder identification ▪ Establishing joint technical committees; ▪ Creating joint development ventures; ▪ Best practices analysis and cooperation identification; ▪ Performing joint research projects(modeling, data collection); ▪ Designing, implementing and adapting institutional and legal frameworks;
PUBLIC INFORMANTION & OUTREACH
▪ Organize and assist stakeholder advisory committees; ▪ Organize and assist community advisory committees; ▪ Encouraging political engagement;
TRIAING
▪ Education and training; ▪ Capacity building;
RESEARCH
▪ Research related to the anticipation/prevention/resolution of water related to conflicts(visioning)

Source : Sadoff & Grey, 2002

C. Transboundary river Cooperation case study

There are several causes of transboundary river dispute.

- Insufficient amount of freshwater due to the population growth
- Lagged scientific technology of developing countries
- Difference of River use between upper stream coundry and downstream country
- Absence of International treaties and cooperation relating with Int'l watercourse management
- Separation and Independence of emerging countries by sudden political structural changes

The international water disputes occur due to interaction of these various factors.

Table 4-5. Selected examples of water-related disputes

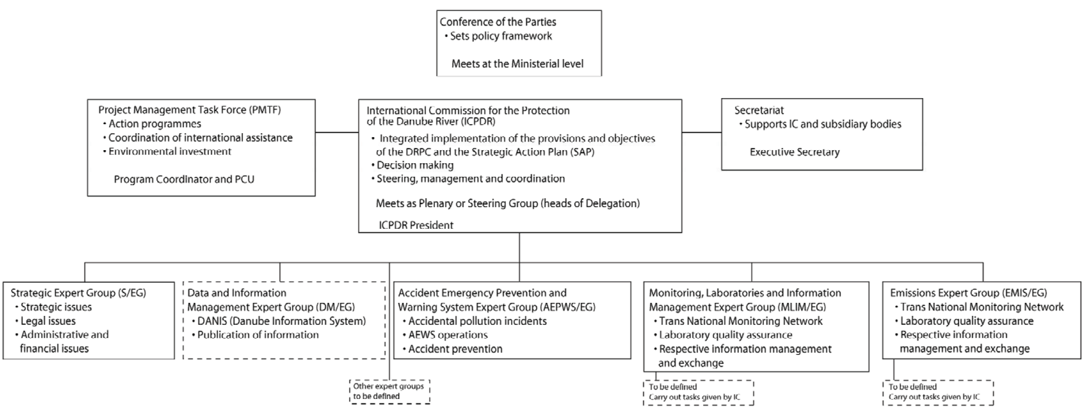
Location	Main Issues - Observation
	Quantity
Cauvery River, South Asia	The dispute on India's Cauvery River sprang from the allocation of water between the downstream state of Tamil Nadu, which had been using the river's water for irrigation, and upstream Karnataka, which wanted to increase irrigated agriculture. The parties did not accept a tribunal's adjudication of the water dispute; this led to violence and death along the river.
Mekong basin, Southeast Asia	Following construction of Thailand's Pak Mun Dam, more than 25,000 people were affected by drastic reductions in upstream fisheries and other livelihood problems. Affected communities have struggled for reparations since the dam was completed in 1994.
Okavango basin, southern Africa	In the Okavango River basin, Botswana's claims for water to sustain the delta and its lucrative ecotourism industry contribute to a dispute with upstream Namibia, which wants to pipe water passing through the Caprivi Strip to supply its capital city with drinking water.
	Quality
Rhine River,Western Europe	Rotterdam's harbor had to be dredged frequently to remove contaminated sludge deposited by the Rhine River. The cost was enormous and consequently led to controversy over compensation and responsibility among Rhine River users. Although the negotiations led to a peaceful solution, in areas that lack the Rhine's dispute resolution framework, siltation problems could lead to upstream/downstream arguments.
	Quantity and quality
Incomati River, southern Africa	Dams in the South African part of the Incomati River basin reduced freshwater flows and increased salt levels in Mozambique's Incomati estuary. This altered the estuary's ecosystem and led to the disappearance of salt-intolerant plants and animals that are important for people's livelihoods.
	Timing
Syr Dar'ya, Central Asia	Relations between Kazakhstan, Kyrgyzstan, and Uzbekistan—all riparians of the Syr Dar'ya, a major tributary of the disappearing Aral Sea—exemplify the problems caused by water flow timing. Under the Soviet Union's central management, spring and summer irrigation in downstream Uzbekistan and Kazakhstan balanced upstream Kyrgyzstan's use of hydropower to generate heat in the winter. But the parties are barely adhering to recent agreements that exchange upstream flows of alternate heating sources (natural gas, coal, and fuel oil) for downstream irrigation and sporadically breach the agreements.

The 145 treaties which govern international watersheds around the world, and the international law on which they are based, are in their respective infancies. More than half of these treaties include no monitoring provisions whatsoever and, perhaps as a consequence, two-thirds do not delineate specific allocations and four-fifths have no enforcement mechanism. Moreover, those treaties which do allocate specific quantities, allocate a fixed amount to all riparian states but one-that one state must then accept the balance of the river flow, regardless of fluctuations.

One problem hampering the development of sophisticated water treaties may have been the difficulty in acquiring information on similar settings. Thus far, each set of negotiators has had to, in effect, independently invent solutions.

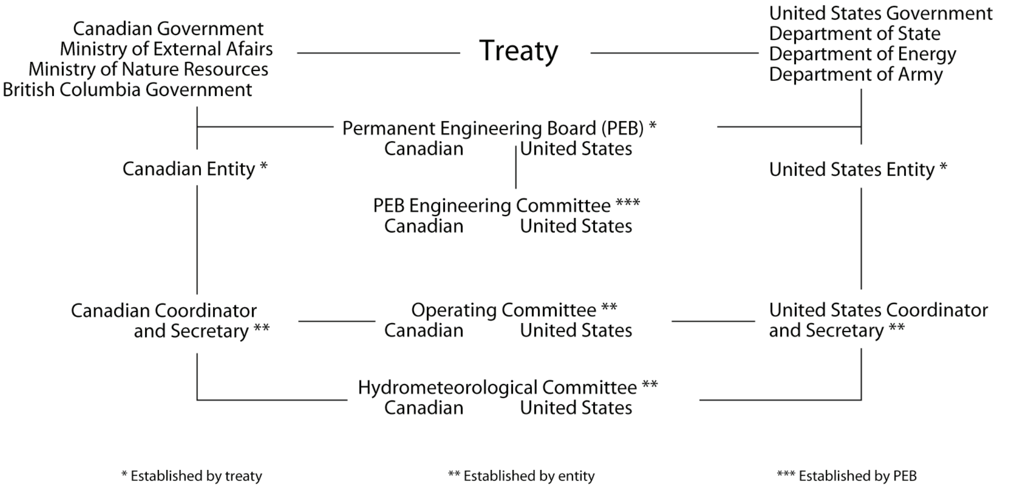
Transboundary water and International Institutions

The international community has long grappled with effective institutional arrangements for managing shared water resources. From the international to the local, grappling with the institutional implications of shared waters has taken many forms, from international declarations to guiding principles to treaties and local management.



Nachtnebel, 1999/2000; Natchkov, 2002

Figure 4-8. Structure of the International Commission for the Protection of the Danube River



Delli Priscoli, 2005

Figure 4-9. Columbia River Treaty Organization flow chart

D. Characteristics of SRB as a Transboundary River

Present Mongolian-Russian Transboundary Agreements and Management System

In 1974, a transboundary agreement between Mongolia and Russia was signed in order to protect the Selenge River Basin. Increased economic and industrial development in both countries was a part of concerns.

In 1995 the agreement was expanded to include the protection of transboundary water resources on almost 100 small rivers and streams in the west (Governments of Russian Federation and Mongolia, 1995).

In 2004, the intergovernmental discussion had concentrated on deciding order of priority for protecting and using of transboundary waters. Agreement in this period had required to adjust due to the political, legislative, and social changes.

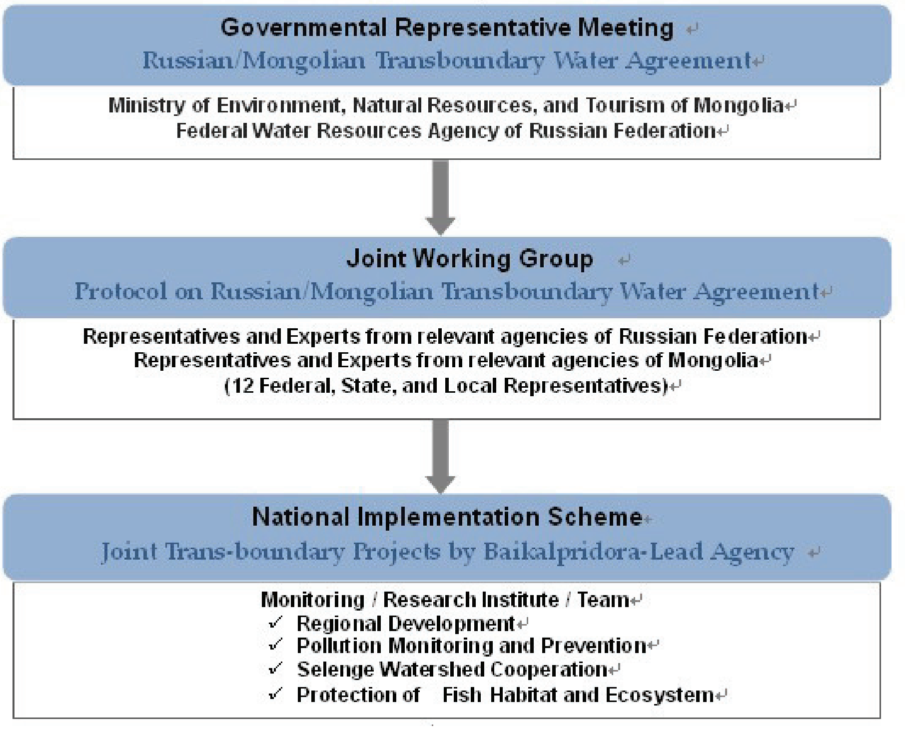


Figure 4-10. Transboundary Institutional Structure

The chart above describes the structure of the Russian-Mongolian Transboundary Agreement (Brunello 2005).

1) Governmental Representative Meeting decides the directions and activities by cooperative bilateral bodies under the agreement. Both governments have authority to nominate the representative through governmental decree.
2) Joint Working Group charges with the preparatory of Governmental Representatives Meeting. And, the other works of Joint Working Group are as follows:
   - ✓ The works below each joint working group are managed separately. However, they could cooperate when the emergency occurred on the territory in two countries.
   - ✓ The meeting of joint working group organizes territories once in two years.

- ✓ The arisen problems during the working have to be discussed and solved on the meetings of joint working group.
- ✓ The questions discussed on the meetings of joint working group are presented on the Governmental Representatives Meetings.
- ✓ The experts can be invited to solve sensitive questions on meetings of joint working group.
- ✓ Joint working group may gather international investments from other organizations to execute joint projects.

3) Joint transboundary projects are facilitated by the Baikalpridora consisting of Regional Development, Pollution Monitoring, Selenge Watershed Cooperation, and the Protection of Fish Habitats and the Ecosystem.
   - ✓ Water quality monitoring activities on Transboundary water by the standard of hydrological alignments: Monitoring the quality of transboundary waters in Russian Federation is implemented by three different federations which are Repubic Buryatiya, Republic Tyva, and the Chita area. These three federations charge of inspecting and supervising the quality of transboundary waters. The method to inspect quality of transboundary waters is developed in second meeting. Method consists with 16 indicators to distinguish polluting substances. The joint Russian-Mongolian working group inspects the quality of transboundary waters by measuring maximum concentration of substances such as mercury, phenol, zinc, and iron.
   - ✓ Reporting System for emergent accident on SRB: The joint reporting system for emergent accident is as follow;

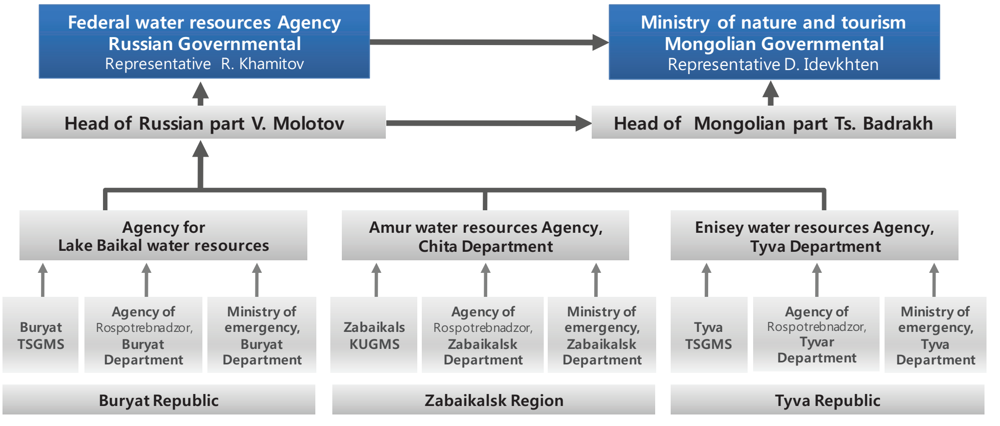


Figure 4-11 . Emergent Accident Reporting System on SRB Transboundary

Evaluating Mongolian-Russian Transboundary Agreements

- ✓ The agreement on the preservation and rational use of the international river remains on the conceptual level, without a concrete principle for joint management.
- ✓ It does not reflect the principle of international agreement.
- ✓ It has no binding force both legally and institutionally
- ✓ There is no standing body governing the matter, although meetings are held from time to time

Evaluating Mongolian-Russian Transboundary System

- ✓ There is no finance system to promote continuous investigation, research, and monitoring activities aimed at preservation and sustainable use of the Selenge River Basin
- ✓ Lack of channel to share information, and the absolute lack of data on the international rivers
- ✓ Need for coordination and standardization of indexes of polluting substances
- ✓ Need for sanitary supply of water sources and investigation and management of water-borne diseases
- ✓ Need for evaluation and preservation for water ecosystem (especially

the fish stock) of the Selenge River Basin
- ✓ Need to facilitate the monitoring system
- ✓ Functioning the Scheme of notifications of the Parties about especially dangerous phenomena at acts of nature and emergencies
- ✓ Current researches and projects are driven mostly by Russia

The characteristic of the Selenge River Basin as an international river

- ✓ Bordered by only two countries (Mongolia and Russia)
  : Most international rivers are bordered by numerous countries, from at least 2-3 up to 17 countries sharing a river => SRB is governed by a bilateral treaty, rather than a regional agreement involving multiple parties
- ✓ Since the downstream country is more powerful than the upstream country, conflict and tension is more likely to arise were there to be an environmental problem.
- ✓ Upstream country has development needs, and there is an ongoing dam construction plan
- ✓ A difference in the regulation standard for heavy metal contamination between the two countries is a major research issue
- ✓ Need to consider the ecological impact on the Lake Baikal, the protection of which is an international concern
- ✓ Border conflict is not included in the issues concerning the joint river
  : There is no reported case of problem due to unilateral development (e.g. water pollution or reduction of flows due to dam construction) as yet, but there exists a possibility of conflict caused by the economic development, overpopulation, and Mongolian dam construction plans

	Water Scarcity (Water Allocation)	Racial / Religion	Economic Development (irrigation / generation)	Environment (water quality / ecology)	Inland transportation	Tension relationship (opposition / cooperation)
The Rhine	X	X	○	◎	◎	Cooperation
The Danube	X	○	◎	◎	X	Opposition
The Jordan River	◎	◎	◎	◎	X	Opposition
The Tigris – Euphrates River	◎	○	◎	X	X	Opposition
The Nile	◎	X	◎	○	X	Opposition
The Ganges	◎	◎	◎	X	X	Opposition
The Mekong	X	X	◎	○	◎	Cooperation
U.S.A / Mexico	◎	X	○	◎	○	Opposition
U.S.A. / Canada	◎	X	◎	◎	◎	Cooperation
*Selenge River	○	X	○	◎	X	Cooperation

Reference : Very affinitive (◎), affinitive (○), No relationship (X)

Figure 4-12.Types of Transboundary River disputes

Table 4-6. Hydrographic characteristic of the Selenge River

State	Length, (km)	Catchment Area thousand (km²)	Ratio of Catchment Area of Lake Baikal (%)	Avg. annual amount of the River flow (km³)	Ratio of the total inflow into Lake Baikal (%)
Mongolia	534.0	299 (66.9%)	55.4	14.1	23.3
Russian	409.0	148 (33.1%)	27.4	32.5	28.8
Total	943.0	447 (100%)	82.8	46.6	52.1

Source: Regional Scheme of Complex use and Conservation of Water Resources of Selenge River Basin (on the Mongolian territory), Ulaanbaatar, 1986

2. Expert survey and Result

A. Background of expert survey

This project has some limitations and data insufficiency because the water quality data result cannot give the full and detail pictures. River pollution by heavy metals is considered to be significant only for local area, not in prolonged reaches. In our case, the current condition of the Selenge River Basin is still considerably good as assimilative capacity is using for self-purification with high rate. But any ecosystems can loss its ability to receive external deterioration and degradation. That is why it cannot be infinitely used by intensive and extensive nature use in Basin, like in our example in Zaamar mining area (Mongolian site). The upstream of the Selenge River Basin is located on Mongolian site and they should use the water resources with care. In order to left for downstream the water resources in good and enough conditions.

Another point of our study is two countries are using different water quality criteria's usage: Mongolia – for drinking water usage, and Buryatia (Russian site) – for fishery water usage. Where we noticed that Russian site is using more strict water quality standard values than one in Mongolia, even thgough Russian site is downstream of the Selenge River Basin. The Selenge River is the main tributary of Baikal Lake (World natural Heritage) which has high biodiversity of plants, fishes and animals

Therefore, the overall objective of this project is to develop the IWMM for sustainability of the SRB to meet international level. Joint research team has tried to identify the needs and expectations of major actors and stakeholders of Mongolia and Russia to develop the potential transboundary water management system on the SRB in addressing common water issues. The survey composed of three parts. The first part is to investigate the recognition of the Transboundary Water Isssues in the SRB, the second part is to investigate the evaluation of the Transboundary Water Management and the third part is to investigate the development of the Transboundary Water Management System on the SRB System.

B. The results of expert survey

Following graphs show the results of expert survey of Transboundary Water Management System on the SRB. 15 Mongolian experts and 19 Russian experts participated in the survey. On the whole, the opinions of experts between Mongolia and Russia are not identical.

Most of experts agreed or slightly agreed that there are several transboundary water issues of the SRB that need to cope with by cooperation activities between Mongolia and Russia.

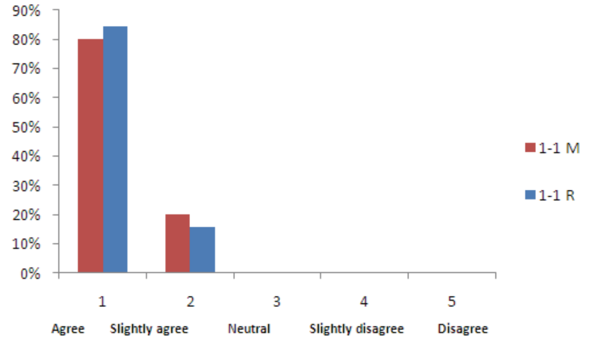


Figure 4-13. Result of the question 1-1 for Mongolia and Russia

Also, most of experts agreed or slightly agreed that the transboundary water issues of the SRB will go on increasing and become significant transboundary issues between Mongolia and Russia.

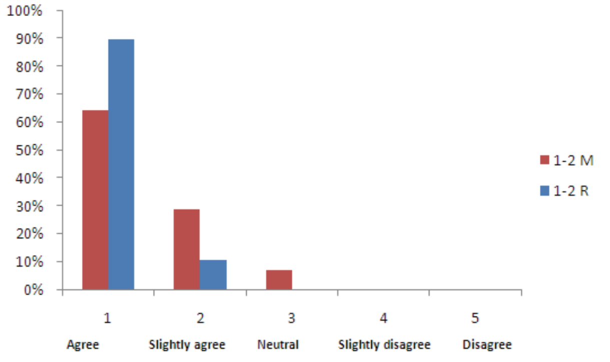


Figure 4-14. Result of the question 1-2 for Mongolia and Russia

Mongolian and Russian experts chose two of the most significant, CURRENT transboundary water issues in the SRB, and ranked them in order.

Mongolian experts chose "Water resources shortage" and "Heavy metal pollution" as a fisrt order, and Russian experts chose "Water pollution (transboundary water pollution)".

Mongolian and Russian experts chose two of the most significant, FUTURE transboundary water issues in SRB, and ranked them in order.

Mongolian experts chose "Water flow allocation" and Russiand experts chose "Water pollution (transboundary water pollution)".

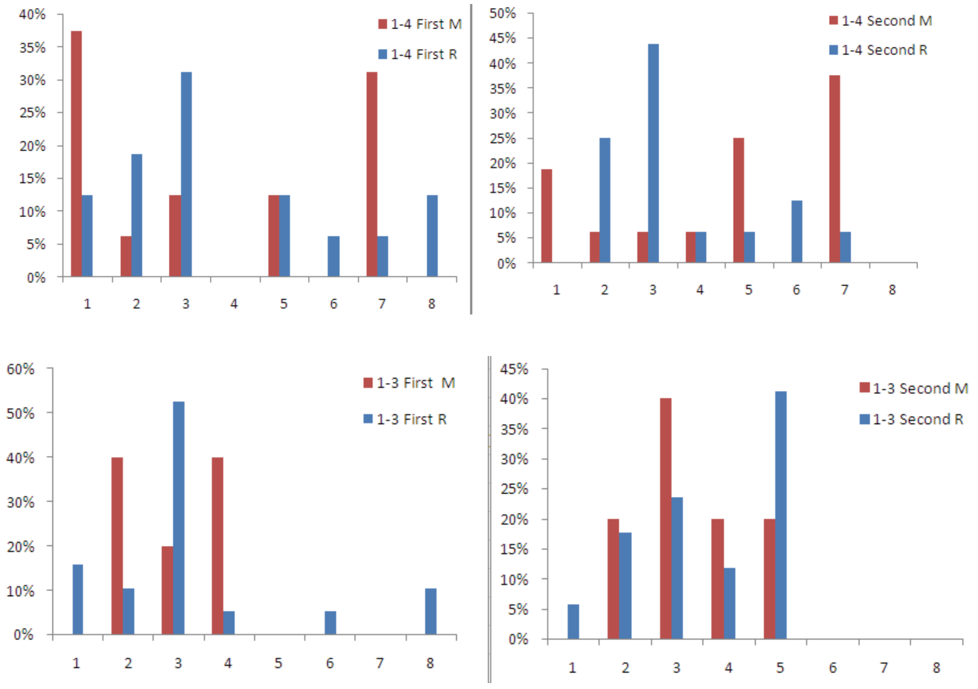


Figure 4-15. Result of the question 1-3 and 1-4 for Mongolia and Russia

1. Water flow allocation
2. Water resources shortage
3. Water pollution(transboundary water pollution)
4. Heavy metal pollution
5. Ecosystem deterioration/Biodiversity loss
6. Climate change/Natural disaster (Flood etc.)
7. Development of river basin (Dan construction etc.)
8. Others

Following results of expert's opinion show that it is needed or not that the bilateral agreements for rational use and protection of water in the SRB between Mongolia and Russia as transboundary water management system have been known well among major actors and stakeholders of relevant organizations in two countries. 90% of the experts of Russian agreed, but over 50% of the experts from Mongolia were neutral or slightly disagreed.

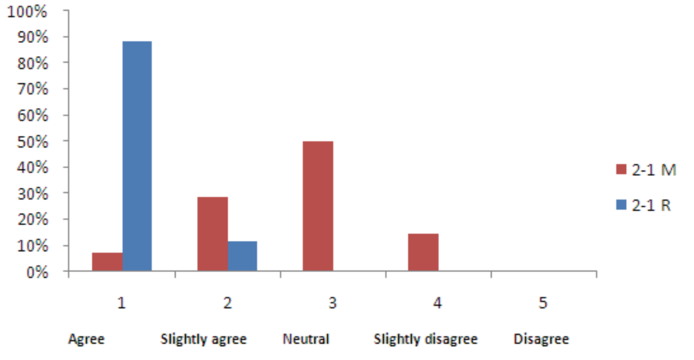


Figure 4-16. Result of the question 2-1 for Mongolia and Russia

Following results of expert's opinion show that it is needed or not that the activities under bilateral agreements produced positive outcomes in addressing rational use and protection of water of the SRB in Mongolia and Russia.

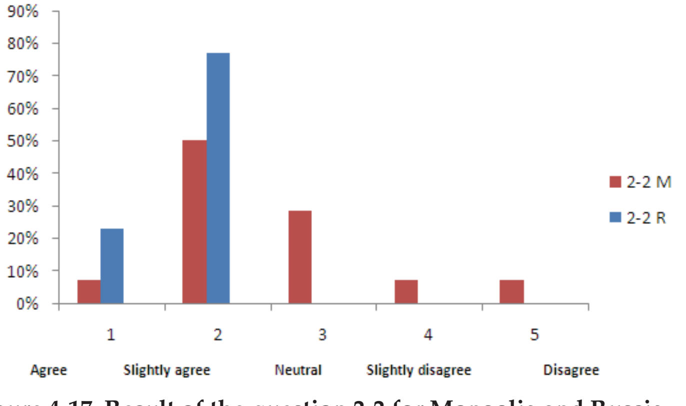


Figure 4-17. Result of the question 2-2 for Mongolia and Russia

Following results of experts' opinion (2-3) show that selections of the most important cooperation activities under bilateral agreements for rational use and protection of water in the SRB between Mongolia and Russia as transboundary water management system. 2-4 results show that selections of the cooperation activities that produced positive outcomes in the water state of the SRB under bilateral agreements.

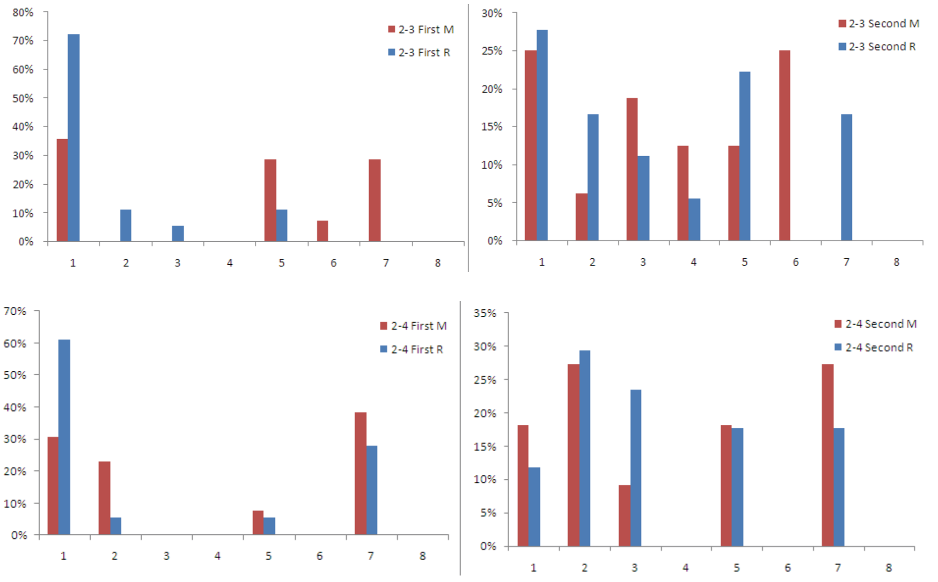


Figure 4-18. Result of the question 2-3 and 2-4 for Mongolia and Russia

1. Monitoring the quality of water
2. Monitoring the sanitary status and epidemiological control on water
3. Studying impact of Mongolia mining factories in SRB to the water status
4. Providing of natural migratory condition of fishes and other water animals in water
5. Treating the scheme of using and protecting water
6. Operating emergent accident reporting system
7. Researching with other scientific organizations for rational use of water
8. Others

They chose two of the concrete achievements through cooperation activities under bilateral agreements. Following graph shows the result. In the Mongolian part, “Establishment of cooperation bodies and dialogue channel” was dominant as a first order, but there was no dominant opinion of the Russian part as a first order.

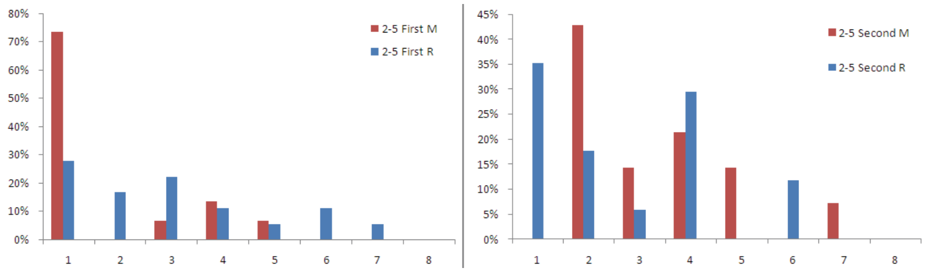


Figure 4-19. Result of the question 2-5 for Mongolia and Russia

1. Establishment of cooperation bodies and dialogue channel
2. Proliferation of cooperation necessity between two countries
3. Improvement of Understanding of water states in various aspect
4. Understanding of water management policies of two countries each other
5. Strengthening of water management policies and investments of two countries
6. Improvement water state including water quality etc.
7. Water management awareness promotion in two countries
8. Others

They chose two of the most serious limitations or weak points in transboundary water management system for addressing rational use and protection of water of the SRB, and ranked them in order. Following graphs show the results.

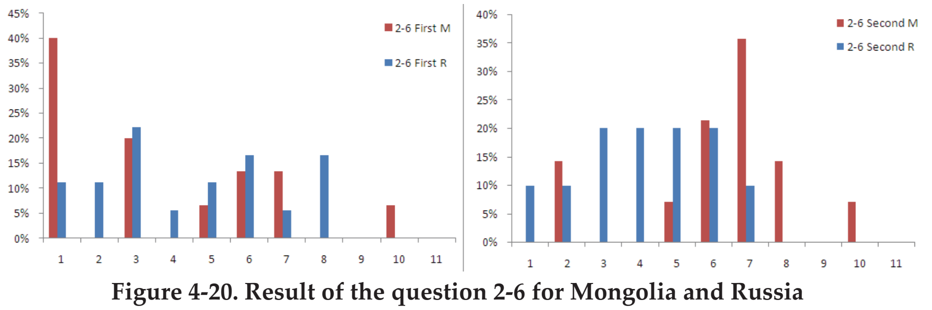


Figure 4-20. Result of the question 2-6 for Mongolia and Russia

1. Insufficient recognition of transboundary water issues
2. Insufficient recognition of the cooperation necessity of each government on

transboundary waterissues
3. Different interests in transboundary water issues between countries
4. Different interests in transboundary water issues in relevant stakeholders of each country
5. Lack of implementation scheme in national level of each country
6. Lack of relevant policies and investment in national level of each country
7. Lack of human/financial resources and institutional arrangement of cooperation bodies
8. Lack of cooperation projects and activities
9. Lack of public awareness of two countries
10. Absence of leading country and competitive to take initiative
11. Absence of legal binding mechanism to each country behavior
12 Others

Most of the experts from both countries agreed that the transboundary water management system of the SRB should be strengthened like other transboundary river management cases for addressing rational use and protection of water in two countries.

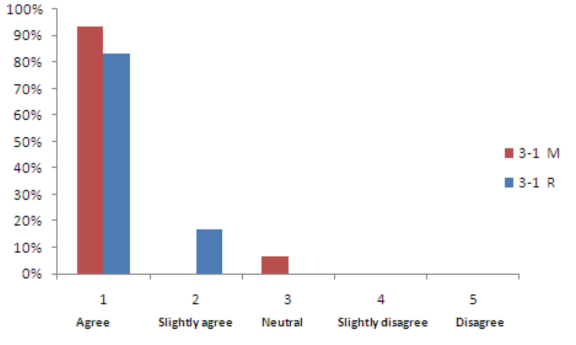


Figure 4-21. Result of the question 3-1 for Mongolia and Russia

Following graph shows opinion that the principle of water use, protection a nd management of the SRB should be applied through agreement between M ongolia and Russia based on the water states and interests of two countries an d relevant stakeholders.

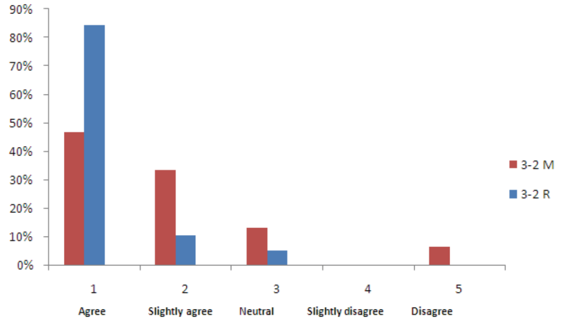


Figure 4-22. Result of the question 3-2 for Mongolia and Russia

Following result (3-3 & 3-4) shows the different opinion between Mongolian experts and Russian experts. The questions are following:

In the long term, Current bilateral agreement need to develop a legal binding treaty by stages for join water management on SRB between two countries

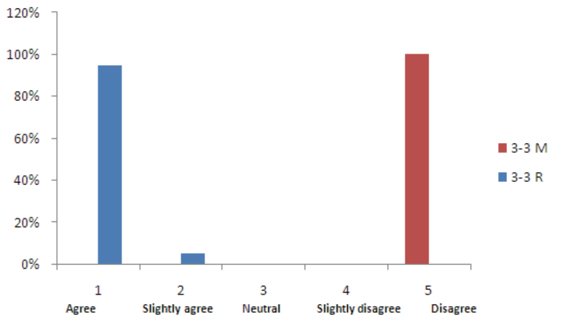


Figure 4-23. Result of the question 3-3 for Mongolia and Russia.

In near future, Current government meeting of transboundary water management system need to develop a permanent joint management organization by two countries.

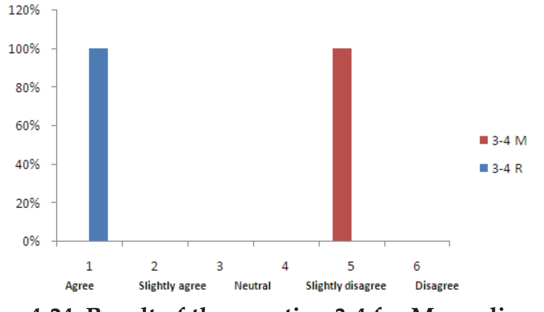


Figure 4-24. Result of the question 3-4 for Mongolia and Russia

Other countries or international organizations need to participate to the cooperation bodies for promoting cooperation activities and developing transboundary water management system and relevant activities.

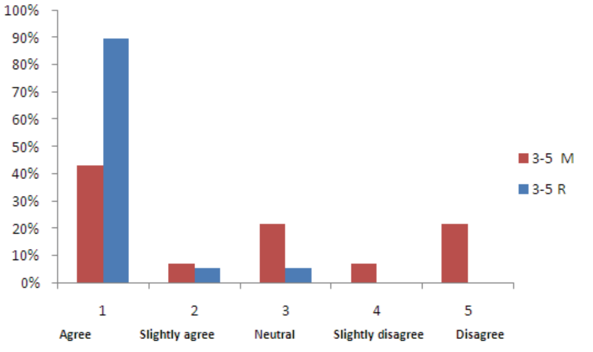


Figure 4-25. Result of the question 3-5 for Mongolia and Russia

Please choose two priority issues that should be addressed in transboundary water management system

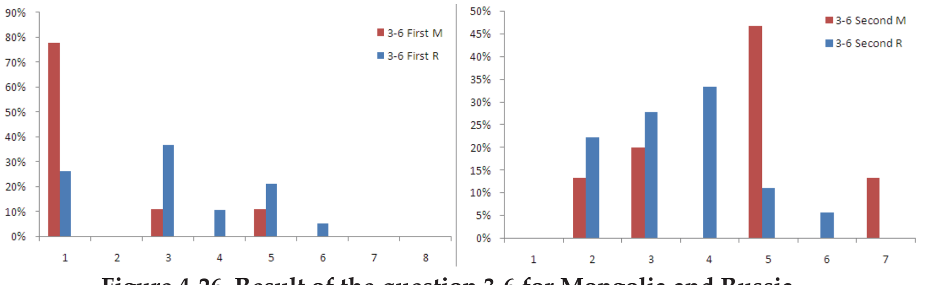


Figure 4-26. Result of the question 3-6 for Mongolia and Russia

1. Fair and proper water flow allocation
2. Mitigation and settlement of water resources shortage
3. Protection of water pollution(transboundary water pollution) and improvement of water quality
4. Protection of Heavy metal pollution and insurance of human health
5. Conservation of ecosystem deterioration/Biodiversity loss
6. Climate change/Natural disaster (Flood etc.) mitigation and adaptation
7. Development and use of river basin (Dan construction etc.)
8. Others in future.

Please choose two priority activities for emission reduction and water quality protection in transboundary water management system in future, rank them in order.

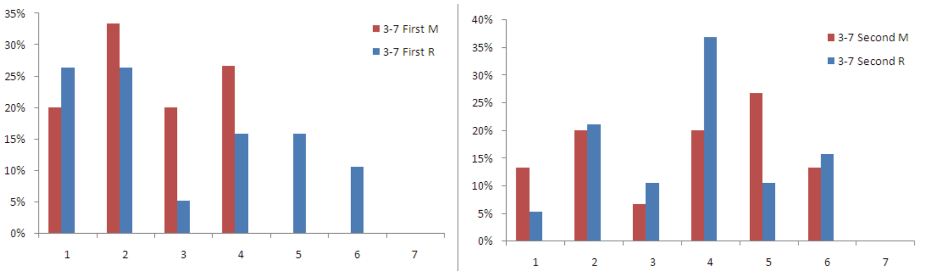


Figure 4-27. Result of the question 3-7 for Mongolia and Russia

1. Strengthening policies dialogue on the emission charge and management system
2. Establishment of joint monitoring and data exchange system
3. Strengthening of emergent environment accident transmission system
4. Adaptation of common water quality standard and pollutant emission standard
5. Financial assistance and technology transfer cooperation between two countries
6. Promotion of international cooperation with other countries and international organization
7. Others

Please choose two important activities for river basin development in transboundary water management system in future, rank them in order.

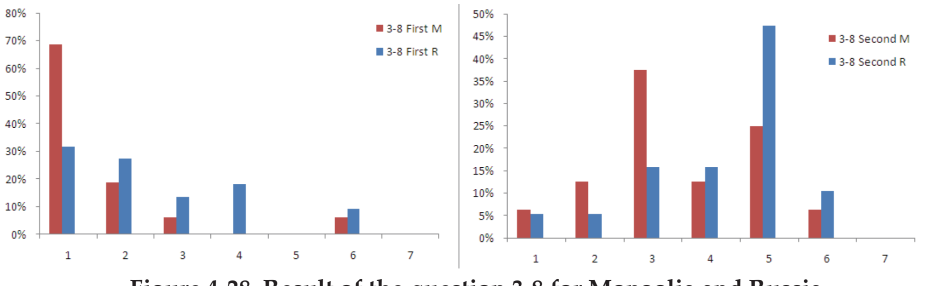


Figure 4-28. Result of the question 3-8 for Mongolia and Russia

1. Strengthening policy dialogue in the process of river basin development
2. Joint implementation process of EIA
3. Protection of water resources and potential development capacity
4. Pre notification system on emission facility construction and river basin development
5. Financial assistance and technology transfer cooperation between two countries
6. Promotion of international cooperation with other countries and international organization

7. Others

Please choose two of the priority options in institutional and financial arrangements for promoting transboundary water management system in future, rank them in order.

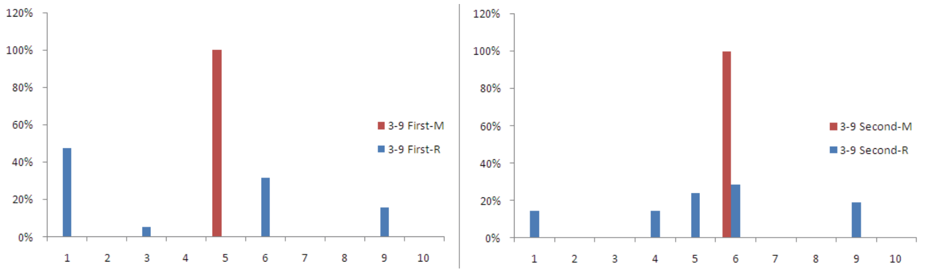


Figure 4-29. Result of the question 3-9 for Mongolia and Russia

1. Strengthening the legal binding force of bilateral agreement between two countries
2. Improving the current governmental meeting into more high level official meeting such as Ministry meeting
3. Setting up the transboundary water issues as a priority cooperation agenda between two countries
4. Establishment a new and permanent joint management organization
5. Establishment and strengthening the implementation scheme in national level of two countries
6. Extension of financial investment and human resources
7. Extension and conduct of join activities in the fields and sizes
8. Systematic and efficient management and organization extension of current cooperation bodies
9. Promotion of international cooperation with other countries and international organization
10. Others

C. Summary

The questions that show similar opinions are following:

- Both experts of Mongolia and Russia think that there are several transboundary water issues of SRB that need to cope with by cooperation activities between Mongolia and Russia.
- Both experts of Mongolia and Russia think that the transboundary

water issues of SRB will go on increasing and become significant transboundary issues between Mongolia and Russia.

- Both experts of Mongolia and Russia think that the activities under bilateral agreements produced positive outcomes in addressing rational use and protection of water of SRB in Mongolia and Russia.
- Both experts of Mongolia and Russia think that the transboundary water management system of SRB should be strengthened like other transboundary river management cases for addressing rational use and protection of water in two countries.

The questions that show different opinions are following:

- About the most significant, CURRENT transboundary water issues in SRB, Mongolian experts answered "Water resources shortage" and "Heavy metal pollution", however Russian experts chose "Water pollution(transboundary water pollution)".
- Russian experts think that the activities under bilateral agreements produced positive outcomes in addressing rational use and protection of water of SRB in Mongolia and Russia, but over half of Mongolian experts do not agree about that
- Russian experts think that the bilateral agreements for rational use and protection of water in SRB between Mongolia and Russia as transboundary water management system have been known well among major actors and stakeholders of relevant organizations in two countries, however Mongolian experts do not thinks that they do not know well.
- About most significant, FUTURE transboundary water issues in SRB, Mongolian experts think "Water flow allocation", but Russian experts think "Water pollution(transboundary water pollution)"
- Russian experts agree that in the long term, Current bilateral agreement need to develop a legal binding treaty by stages for join water management on SRB between two countries, howver Mongolian disagree perfectly.
- Russian experts agree that in near future, Current government meeting of transboundary water management system need to develop a permanent joint management organization by two countries, but

Mongolian experts disagree perfectly.

- Russian experts agree that other countries or international organizations need to participate to the cooperation bodies for promoting cooperation activities and developing transboundary water management system and relevant activities, but over half of the Mongolian experts disagree.
- About priority issues that should be addressed in transboundary water management system in future, Mongolian experts chose “Fair and proper water flow allocation”, but Russian experts chose ” Protection of water pollution(transboundary water pollution) and improvement of water quality”.
- About the priority options in institutional and financial arrangements for promoting transboundary water management system in future, Mongolian experts chose “Establishment and strengthening the implementation scheme in national level of two countries” but Russian experts chose “Strengthening the legal binding force of bilateral agreement between two countries”.

3. Policy Alternative on Transboundary Water Management System

A. Policy Implication of Transboundary Water Issues and Survey Results

The main policy implication of the results of field work and survey are as follows:

First of all, transboundary water issues. Based on current and future issues related to the transboundary water management, issues such as water flow allocation, water resource shortage, transboundary water pollution, and dam construction should be given full attention.

The policy implication derived from the expert evaluation on current transboudary water management system which has been reflected in our questionnaire is is as follows. First, introduction of a system with institutionally and legally binding should be considered. Second, organizational and financial aspects of institutional arrangement need to be strengthened. Third, monitoring and data sharing system should be built. Fourth, implementation scheme in national level of each country is needed in order to ensure the domestic implementation of the agreement or joint projects.

The policy implication from expert evaluations on the transboudary water management system is as follows:

First, there should be mutual agreement as to the level and characteristics of the transboundary water management agreement, to decide on the need to conclude a legal binding treaty. Second, there should be mutual agreement on the nature and form of the organization in charge of transboundary water management system, e.g. permanent joint management organization. Third, transboundary water management system need to emphasize the priority of tackling such issue as fair and proper water flow allocation, protection of transboundary water pollution and improvement of water quality, conservation of ecosystem deterioration/biodiversity loss. Fourth, a successful transboundary water management system would need policy discussions on the domestic pollution management system for emission reduction and water quality protection in each country. Cooperation in building the joint monitoring and data exchange system, emergent environment accident transmission system, and adopting common water quality standard and pollutant emission standard is also crucial. Fifth, there should be frequent policy discussion with regard to river basin development, implementation of EIA procedure of each country, and protecting water resources and development capacity. Sixth, as for the institutional and financial arrangement, domestic implementation system should be established and there should be efforts to increase financial and human resources.

B. Design of Transboundary water management system on SRB

a. Framework of M/R Transboundary water management system on SRB

The basic design of transboundary water management system on SRB is; first, to step up the level of current cooperation system. An implementing committee is recommendable in order to ensure the systematic and stable implementation of the cooperation projects, going a step further from the current governmental representative meeting. Second, extend the scope of the projects by organizing specialist groups and working groups to facilitate the management system. Third, build a joint monitoring network and information sharing system on water quality and water resources in each country. Fourth, perform a joint EIA on basin development projects, such as developing water resources. Fifth, implementation schemes should be built and fiscal investment should increase at the national levels to guarantee the effectiveness of the management system. Sixth, as regards such issues as level and nature of transboundary water management agreement and the organization in charge of transboundary water management system, and water flow allocation, building a long-term channel for strategic dialogue is recommendable. Following figure is the framework of transboundary water management system on SRB between Mongolia and Russia.

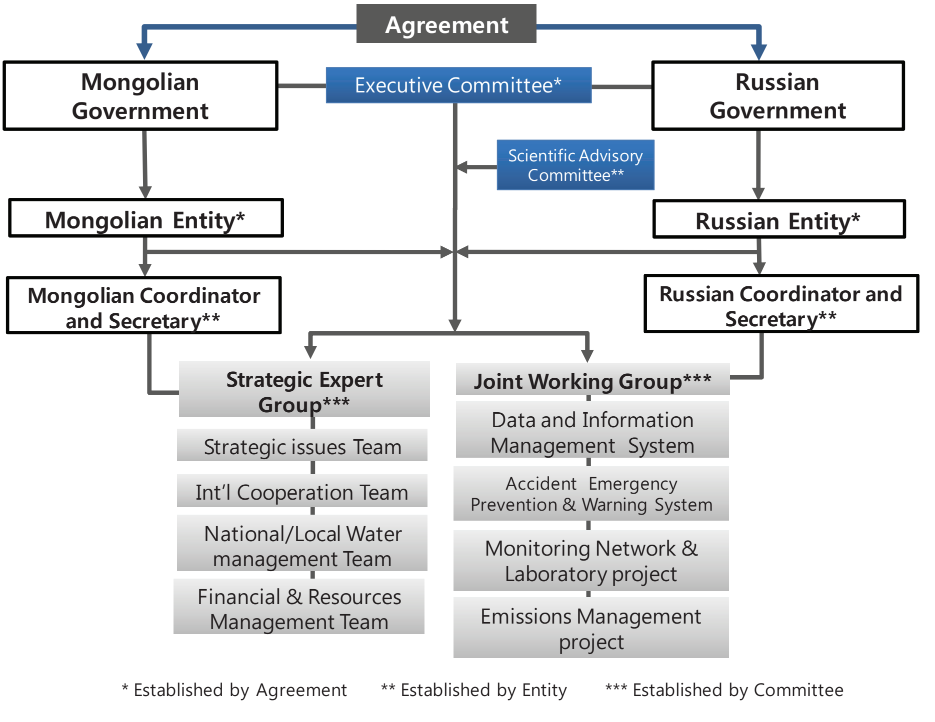


Figure 4-30. Design of Transboundary water management system on SRB

Transboundary watermanagement system on SRB is the ultimate goal of both countries, but its introduction will be possible after a period of coordination between the authorities of upstream and downstream countries. Just as domestic policies proceeds by stages, our policy proposal consists of three stages of implementation.

At the first stage of introduction, water research will be jointly conducted by the two countries and a third research entity, broadening the basis of recognition and understanding among the two countries on the shared use of the international river. For this, the level of channel for dialogue needs to be upgraded and rutinized.

At the second stage, the two countries will build a system for measuring the water environment and sharing information. Government of each countries will be represented in an executive committee and scientific advisory committee for technical cooperation. Agreement on a common standard for water quality is one of the major tasks.

At the third stage, both countries will conduct a sustained joint monitoring on the SRB, according to the management standard agreed and implement the action program based on the common vision for sustainable development of SRB

Table 4-7. Policy Proposal of Transboundary Water Management by Stages

Stage	Mongolia / Russia
1st	- Researching with other scientific organizations for rational use of water - Improvement of insufficient recognition of the integrated management necessity of each government on water issues - Harmonizing the different interests in water issues among relevant departments and stakeholders - Routinizing the channel for dialogue
2nd	- System building and information sharing on the measurement of water environment - Building an Executive Committee consisting of government officials of Mongolia and Russia - Building Scientific Advisory Committee - Technical cooperation - Agreement on the common standard for water quality
3rd	- Sustained monitoring of the water environment on SRB - Developing a Shared Vision by Strategic Exper Group - Development of concerted action programs by Joint Working Group

In the long term, transboundary water management of an international level will call for the following additional measures.

- In near future, Current government meeting of transboundary water management system need to develop a permanent joint management organization by two countries.
- In the long term, Current bilateral agreement needs to develop a legal binding treaty by stages for join water management on SRB between two countries.
- Other countries or international organizations need to participate to the cooperation bodies for promoting cooperation activities and developing transboundary water management system and relevant activities.

b. Indicators for M/R Transboundary water management on SRB

As noted before, there is a need for the joint management of the SRB water management indicators currently managed on domestic levels of each countries. For this, major monitoring spots in the SRB should be designated, and an integrated water management data from scientific and objective measurement should be accumulated and shared. This will serve as an important basis for mutual consultation and coordination in future development projects of the Selenge River.

Table 4-8. Indicator for Transboundary Water management system on SRB

Category	Sub-category	Management indicator
Freshwater	**Water quantity**	• Changes in river flow • Changes in water table • Rate of water intake • Daily water consumption per capita
	Water quality	• Water pollution rate of each basin area • water quality • waste water quality

Biodiversity	**ecosystem**	• reservation ratio • number of national biospecies • number of endangered species
Consumption/ Production	**Waste management**	• household and general waste generation • industrial waste generation • livestock excrement dumped into a river • reuse of waste
Disaster	**Disaster management**	• damage caused by natural disaster • Environmental Accident event

Chapter Ⅴ. International Cooperation for IWMM on SRB

1. Korea-Mongolia-Russia Environmental Cooperation Projects on Water Management System

Issues facing the countries

Issues between the two countries have fewer abilities to manage an integrated water management system and absence of an international management system.

Mongolia

- Scanty rainfall and imbalance in the water supply
- Indiscriminate mine development → effluence containing a lot of mineral
- Water pollution due to rapid urbanization and industrialization

Russia

- Change in Industrial structure following the downfall of planned economy
- Insufficiency, obsolescence and managerial inefficiency of treatment facilities.
- Increase in non-point source pollution load due to deforestation

A. Cooperation Project of Development Water Resources Area

Mongolia has an arid climate condition with an average rainfall of 200mm per annum, which tends to be concentrated in the summer. The country's underground water table is lowering every year and it is expected to face water scarcity issue in the future.

It is time to take positive actions to mitigate the water shortage, increasing the availability of water resources by building a system to reuse treated wastewater. Investigating and rationalizing current and future practice of the groundwater usage, carrying out the pilot project of town waterworks, building the system for town wastewater management are also called for.

Project title	Contents
Study on the treated waste water reuse project in metropolitan Mongolia/Russia	• establishing treated wastewater reuse system • expanding demand for and systematic availability of the reuse of treated wastewater
Rationalizing the groundwater utilization in Mongolia/Russia	• rationalizing the ground water use in the region without access to public water supply • small-scale town water supply system using ground water
Water resources development project	• developing ground water • development of small-scale well and irrigation water

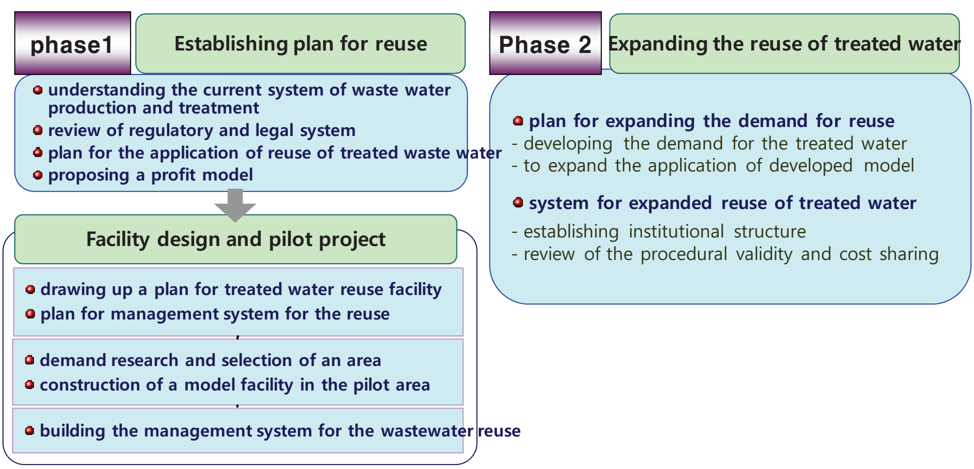
Treated wastewater reuse project and expanding demand

Background

- average annual rainfall of Ulaanbaatar is 200mm
- the city's underground water table is lowering
- reuse of treated wastewater to increase availability of water resources

Objective

- mitigating water shortage in Ulaanbaatar through reuse of treated water
- to expand the reuse of treated wastewater



B. Cooperation Project of Water Management Area

Establishing and implementing policy is essential for efficient water management. Water management policies include the management of pollution sources, building the monitoring system for water environment, improving the water/ wastewater management system. To guarantee a sustained effectiveness in the execution of these policies, recruiting and educating specialists on a long-term basis is indispensable.

Project title	Contents
Non-point source management in Mongolia and Russia	• investigate the state of the non-point pollution sources in rural areas of Mongolia, and proposing a management plan • investigate the state of the non-point source pollution in Russia and proposing a management plan
Automated water quality/quantity monitoring system	• Establishing automated monitoring system for efficient water quality/quantity monitoring • monitoring surface water/ground water • launching a pilot project and building the automatic measurement network
Improving the water/wastewater management system	• improving the water/waste water management system • managing drinking water quality • introducing network information system for water and waste water
Environment-related capacity building projects in M/R	• capacity building for voluntary/long-term environmental improvement and management • increasing environmental infrastructure and education program for the specialist

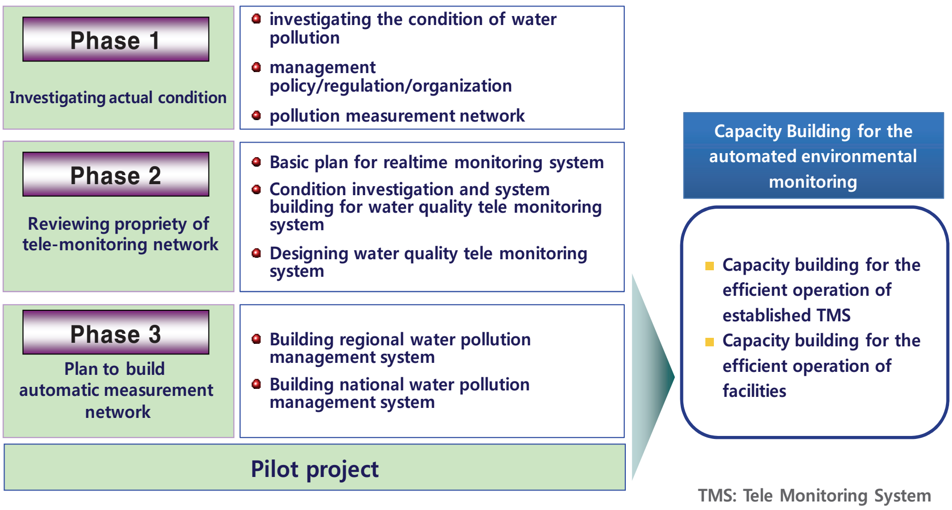
Automatic water quality/quantity monitoring system

Background

- lack of continued data monitoring system for the water quality/quantity

Objective

- building tele monitoring system(TMS) for the effective management of Mongolia/Russia



C. Cooperation Project of SD in Mining Industrial Area

Indiscriminate development of mines led to the destruction of ecosystem, and water pollution. Korea can propose to Mongolia and Russia, a technological cooperation project for environmental mine development.

Project title	Contents
Transferring technology for industrial waste water treatment in the mining area	• developing technology for industrial waste water treatment • technology transfer for the treatment of wastewater in industrial complex

D. Alternative Financial Resources for improving water management

Mongolia and Russia need to develop financial resources for environmental projects. Korea can share its experience and provide technological advice, especially for establishing a sustainable and rational financial structure for the basic facilities and pollution management.

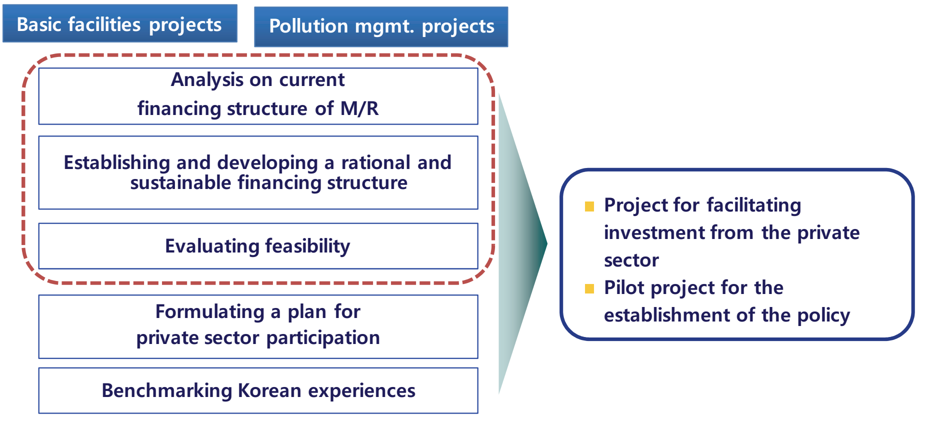


Figure 5-1. Financial support for cooperation project process

Korea's current taxation regime for water use is based on the user pays approach, in order to facilitate the water quality improvement effort and to obtain fund to support the communities living near the upstream reservoir. To provide economic incentives for water quality protection, Korea also has discharge fee, charge for excess discharge, environmental improvement fee.

2. Implementation Scheme for Environmental Cooperation Projects

A. System of Implementation of Cooperation Project

Environmental cooperation projects usually consist of Knowledge dissemination, Feasibility Study, Investment Project, Capacity building, Joint Project. Each project requires different ability and capacity. Following figure shows the modules for implementing the environmental cooperation projects focusing on the activities of 'Int'l Joint Project', 'ODA/EDCF', 'Knowledge Partnership Project', 'KOICA'.

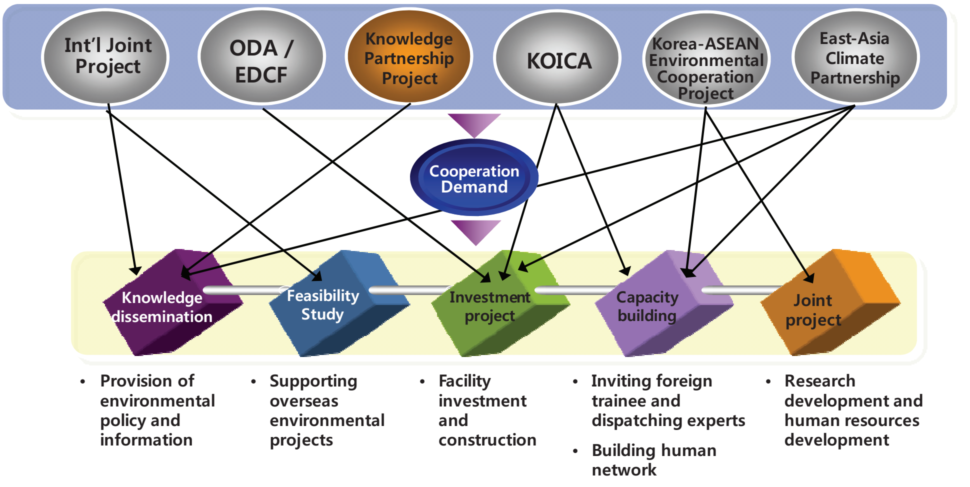


Figure 5-2. Basic modules for cooperation projects

Structures and roles of Project Implementing Organization

Following figures show the structure of relationship between various governments and research organizations and their roles in the implementation of the cooperation projects.

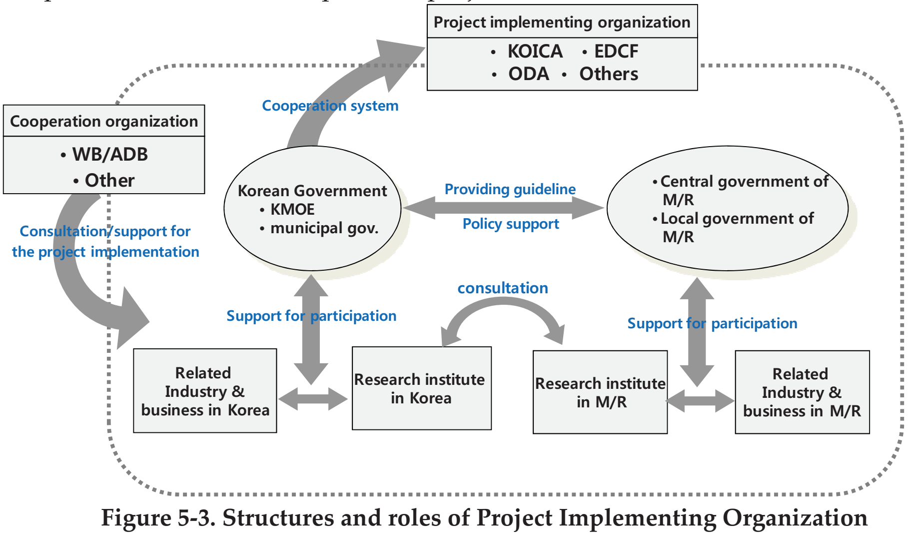


Figure 5-3. Structures and roles of Project Implementing Organization

B. Process for the Cooperation Project

It is necessary to establish an implementation strategy for Korea-Mongolia-Russia environmental cooperation project. The cooperation project proceeds as the following figure shows: reviewing current Korea-Mongolia-Russia cooperation projects, establishing basic direction of Korea-Mongolia-Russia environmental cooperation project, followed by the SWOT analysis for the project, building the positioning strategy and successive implementation system to sort out priorities of the cooperation projects.

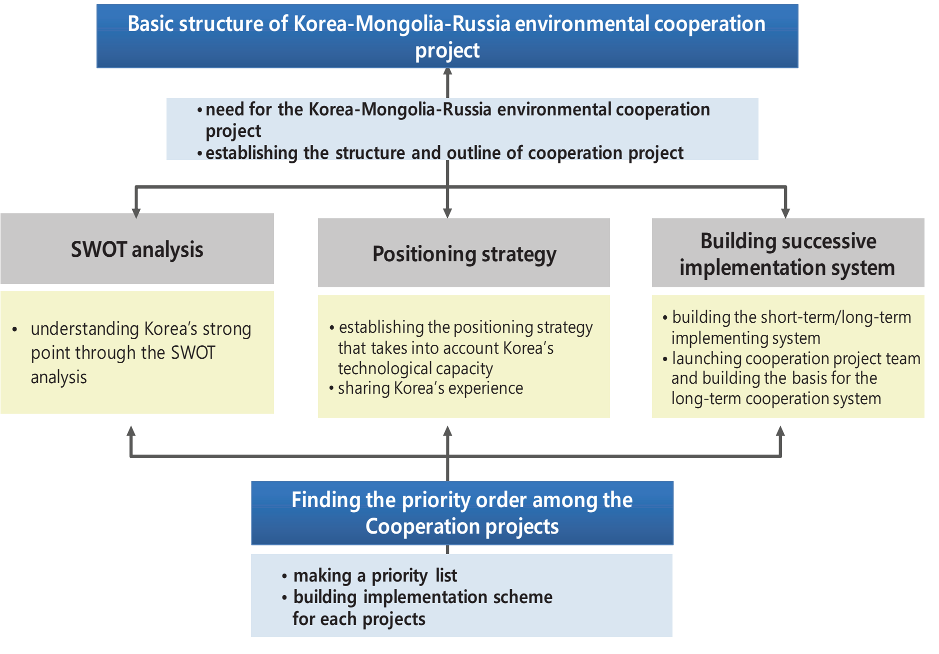


Figure 5-4. Process for the Cooperation Project

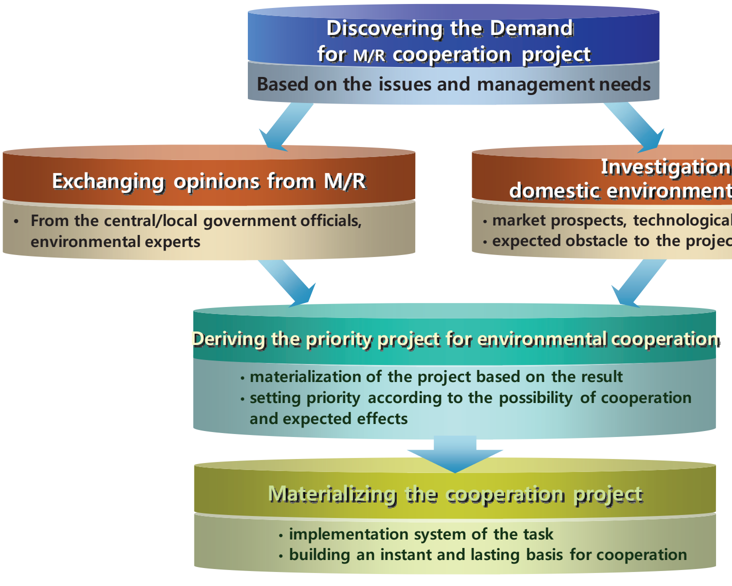


Figure 5-5. Deriving the Cooperation Project

Chapter Ⅵ. Summary and Conclusion

This project has been launched in order to develop an integrated water management model in the Selenge River Basin. This report describes the results of phase 3, and includes 1) State of Water Environment and Resources in the SRB, 2) Domestic Integrated Water Management Model on the SRB; 3) Transboundary Water Management System on the SRB, 4) International Cooperation for IWRM on the SRB.

Water Environment Analysis

In total, 68 sampling stations were identified, with 39 in Mongolia and 21 in Russia. Frankly, it is impossible to draw a conclusion on the quality of surface water by one-time monitoring and analysis. It is necessary to conduct year-round and annual monitoring. As the results of analysis, some sites indicated pollution level affecting wastewater treatment plant and mining. The highest SS were at SM10, and SM21, it measured at start of the agricultural irrigation which has the dark stream water because of rain and discharge from the gold mining sites in the Mongolia. Main sources of pollution identified in Mongolia were Zaamar gold placer, upstream of the Orkhon, and the Shar River gold mining, population/settlements, agriculture and WWTPs.

The level of anthropogenic impacts on waters of the Selenge River Basin is great. The Selenge River Basin's catchment area is covered 27% of the whole territory of the Buryatia republic. But there is living 84% of the population and concentrated about 85% of the industrial and agricultural sectors of economics of the Republic of Buryatia. There were observed polluted stream in the Selenge River Basin – Modonkul stream which was affected by the tailing dump of Dzhidinsk Tungsten-Molybdenum Complex. Because of closure of large enterprise of mining without any reclaiming actions, their territories are considered as the main pollution sources (non-point sources).

Rivers in the Selenge River Basin experience the mudflows and floodings. Snowmelt flows generally occur during spring. Analysis of average monthly discharges of the Selenge River indicates that about 50-70% of total annual discharge is concentrated in three summer months, and 20% is recorded in the spring. The estimated groundwater potential resource was 6,100 m^3/year. Groundwater is one of the most important mineral resources of the Selenge River Basin within the territory of Mongolia. The hydrogeology of the Selenge River Basin is varied and consists of a combination of alluvial deposits, cambrian and precambrian limestone, granite of varying age, sedimentary deposits (including sandstone, siltstone and conglomerate), and metamorphic rocks. For the major cities of Ulaanbaatar, Erdenet, Darkhan, Murun, Sukhbaatar, Tsetserleg, and Zuunkharaa, are the main water sources of the alluvial deposits along river basins.

The total number of rivers in the Russian part of the Selenge River Basin is more than 17,000. Their total length is about 70,000 km. Main tributaries include the Dzhida, Chikoi, Khilok, Uda, and Itantsa Rivers. The total watershed area of the entire Basin is 151,130 Km^2, with the Russian area taking up 134,130 Km^2, or 90% of the Selenge River Basin. The total average long-term water supply is 17.38 Km^3, which accounts for 58% of the Selenge River flow or 93% of the river flow formed in the Russian territory.

Domestic Integrated Water Management Model on SRB

Through discussion of relevant experts on parameters related to water issues, 17 parameters were produced. Designation of cities impacting the water issues of the Selenge River Basin was performed via the field research results in this project, as well as through discussions between experts from Mongolia, Russia, and Korea.

On the Selenge River Basin, we have identified 8 Hot Spots in two countries (Mongolia and Russia-Buryatia). The water quality related issues are presented by two origins: Mining and Urbanization. In order to improve the water quality conditions in Selenge River Basin, we need to identify the exact locations of Hot Spot and then observe the existing management measures in place. After that, there need to check the efficiency of the treatment operations for mitigation of pressure on water quality and improvement of local water quality condition. The origins of water quality pollutions are different from place to place (mining and urbanized areas). The management options and approaches have to be properly defined and established according to management priorities. To determine the management priorities, we used mDSS model. The data was pretreated for main issue priorities using expert survey analysis, weighting the issues priorities and normalized numbers of the weighted values, and fitted the data in the mDSS software. In the process of design of mDSS model, the database (DB) was transfered into analysis matrix (AM). Then it was setted by the ideal point method (TOPSIS). Aggregating the group members' preferences in the group decision, final solution rank were achieved by borda rule.

The overall objective of this project is to develop the IWMM for sustainability of the SRB in national and international level. Therefore, joint research team tries to identify the needs and expectations of major actors and stakeholders of Mongolia and Russia to develop the potential domestic & transboundary water management system on the SRB in addressing common water environmental issues. The survey composed of three parts. The first part is to investigate the Recognition of the Domestic Water Isssues in the SRB, the second part is to investigate the Evaluation of the Current Water Management Policy of M/R on the SRB and the third part is to investigate the Development of the water management system on SRB. Most of experts of both countries agreed that there are several domestic and transboundary water issues of the SRB that need to cope with by ingegrated water management system in Mongolia and Russia

Evaluation of the current water management systems of Mongolia and Russia yielded the following policy suggestions with regard to the IWMM.

For Mongolia, firstly, the rights concerning the water use, for example the ownership of wells in rural pastures, should be properly established through institutional improvement. Second, policies strengthening the coordination capacity of the water management organization and the role of local government should be introduced. Third, as a policy to establish the financial bases for the water management system a law package should be developed, incorporating current laws on water management and other user charges of water, water resource preservation fee. The decreasing an influence of main pollutants like Erdenet and central WWTP, Ulaanbaatar, should be made by governmental support through the application of an advanced technology and techniques.

For Russia, firstly, introduction of rational and efficient water supply system are called for, in order to guarantee the drinking water safety and to promote economic use of water resources. Second, regulation policy needs to be strengthened in order to improve water quality and minimize the adverse effect of harmful materials. Third, there should be policies to improve the water management system, create financial resources and increase investment.

At the institutional level, user charge system had high propriety of introduction, but administrative support and substructure for implementation should be in place to guarantee its successful implementation. Policy of water source protection, which consists of regulations on development in upstream region or upstream reservoirs, is highly in demand, but its regulative nature necessitates administrative complementation. Policy means such as EIA, monitoring system, solid waste management system should be accompanied by technological, financial, as well as administrative supports. In general, project means related to the infrastructure, such as reusing water, building local WWTPs were not supported by adequate policy support in technological, financial, and administrative aspects. Especially, financial condition has been identified as the pivotal factor in the successful implementation of projects

In addition to these expert survey results, feasibility analysis was performed to identify which policy options are possible or impossible in Mongolia and Russia. Most policy alternatives have high administrative feasibility in both Mongolia and Russia. However Mongolia and Russian experts tended to assign low numbers to economic feasibility.

For each country, integrated water management on the SRB is a long term goal, but its introduction may not be readily available. Therefore it is recommendable to gradually proceed with relevant domestic policies in each country. In this report, three stages are suggested forwarding the integrated water management on the SRB. Lastly, a sustained management of water-related indicators should be a part of the SRB integrated water management plan.

Transboundary Water Management System on SRB

This report introduced the transboundary river theory, issues of transboundary river management, transboundary river cooperation cases study in other regions and countries. The characteristics of the SRB as a transboundary river are identified through analyzing the situation of the SRB.

Also, we have conducted expert survey of three countries including Korea, Mongolia and Russia for selecting the policy alternative on transboundary water management system. This report suggested the basic design of transboundary water management system on the SRB. The basic design of transboundary water management system on the SRB is; first, to step up the level of current cooperation system. An implementing committee is recommendable in order to ensure the systematic and stable implementation of the cooperation projects, going a step further from the current governmental representative meeting. Second, extend the scope of the projects by organizing specialist groups and working groups to facilitate the management system. Third, build a joint monitoring network and information sharing system on water quality and water resources in each country. Fourth, perform a joint EIA on basin development projects, such as developing water resources. Fifth, implementation schemes should be built and fiscal investment should increase at the national levels to guarantee the effectiveness of the management system. Sixth, as regards such issues as level and nature of transboundary water management agreement and the organization in charge of transboundary water management system, and water flow allocation, building a long-term channel for strategic dialogue is recommendable.

As noted before, there is a need for the joint management of the SRB water management indicators currently managed on domestic levels of each country. Major monitoring spots in the SRB should be designated, and an integrated water management data from scientific and objective measurement should be accumulated and shared. This will serve as an important basis for mutual consultation and coordination in future development projects of the Selenge River.

International Cooperation for IWMM on SRB.

For establishing and implementing IWMM on the SRB, We suggested the Korea-Mongolia-Russia Environmental Cooperation Projects on Water Management System. The environmental cooperation projects in water resources develpotment projects are including 1) studing on the treated waste water reuse project in metropopolitan of M/R, 2) Rationalizing the groundwater utilization in M/R, 3) water resources developemt project. The environmental cooperation projects in water manangement area are including 1) non-point source management in M/R, 2) automated water quality/quantity monitoring system, 3) improving the water/wastewater management system, 4) enrivonmental related capacity building projects. This report also suggested the trasfering technology for industrial waste water treatment in the mining area as a prior cooperation project of SD in Mining Industrial Area. Lastly, the implementaltion scheme for environmental cooperation project between Korea and other countries is suggested.

References

Altansukh, O. 2008. “Surface water quality assessment and modelling: a case study of the Tuul River, Ulaanbaatar, Mongolia.” Masters Thesis. Available online at: www.itc.nl/library/papers_2008/msc/wrem/altansukh.pdf

Stubblefield, Andew et al. 2005. Impacts of Gold Mining and Land Use Alterations on the Water Quality of Central Mongolian Rivers. “*Integrated Environmental Assessment and Management”* 1(4): 365–373

AWWA, WEF. 1995. *Standard Methods for the Examination of Water and Wastewater, 19th ed*. Maryland: APHA Publications

Basandorj, D. and G. Davaa. “2005. Mongolian National Case Study – Reference to Tuul River Basin”. Case Study prepared for the 2nd World Water Report by UNESCO Office Beijing in collaboration with World Water Assessment Programme, UNESCO Paris and Mongolian National IHP Committee , Ulaanbaatar.

Batima, P., Ts. Sosorbaram, U. Amarsanaa, Sh. Enkhtsetseg, S. Sojidma, & T. Bulgan . 1997. *Inventory of Pollution Sources for the Tuul River*. Ulaanbaatar.

Boris, S., B. Karpoff, and E. William. 2005. “Report on Placer gold properties in the Tuul Valley Zaamar Goldfield, Mongolia”. Toronto: Roscoe Postle Associates INC,

Borisova, T.A. 2010. “Theoretic-methodical approaches of research of nature-anthropogenous risks on the Baikal natural territory//Safety of ability to live”. *New technologies*, 2: 40-45. Moscow: Publishing House

CBD. 1996. "CBD Strategy and Action Plan – Mongolia". Ulaanbaatar. Available online at: www.cbd.int/doc/world/mn/mn-nbsap-01-p2-en.pdf [August 2009]

Bandaragoda, D. J. 2000. A Framework for Institutional Analysis for Water Resources Management in a River Basin Context International Water Management Institute.
Rogozina A.L. ed. 2003. *An estimation and management of natural risks*: Thematic volume , Moscow: Publishing firm KRUK, p. 320.

Emerton, L, N. Erdenesaikhan, B. de Veen, D. Tsogoo, L. Janchivdorj, G. Gav aa, Enkhtsetseg, Suv daa, Ch. Dorjsuren, D. Sainbayar, and A. Enkhbaatar, 2009. "The Economic value of the Upper Tuul ecosystem, Mongolia: draft report".

Enkhtuya, M. 2009. "Assessment of Selenge River Water Quality in Mongolia by DPSIR approach". Seoul.

Enkhtuya, M. 2009. "Assessment of Selenge River Water Quality in Mongolia by DPSIR approach". Seoul.

Enviroplan Services. 1999. "An Assessment of Environmental Impacts and Issues Relating to Gold Mining in the Zaamar Region." World Bank Report, Project No. LENE 56823, Mongolia.

Fondazione Eni Enrico Mattei. 2006. *mDSS4 USERS' Guide*. Venice, Italy
Fondazione Eni Enrico Mattei. 2008. *mDSS4 USERS' Guide* - INTRODUCTION AND APPLICATION CONTEXT. Venice, Italy.

Heaps. 2004. Heaps, TA, "Canadians at the Gate."
http://www.corporateknights.ca/stories/Mongolia.asp

Institute of Geoedology, MAS. 2009. *The final report of MON8006 TC project of IAEA.*

Choijilsuren, Javzan, Ayato Konzu et al. 2007. Water Quality of Tuul River deterioration due to discharge from the waste treatment plant of Ulaanbaatar, Mongolia.

Javzan,Ch, B. Tsengelmaa,A. Saulegul, and D. Tomorsukh. 2007. "Water quality changes of the Tuul river". Special edition. *Geoecologycal issues of Mongolia*. Institute of Geoecology, Ulaanbaatar.

KEI. 2004. *Integrated Watershed Management for Laguna de Bay for the Philippines.*

———.2006. *Joint Research between Korea and Mongolia on Water Quality and Contamination of Transboundary Watershed in Northern Mongolia.*

Khazheeva, Z.I., A.K. Tulokhonov, and L. T. Dashibalova. 2007. "Seasonal and Spatial Dynamics of TDS and Major Ions in the Selenge River." *Water Resources*, 34(4): 444–449.

Kichigina, N.V., L.M. Korytny. 1997. Division of the Eastern Siberia on danger of flooding//. *Geography and natural resources,* 3: 50-60.
Lee, J., S. Yun, M. Badarch, J. Lee, O. Auyr, J.Kwon, D.and Kim. 2006. "Joint Research between Korea and Mongolia on Water Quality and Contamination of Transboundary Watershed in Northern Mongolia". Seoul.

Ministry of Natural Resources of Russian Federation, Federal Agency of Water Resources, Management of Water Resource of Lake Baikal. 2006. *Report of State and use of water resources Republic of Buryatia.* Ulan-Ude City, Russia.

Ministry of Natural Resources. 2006. *State report of Lake Baikal Protection*. Russia.

NeWater. 2005. *THE RELATIONSHIP BETWEEN IWRM AND ADAPTIVE MANAGEMENT* -Discussion input for NeWater international platforms.

Pavlov, D.F., I.I. Tomilina, J.J. Merilainen et al. Levels of Heavy Metals and Organochlorine Pesticides and Schneider and Ankers. 2005. "Potential interventions for the Swiss Agency for Development and Cooperation (SDC) in the Livestock Sector in Mongolia." Switzerland. Available online: www.sdc.mn/ressources/resource_en_91380.pdf [August 2009]

Semenova, B. A. and B. Myagmarjav. 1977. *Hydrological regime of the Selenge River basin.* Leningrad Nilsson, Susanna.

Nilsson, Susanna. 2003. THE ROLE AND USE OF INFORMATION IN TRANSBOUNDARY WATER MANAGEMENT Toxicity Assessment of Bottom Sediments in the Selenge River Basin in Mongolia, Inter. Conf. Ulan-Ude.

Tsengelmaa, B., R. Natasha, A.Saulegul. 2007. "Ecological Impact Assessment of Gold Mining on the Tuul River Ecosystem". Ulaanbaatar.

Tsengelmaa, B, A. Mongontsetseg, Ch. Javzan. 2007. "Study the effects of goldmining for the chemical composition and water quality of the Tuul River." Special edition. *Geoecologycal issues of Mongolia*, Institute of Geoecology, Ulaanbaatar.

Tsengelmaa. B., Natasha Roza-Butler, A. Saulegul. 2007. *Ecological Impact Assessment of Gold Mining on the Tuul River Ecosystem*, Mongolia Ulan Bator. Ulan-Ude: Publishing House of Buryat Scientific.

UNESCAP. 2008. "The Status and Challenges of Water infrastructure Development in Mongolia". First Regional Workshop on Development of the Eco-Efficient Water Infrastructure. Korea. Available online at:

http://www.ecowaterinfra.org/knowledgebox/documents/Mongolia-%20country%20report2.pdf [5/8/2009]

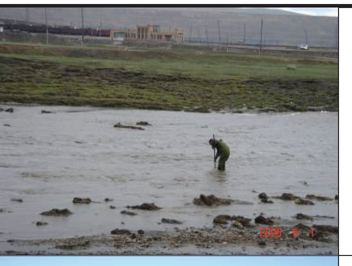
World Bank. 2006. "Mongolia: a review of environmental and social impacts in the mining sector."

Appendix 1. Data and Result of Water Quality Analysis

Table 1. Site description, Mongolia, 2007

Sites	Site picture	Site description
SM-1 (2007.7.17) Khuvsgul Lake N 50°30' 06.0" E 107° 19' 51.5"		Fresh water
SM-2 (2007.7.17) Khuvsgul Lake outlet N 50° 24' 58.4" E 100° 08' 58.0"		Freash water
SM-3 (2007.7.18) Delger River at Murun (camping site) N 49° 37' 58" E 99° 58' 17.4"		Fresh water

SM-4 (2007.7.18) Delger River, Murun bridge N 49° 34' 57.6" E 100° 09' 15.7"		Fresh water
SM-5 (2007.7.19) Selenge River, Hutag Ondor N 49° 22' 49.0" E 102° 51' 03.1"		High turbidity
SM-6 (2007.7.20) Khangal River N 47° 01' 39.5" E 104° 05' 33.8"		High conductivity
SM-7 (2007.7.20) Tailing Dam, Erdenet copper mining N 49° 05' 44.6" E 107° 05' 25.4"		High conductivity Low dissolved oxygen
SM-8 (2007.7.20) Tailing dam, Erdenet copper mining N 49° 04' 24.4" E 104° 11' 19.9"		High turbidity High conductivity

SM-9 (2007.7.20) Kharaa river, upstream of Darkhan city N 49° 23' 13.6" E 105° 53' 49.3"		high turbidity riverbank erosion
SM-10 (2007.7.20) Darkhan WWTP outlet N 49° 30' 29.4" E 105° 54' 12.1"		High conductivity Low dissolved oxygen
SM-11 (2007.7.21) Yeroo River N 47° 49' 62.4" E 106° 14' 39.2"		Fresh water
SM-12 (2007.7.21) Orkhon River, Before combine Selenge River. N 50° 15' 02.5" E 106° 08' 14.0"		High turbidity
SM-13 (2007.7.21) Selenge River Before combine Orkhon River. N 50° 15' 0.06" E 106° 08' 04.5"		High turbidity

SM-14 (2007.7.21) Selenge River after combine Orkhon River N 50° 15' 10.8" E 106° 08' 15.1"		High conductivity
SM-15 (2007.7.27) Shar River gol mining site N 49° 13' 08.5" E 106° 29' 59.3"		High conductivity
SM-16 (2007.7.17) Shar River downstream of mining N 49° 14' 32.5" E 106° 23' 48.3"		High conductivity

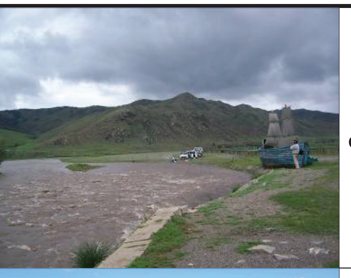
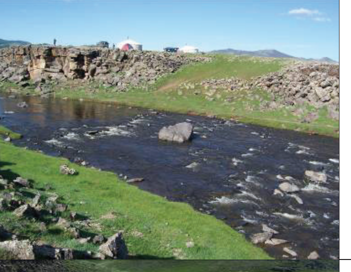
Table 2. Site description, Mongolia, 2008

Sites	Site picture	Site description
SM1 (2008.6.25) Downstream of "Terelj" bridge N 47° 49' 62.4" E 107° 19' 51.5"		downstream of "Terelj" bridge small rain low water temperature high turbidity

SM2 (2008.6.25) Wastewater of Nalaikh N 47° 48' 18.7" E 107° 16' 56.9" A=1386m		width: 2m the wastewater from Nalaikh city bubble and garbage
SM3 (2008.6.25) Tuul river upstream of wastewater treatment plant N 47° 51' 54.7" E 106° 41' 44.0"		freshwater small rain
SM4 (2008.6.25) WWTP N 47° 49' 62.4" E 106° 44' 89.3"		1km away from UB WWTP outlet foul smell very low DO very hign conductivity
SM6 (2008.6.26) "Tavan Tolgoi" bridge N 47° 48' 14.9" E 106° 36' 56.2"		wetland nearby river pasturage
SM7 (2008.6.26) "Altanbulag" bridge N 47° 42' 01.3" E 106° 17' 86.9"		high turbidity tree and wetland nearby river high velocity

SM8 (2008.6.29) Tuul-Khustai N 47° 38' 58.4" E 106° 02' 39.7" A=1142m		measure at the branch of Tuul river nearby Khustai national park
SM9 (2008.6.27) Kharaa river N 49° 23' 20.5" E 105° 53' 50.3"		high turbidity riverbank erosion
SM10 (2008.6.27) Kharaa river in "Burentolgoi" N 49° 35' 38.9" E 105° 51' 42.9" A=665m		Irrigation water intake high turbidity (over range)
SM11 (2008.7.01) "Zaamar" bridge N 48° 13' 58.2" E 104° 19' 43.0" A=940m		un mining from downstream of this site horse under the bridge
SM12 (2008.7.01) "Shijir Alt" bridge N 48° 17' 21.8" E 104° 24' 22.5" A=942		the downstream of SM11 nearby mining site

SM13 (2008.7.02) "Monpoliment" dredge pond N 48° 24' 26.5" E 104° 31' 52.0" A=913m		Bayangol dredge high conductivity big dredge is working
SM13-1 (2008.7.02) Tuul river N 48° 24' 28.8" E 104° 31' 52.5" A=913m		nearby dredge site Tuul river
SM14 (2008.7.02) "Altan Dornod" ground water N 48° 18' 22.7" E 104° 27' 02.4" A=982m		Ar Naimgan pond green color high DO almost ground water
SM15 (2008.7.03) "Khugshin Orkhon" river N 47° 46' 07.4" E 102° 42' 35.4" A=1339m		much rain and wind flatland and grassland inlet of Ugii Lake
SM16 (2008.7.03) Ugi Nurr (lake) N 47° 46' 42.1" E 102° 43' 18.5" A=1340		much rain and wind mud flat

SM17 (2008.7.03) "Orkhon" river in Khar Khorin N 47° 10' 45.7" E 102° 47' 23.3" A=1482m		high velocity 100~150m downstream site of weir small rain
SM18 (2008.7.05) Ulan river N 46° 46' 54.0" E 101° 57' 22.6" A=1825m		low temperature basalt site high DO 700m upstream site of waterfall
SM19 (2008.7.05) upstream of Orkhon river N 46° 47' 41.3" E 101° 56' 29.1" A=1812m		high velocity basalt site
SM20 (2008.7.06) The most upstream of Orkhon river N 46° 52' 28.1" E 101° 40' 32.2" A=1939m		grassland and mountain clean water
SM21 (2008.7.06) Branch of Orkhon river N 46° 52' 28.1" E 101° 40' 32.2" A=1939m		high turbidity gold mining in upstream gravel yellow color

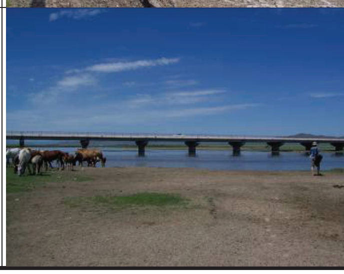
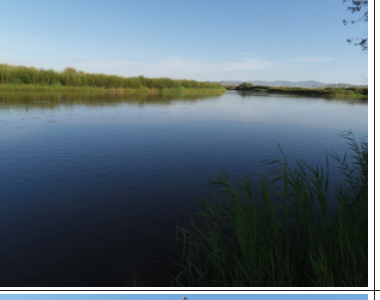
SM22 (2008.7.08) "Khugshin Orkhon" river bridge N 47° 08' 54.9" E 102° 59' 03.9" A=1493		flatland and grassland bank erosion high velocity
SM23 (2008.7.08) "Lun" bridge N 47° 51' 40.4" E 105° 11' 58.9" A=997m		grass, bubble, suspension wide width large riverside

Table 3. Site description, Mongolia, 2009

Sites	Site picture	Site description
SM1 (2009.7.27) Bayanchandmani soum, well N 48° 13' 18.4" E 106° 17' 26.6"		- Mn, NH4: drinking water quality standard ↑(soum data) - As: high(UNEP report)
SM2 (2009.7.27) Khangal River after Erdenet city N 49° 04' 26.4" E 104° 11' 18.0"		-Tailing Dam downstream -The same site (SM8 of 1st) -High turbidity -High conductivity -High DO

SM3 (2009.7.28) Erdenet WWTP outfall N 49° 03' 38.6" E 104° 09' 00.2"		- before khangal river - domestic water 18,000 ton/day(erdenet city) - looks very clean
SM4 (2009.7.28) Erdenet r. (front of Erdenet WWTP outfall) N 49° 03' 38.6" E 104° 09' 00.2"		- very high SS - high velocity - high DO - high turbidity - high conductivity - Same site(SM3 of 2009)
SM5 (2009.7.28) Erdenet Tailing Dam Reuse pond N 49° 04' 34.4" E 104° 09' 20.5"		- bubble - stagnant waters - high turbidity - high conductivity
SM6 (2009.7.28) Erdenet r. near copper mining tips N 49° 01' 43.7" E 104° 05' 37.3"		- very high DO - 200m from the same site of 1 st study(SM8) - Starting from 1km upstream(ground water) - many livestocks

SM7 (2009.7.28) Khangal r. agricultural area near of Jargalant ErdenetN 49° 01' 11.8" E 104° 26' 47.5"		- high DO - agricultural water
SM8 (2009.7.29) Haraa-Orkhon joining point N 49° 37' 51.4" E 105° 50' 02.9" Altitude: 668m		- point after confluence of Haraa river and Orkhon river - left: Haraa river - right: Orkhon river
SM9 (2009.7.29) Burentolgoi village well N 49° 37' 30.5" E 105° 53' 14.4" Altitude: 659m		-Low DO and temperature -High turbidity -High conductivity -Head loss: 5m -Yellow color -Shallow well
SM10 (2009.7.29) Shariingol river , mouth of a river N 49° 50' 53.1" E 106° 07' 19.6" Altitude: 629m		Very flat area Orkhon r. -Bank erosion -Very high turbidity

SM11 (2009.7.29) Darkhan WWTP outfall N 49° 30' 27.4" E 105° 54' 12.6" Altitude: 681m		-Looks very clean -Respectively low DO -Low velocity The same site SM10 2007
SM12 (2009.7.29) Haraa river bridge upstream of Datkhan sity N 49° 23' 16.2" E 105° 53' 49.9" Altitude: 697		High velocity -High turbidity -Many livestock's -The same site (SM-9 of 2007 and SM9 of 2008)
SM13 (2009.7.30) NO.6 well of TETS-4, Tuul river valley N 47° 37' 40.8" E 106° 37' 52.3" Altitude: 1228m		- intake using pumping station on the waterside of tuul river - supplied a power station with water - flood plain behind river bank - looks very clean but very low DO - somewhat low pH

SM14 (2009.7.30) Tuul river(downstream from CWWTP) N 47° 51' 47.0" E 106° 41' 29.5" A=1245m		-High velocity -Downstream from UB after combine CWWTP with Tuul r. outfall -Large water quantity -The same site (SM3 of 2nd)
SM15 (2009.7.30) UB WWTP outfall N 47° 53' 42.5" E 106° 44' 24.3" A=1256m		- UB effluent - high turbidity - very low DO - smell(sewage) - Same site(SM4 of 2nd)
SM16 (2009.7.30) Tuul river bridge (road to Terelj Resort) N 47° 49' 15.5" E 107° 20' 52.6" A=1389		-Looks very clean water -Upper drinking source (UB) -Road to Terelj national park -The same site (SM1 of 2nd)
SM17 (2009.7.30) Wastewater of Nalaikh N 47° 48' 20.7" E 107° 16' 55.6" A=1388m		-Width: 2m -The wastewater from Nalaikh city (bubble) -Past Nalaikh coal mining industry but now closed -The same site (SM2 of 2nd)

SM18 (2009.7.31) Central water source area well No 37 N 47° 54' 09.8" E 106° 56' 48.7" A=1295m		- intake on tuul river - clean water(no filtration) - somewhat high DO - low temperature
SM19 (2009.7.31) Bayanzurkh Bridge N 47° 53' 24.5" E 107° 03' 45.5" A=1321m		- high DO - low turbidity - low conductivity

Table 4. Site description, Russia, 2007

Sites	Site picture	Site description
SR-1 (2007.07.22) Mongolian-Russian Boundary, Naushki N 50° 23′ 07.0″ E 106° 04′ 51.8″		high turbidity high water level brown color
SR-2 (2007.07.23) Dzida River, inflow into Selenga River N 50° 44′ 07.3″ E 106° 16′ 20.8″		a little turbidity

SR-3 (2007.07.23) Temnik River, inflow N 51° 01′ 17.4″ E 106° 24′ 28.4″		a little turbidity
SR-4 (2007.07.23) Chikoi River, Inflow N 51° 02′ 32.8″ E 106° 39′ 17.4″		A little turbidity
SR-5 (2007.07.23) Khilok River, inflow N 51° 18′ 56.0″ E 106° 59′ 20.3″		a little turbidity
SR-6 (2007.07.24) Selenga River, before Uda River (Vakhmistrovo) N 51° 49′ 07.7″ E 109° 33′ 24.1″		turbidity
SR-7 (2007.07.24) Uda River, inflow into Selenga River N 51° 49′ 41.9″ E 109° 34′ 15.0″		a little turbidity

SR-8 (2007.07.24) Selenga river, after confluence of Uda and Selenga river N 51° 52′ 41.9″ E 109° 31′ 25.5″		a little turbidity
SR-9 (2007.07.24) Selenga River, Selenginsk N 52° 04′ 04.1″ E 106° 53′ 22.5″		high turbidity
SR-10 (2007.07.24) Selenga River, nearby Pulp-Paper Factory and a new bridge N 52° 02′ 15.5″ E 106° 48′ 58.3″		a high turbidity
SR-11 (2007.07.25) Selenga River, Kabansk N 52° 05′ 34.1″ E 106° 37′ 44.0″		a little turbidity high water level brown color
SR-12 (2007.07.25) Selenga River, Murzino N 52° 12′ 10.9″ E 106° 28′ 05.5″		a little turbidity high water level brown color

Table 5. Site description, Russia, 2008

Sites	Site picture	Site description
SR1 (2008.06.28) Selenge River Murzino N 52° 05' 36.72" E 106° 37' 42.36"		a little turbidity high water level brown color
SR2 (2008.06.28) Selenge River, Kabansk N 52° 02' 33.72" E 106° 37' 10.02"		a little turbidity high water level brown color
SR3 (2008.06.28) Selenge River, Beregovayat N 52° 01' 23.94" E 106° 45' 3.6"		turbidity high water level brown color
SR4 (2008.06.28) Selenge River, Bridge N 52° 03' 24.48“ E 106° 52' 42.66"		turbidity brown color wide width

SR5 (2008.06.28) Selenge River, Downstream of Ulan-Ude N 51° 54' 2.28" E 107° 29' 3.66"		turbidity, brown color high water level
SR6 (2008.06.29) Selenge River, Olen Hill N 51° 45' 3.06" E 107° 28' 57.96"		high turbidity brown color high water level
SR7 (2008.06.29) Selenge River, confluence of Uda and Selenge River N 51° 49' 20.04" E 107° 34' 27.54"		many trash in bank and in river beach in right bank
SR8 (2008.07.01) Modongul Stream N 50° 18' 39.54" E 103° 17' 46.02"		transparent low temperature
SR9 (2008.07.01) Waste water of mining N 50° 18' 43.56" E 103° 17' 46.86"		Filtrated water form dam of wolfram and molybdenium mining (mining 15 years ego closed). yellow color high turbidity

SR10 (2008.07.01) Modongul Stream, Zakamensik N 50° 22' 53.58" E 103° 17' 19.68"		brown color high velocity bank erosion
SR11 (2008.07.01) Modongul Stream, after Zakamensik WWTP N 50° 24' 38.58" E 103° 18' 30.48"		high velocity bank erosion brown color
SR12 (2008.07.02) Dzida River, Khamnei N 50° 23' 37.08" E 103° 51' 09.00"		- forest mountain - transparent
SR13 (2008.07.02) Selenge River, Naushk N 50° 23' 10.62" E 106° 04' 52.14"		High turbidity high water level brown color boundary of two countries
SR14 (2008.07.02) Selenge River, Novoselenge N 51° 05' 41.34" E 106° 38' 52.22"		high turbidity brown color hight water level

Table 6. Site description, Russia, 2009

Sites	Site picture	Site description
SR1 (2009.07.28) Modongul river upstream -zakamensk N 50° 18' 66.2" E 103° 17' 76.5" A=1,182m		- looks very clean - low temperature - depth: 20cm - same site (SR8 of 2nd) - Artificially created bank (sandy soil)
SR2 (2009.07.28) Modongul river (mine water) - zakamensk N 50° 18' 70.2" E 103° 17' 80.2" A=1,177m		- very high conductivity - very low pH - looks very dirty - stream rock covered with iron oxide(typical AMD) - Same site (SR9 of 2nd) - Artificially created bank - low temperature
SR3 (2009.07.28) Modongul Stream, after Bridge, after Zakamensk town N 50° 24' 63.4" E 103° 18' 50.9" A=1,038m		Zakamensk WWTP - Artificially created bank - high velocity - increased turbidity visual - Same site (SR11 of 2nd)
SR4 (2009.07.29) Gusinoozersk(Water after state district power plant (SDPP)) N 51° 17' 63.9" E 106° 28' 91.3" A=558m		- high temperature(bubble) - outlet connected with lake - There are many fishes in this lake - propagation of green algae

SR5 (2009.07.29) Gusinoozersk(Water before SDPP) N 51° 17' 74.7" E 106° 27' 37.2" A=555m		- depth: 1.5m - low velocity
SR6 (2009.07.29) Gusinoozersk lake N 51° 17' 61.0" E 106° 26' 82.1" A=553m		- consist of gravel - high pH comparatively (similar with SR4, SR5)
SR7 (2009.07.30) Selenga river, Murzino N 52° 11' 51.1" E 106° 29' 48.0" A=460m		- natural river bank erosion (increase of turbidity) - high velocity - Same site(SR1 of 2nd, SR12 of 1st)
SR8 (2009.07.30) Selenga river, selenginsk N 52° 01' 98.6" E 106° 49' 52.9" A=476m		- low velocity - similar with SR7 - power plant located in 3km upstream - Same site(SR9 of 1st)

SR9 (2009.07.30) Selenginskyi bridge before Ulan-Ude(Olen Hill) N 51° 44' 19.8" E 107° 28' 03.3" A=505m		- Same site(SR6 of 2nd) - bank of gravel type
SR10 (2009.07.30) Selenge river, Uda river (inflow into Selege river) N 51° 49' 30.2" E 107° 34' 49.6"		- high pH comparatively - stagnation waters - Same site(SR7 of 1st/2nd)
SR11 (2009.07.30) Selenge river after WWTP N 51° 53' 25.5" E 107° 30' 84.3" A=497m		- breaking of natural river bank - Same site(SR5 of 2nd)

Table 7. Physical Water Quality Parameters Analysis Result in Mongolian site, 2007

Stn	Date	Turb. (NTU)	Cond. (mS/m)	DO (mg/L)	Tem. (℃)	pH
SM-1	07.17	13	26.4	8.6	11.5	8.25
SM-2	07.17	15	24	10.53	17.3	8.61
SM-3	07.18		30.2	6.68	19	8.1
SM-4	07.18		30.7	7.06	20.4	8.21
SM-5	07.19	335	30	6.2	20.8	8.09
SM-6	07.20	19	82.4	10.36	11.1	8.34
SM-7	07.20	19	197.7	2.3	19.5	9.2
SM-8	07.20	114	125.8	8.99	13.4	8.19

SM-9	07.20	12	39.3	7.75	22.4	8.56
SM-10	07.20		53.5	5.25	20.8	7.68
SM-11	07.21	16	11	8.11	19.9	8.2
SM-12	07.21	53	26.4	7.22	21.8	8.27
SM-13	07.21	47	26.2	7.04	22.6	8.34
SM-14	07.21	23	24.1	7.76	22.3	8.6
SM-15	07.27	26	57.4	9.27	28.2	8.43
SM-16	07.27	37	101.1	6.48	26.6	8.29

Table 8. Physical Water Quality Parameters Analysis Result in Mongolian site, 2008

Stn	Date	Turb. (NTU)	Cond. (mS/cm)	DO (mg/L)	Tem. (℃)	pH	SS (mg/L)
SM1	06.25	120	0.043	10.49	9.99	6.77	20
SM2	06.25	138	0.659	8.65	18.9	8.54	53
SM3	06.25	294	0.063	9.78	14.2	7.53	94
SM4	06.25	310	0.93	1.65	17.5	7.61	132
SM6	06.26	593	0.076	9.65	12.9	7.5	149
SM7	06.26	782	0.08	8.88	16	7.53	228.67
SM8	06.29	207	0.121	7.79	17.4	7.5	101
SM9	06.27	720	0.267	7.2	23.6	7.76	661
SM10	06.27	999	0.28	6.58	25.4	8.21	1060
SM11	07.01	122	0.55	6.42	25.7	8.1	59.5
SM12	07.01	190	0.547	6.63	24.9	8.1	86.5
SM13	07.02	472	0.99	7	22.6	8.11	194.67
SM13-1	07.02	153	0.538	7	22.8	8.02	93.5
SM14	07.02	45	0.55	10.27	21.6	8.46	18.
SM15	07.03	45	0.365	7.22	16.5	8.03	23
SM16	07.03	19	0.512	7.89	15.4	8.27	11
SM17	07.03	505	0.148	8.93	15.8	7.92	350
SM18	07.05	58	0.028	10.7	9	6.88	9
SM19	07.05	152	0.096	9.94	11.3	7.83	62.5
SM20	07.06	34	0.059	7.88	18.7	7.15	11
SM21	07.06	999	0.104	10.9	20.4	7.76	1772
SM22	07.08	210	0.746	9.89	15.1	8.45	73
SM23	07.08	113	0.186	8.69	25.9	7.87	45.5

Table 9. Physical Water Quality Parameters Analysis Result in Mongolian site, 2009

Stn	Date	Turb. (NTU)	Cond. (mS/cm)	DO (mg/L)	Tem. (℃)	pH	SS (mg/L)
SM-1	07.27		0.355		8.1	6.20	
SM-2	07.27	140	1.100	10.33	12.0	7.79	78
SM-3	07.28	43	0.502	9.69	14.0	6.60	0.67
SM-4	07.28	198	1.020	10.52	13.5	7.74	54.7
SM-5	07.28	172	1.320	8.94	14.4	6.53	16
SM-6	07.28	60	0.750	12.51	19.6	8.08	25
SM-7	07.28	86	0.980	10.29	19.9	7.93	12.7
SM-8	07.29	86	0.455	7.47	18.6	7.55	34
SM-9	07.29	182	2.510	4.39	4.7	6.77	
SM-10	07.29	585	0.288	9.06	20.1	8.12	300
SM-11	07.29	35	0.502	5.23	20.7	7.31	0.67
SM-12	07.29	191	0.306	9.10	23.1	7.88	40
SM-13	07.30		0.244	2.33	9.5	5.96	
SM-14	07.30		0.188	8.81	18.0	6.98	12.7
SM-15	07.30	99	0.708	0.76	17.3	7.23	60
SM-16	07.30		0.072	8.30	15.6	6.28	5
SM-17	07.30		0.588	9.08	20.6	8.24	31.3
SM-18	07.31		0.100	10.08	8.1	5.68	
SM-19	07.31	8	0.061	10.41	16.7	6.23	5.5

Table 10. Physical Water Quality Parameters Analysis Result in Russian site, 2007

Stn	Date	Turb. (NTU)	Cond. (mS/cm)	DO (mg/L)	Tem. (℃)	pH
SR-1	07.22	67	26.7	7.42	22.3	8.22
SR-2	07.23	20	26.7	7.29	19.6	8.25
SR-3	07.23	18	22.7	8.02	21.6	8.33
SR-4	07.23		8.1	7.76	22.6	8.29
SR-5	07.23		14.5	7.89	23.3	8.53
SR-6	07.24	45	20.2	7.31	23.3	8.36
SR-7	07.24	10	15	8.04	22.3	8.37
SR-8	07.24	21	17.8	7.74	23.1	8.43
SR-9	07.24	42	20.1	7.62	23.1	8.46
SR-10	07.24	37	19.7	7.54	23	8.47
SR-11	07.25	22	20.1	7.04	22.7	8.42
SR-12	07.25	24	19.9	7.32	22.9	8.46

Table 11. Physical Water Quality Parameters Analysis Result in Russian site, 2008

Stn	Date	Turb. (NTU)	Cond. (mS/cm)	DO (mg/L)	Tem. (℃)	pH
SR-1	06.28				20	7.5
SR-2	06.28				20.6	7.5
SR-3	06.28				19	7.39
SR-4	06.28				21	7.42
SR-5	06.28				21.5	7.42
SR-6	06.29				21	7.36
SR-7	06.29				21.6	7.51
SR-8	07.01				4	7.56
SR-9	07.01				7.3	5.45
SR-10	07.01				12.2	6.92
SR-11	07.01				11.9	6.89
SR-12	07.02				15	7.23
SR-13	07.02				20.2	7.41
SR-14	07.02				21.4	7.42

Table 12. Physical Water Quality Parameters Analysis Result in Russian site, 2009

Stn	Date	Turb. (NTU)	Cond. (mS/cm)	DO (mg/L)	Tem. (℃)	pH	SS (mg/L)
SR-1	07.28		0.138		11.1	6.90	0.67
SR-2	07.28		3.600		13.4	3.20	90
SR-3	07.28		0.366		17.0	7.10	26
SR-4	07.29		0.372		27.0	8.48	1.3
SR-5	07.29		0.369		20.4	8.38	3.3
SR-6	07.29		0.367		24.0	8.55	4
SR-7	07.30		0.137		21.7	8.06	21
SR-8	07.30		0.138		21.3	8.04	30
SR-9	07.30		0.150		21.6	8.19	18
SR-10	07.30		0.180		19.3	8.53	4
SR-11	07.30		0.140		20.9	7.83	17.3

Table 13. Heavy Metal Result in Mongolian part, 2007

Stn	Date	As (μg/L)	Pb (μg/L)	Fe (μg/L)	Cd (μg/L)	Cr (μg/L)	Cu (μg/L)	Mn (μg/L)	Zn (μg/L)	Ni (μg/L)
SM-1	07.17	0.66	1.68	4.4	0.01	0.57	0	0.37	8.76	0.08
SM-2	07.17	0.66	0.39	9.2	0	0.51	0	1.14	4.28	0.08
SM-3	07.18	0.41	0.28	9.8	0.01	0.67	0.03	3.43	9.84	0.42

SM-4	07.18	0.5	0.66	12.9	0.02	0.56	0	5.03	6.8	0.39
SM-5	07.19	1.44	0.31	122.9	0.05	1.2	3.94	8.88	309	1
SM-6	07.20	2.15	0.79	14.3	0.12	1.91	2.8	7.35	8.76	0.81
SM-7	07.20	20.2	0.38	32.5	19.8	2.02	51	5.72	6.75	1.58
SM-8	07.20	3.45	0.23	101	0.43	1.67	18.2	84.2	15.3	1.59
SM-9	07.20	2.46	0.23	30.8	0.03	1.03	0.52	6.57	5.91	0.37
SM-10	07.20	1.35	0.85	40.3	0.02	2.85	1.72	5.15	17.1	0.72
SM-11	07.21	1.77	0.43	83.7	0.01	0.52	0.03	6.96	6.41	0.29
SM-12	07.21	1.38	0.38	52.4	0.01	0.54	0.63	18.3	15.4	0.75
SM-13	07.21	1.39	0.51	165.9	0.02	1.34	1.42	18.6	401	1.32
SM-14	07.21	2.74	0.39	92.7	0.01	0.66	0.67	7.95	8.71	0.45
SM-15	07.27	1.75	0.2	20.1	0.05	1.09	1.07	31	10.1	0.99
SM-16	07.27	7.67	0.28	49.4	0.05	1.19	2.3	61	11.6	1.45

Table 14. Heavy Metal Result in Mongolian part, 2008

Stn	Date	As (μg/L)	Pb (μg/L)	Co (μg/L)	Fe (μg/L)	Cd (μg/L)	Cr (μg/L)	Cu (μg/L)	Mn (μg/L)	Zn (μg/L)	Ni (μg/L)
SM1	06.25	0.93	1.97	0.22	130.99	0.20	1.50	1.64	6.41	18.80	0.75
SM2	06.25	6.60	1.03	0.82	338.09	0.06	1.56	3.44	159.89	130.20	3.52
SM3	06.25	1.01	0.47	0.17	178.58	0.02	0.68	1.44	11.21	28.59	0.94
SM4	06.25	1.76	0.70	0.43	388.90	0.03	7.86	2.81	115.29	75.55	2.88
SM6	06.26	1.15	0.41	0.24	272.58	0.02	0.71	1.46	33.95	63.84	1.08
SM7	06.26	1.61	0.53	0.32	360.48	0.02	0.93	2.24	60.76	598.45	1.35
SM8	06.29	2.32	0.46	0.32	320.83	0.01	0.82	1.70	33.58	98.52	1.57
SM9	06.27	3.37	1.23	0.71	1152.21	0.03	1.63	3.60	60.51	365.89	3.88
SM10	06.27	3.37	1.15	0.48	846.54	0.03	1.28	3.66	38.94	110.58	3.69
SM11	07.01	9.55	0.31	31.27	254.71	0.12	1.07	2.76	42.06	52.41	3.06
SM12	07.01	9.73	0.51	0.67	254.96	0.16	1.28	2.79	26.67	54.68	3.02
SM13	07.02	2.92	0.30	0.50	515.38	0.12	1.02	3.35	38.68	170.12	3.93
SM13-1	07.02	10.41	0.39	0.60	388.83	0.11	0.57	2.78	51.82	113.45	3.46
SM14	07.02	10.72	0.14	0.19	295.64	0.04	1.59	0.92	2.54	38.91	2.74
SM15	07.03	6.34	0.36	0.37	366.40	0.05	0.92	1.46	18.99	21.22	3.07
SM16	07.03	6.18	0.16	0.34	170.73	0.05	1.17	1.17	22.93	54.19	2.26
SM17	07.03	2.80	0.55	0.36	410.89	0.02	0.89	1.71	21.99	75.38	1.73
SM18	07.05	0.30	0.13	0.12	83.89	0.02	0.48	1.47	3.51	40.06	0.74
SM19	07.05	2.58	0.24	0.16	164.42	0.01	0.54	1.55	6.95	197.69	1.32
SM20	07.06	7.38	0.53	0.10	79.88	0.02	0.51	1.52	5.06	22.16	0.98
SM21	07.06	1.90	3.01	1.36	1324.55	0.08	2.09	2.95	117.56	372.90	2.72
SM22	07.08	12.46	0.36	0.87	427.00	0.11	2.78	2.59	23.62	113.07	4.22
SM23	07.08	3.89	0.43	0.21	222.51	0.02	0.70	1.74	73.29	54.00	1.99

Table 15. Heavy Metal Result in Mongolian part, 2009

Stn	Date	As (μg/L)	Pb (μg/L)	Fe (μg/L)	Cd (μg/L)	Cr (μg/L)	Cu (μg/L)	Mn (μg/L)	Zn (μg/L)	Ni (μg/L)	Co (μg/L)	Ag (μg/L)
SM-1	07.27	1.612	0.258	99.83	0.026	0.743	0.984	0.508	48.787	0.952	0.085	0.065
SM-2	07.27	1.955	0.185	200.791	0.121	0.854	20.88	60.645	20.206	2.464	0.237	0.022
SM-3	07.28	0.714	0.384	93.799	0.035	0.576	3.437	29.97	32.365	1.672	0.29	0.028
SM-4	07.28	2.619	0.11	158.284	0.078	1.093	17.532	7.261	14.803	2.033	0.178	0.013
SM-5	07.28	5.465	0.11	212.255	1.866	0.405	47.065	182.661	24.734	3.347	0.613	0.015
SM-6	07.28	1.539	0.119	143.309	0.102	1.364	3.254	4.622	14.255	1.583	0.205	0.01
SM-7	07.28	1.829	0.121	216.765	0.105	0.812	10.167	6.318	16.011	2.152	0.167	0.008
SM-8	07.29	2.681	0.01	66.889	0.022	1.664	1.785	1.862	11.066	1.059	0.199	0.003
SM-9	07.29	5.734	0.226	257.825	0.053	1.994	12.318	303.776	33.005	7.793	1.008	0.014
SM-10	07.29	2.887	0.442	465.439	0.024	0.95	2.369	11.105	37.298	1.867	1.036	0.013
SM-11	07.29	1.361	0.283	128.864	0.027	1.108	1.834	6.596	45.792	1.909	0.544	0.083
SM-12	07.29	2.557	0.206	116.751	0.029	0.556	1.458	8.71	42.531	1.168	0.27	0.022
SM-13	07.30	0.182	0.087	84.157	0.005	0.204	0.327	33.817	4.912	0.663	0.052	0.013
SM-14	07.30	1.142	0.234	102.156	0.043	0.82	1.18	52.71	41.617	0.858	0.516	0.015
SM-15	07.30	1.342	0.566	284.211	0.042	4.926	2.427	98.476	3.206	2.128	0.694	0.113
SM-16	07.30	0.683	0.377	64.823	0.01	0.347	0.961	7.751	39.187	0.486	0.248	0.006
SM-17	07.30	6.739	0.888	191.740	0.057	0.700	3.776	130.085	29.131	2.740	0.858	0.011
SM-18	07.31	0.299	0.509	111.544	0.019	0.21	15.359	0.848	10.124	0.398	0.03	0.009
SM-19	07.31	0.805	0.119	57.555	0.011	0.3	1.021	11.982	29.739	0.478	0.29	0.004
SM-A		0.831	1.046	339.772	0.104	0.885	4.366	57.524	64.153	1.433	0.201	0.093
SM-B		2.824	4.865	179.822	0.086	1.086	4.702	108.433	39.438	1.808	0.407	0.02
SM-C		0.774	0.292	198.522	0.254	0.912	3.814	18.191	17.339	2.204	0.227	0.015
SM-D		0.553	3.03	276.513	0.057	0.86	8.47	10.478	16.199	1.92	0.127	0.01

Table 16. Heavy Metal Result Russian part, 2007

Stn	Date	As (μg/L)	Cd (μg/L)	Cu (μg/L)	Zn (μg/L)	Fe (μg/L)	Pb (μg/L)	Ni (μg/L)	Mn (μg/L)	Cr (μg/L)
SR-1	07.22	1.22	0.02	1	301	161.8	0.79	1.3	12.3	1.09
SR-2	07.23	0.41	0.02	0.32	8.66	21.4	0.27	0.5	3.39	0.49
SR-3	07.23	0.74	0.01	0.24	4.05	56.3	0.4	0.55	6.84	0.44
SR-4	07.23	1.55	0.01	0	2.49	42.2	0.21	0	5.77	0.26
SR-5	07.23	0.41	0.01	0	1.92	40.7	0.16	0.15	8.88	0.34
SR-6	07.24	1.13	0.01	0.34	7.46	47	0.54	0.48	3.44	0.43
SR-7	07.24	0.4	0.01	0.01	68.9	54.4	0.18	0.06	9.52	0.45
SR-8	07.24	0.73	0.01	0	6.88	47.6	0.33	0.36	9.49	0.53

SR-9	07.24	1	0.01	0.1	6.42	40.6	0.91	0.37	2.52	0.42
SR-10	07.24	1.04	0.03	0.18	8.89	58.4	0.39	0.73	6.12	0.53
SR-11	07.25	1.04	0.01	0.1	8.72	33.3	0.24	0.33	4.31	0.46
SR-12	07.25	1.06	0.01	0.07	7.67	36.4	0.18	0.4	3.91	0.51

Table 17. Heavy Metal Result in Russian part, 2008

Stn	Date	As (μg/L)	Cd (μg/L)	Cu (μg/L)	Zn (μg/L)	Fe (μg/L)	Pb (μg/L)	Ni (μg/L)	Mn (μg/L)	Cr (μg/L)
SR1	06.28	1.088	0.01	1.981	18.616	294.434	0.341	2.294	20.279	0.524
SR2	06.28	1.085	0.019	1.866	15.471	248.394	0.295	2.14	18.614	0.475
SR3	06.28	0.992	0.015	1.649	16.886	235.862	0.35	2.043	27.437	0.465
SR4	06.28	1.153	0.01	1.804	17.423	229.21	0.292	2.182	13.649	0.511
SR5	06.28	1.484	0.015	2.008	20.841	291.978	0.395	2.246	26.487	0.564
SR6	06.29	1.475	0.017	2.481	19.37	320.22	0.421	2.397	15.568	0.613
SR7	06.29	0.429	0.076	1.016	12.685	200.985	0.619	1.13	9.596	0.789
SR8	07.01	0.17	0.02	1.699	16.876	102.847	0.215	1.07	2.1	0.535
SR9	07.01	0.178	3.581	15.488	123.306	202.398	0.886	4.337	261.572	0.48
SR10	07.01	0.337	0.096	3.754	19.227	209.293	0.335	3.469	12.958	0.577
SR11	07.01	1.283	791.836	5470	30000	1480	389.187	418.822	40900	1.684
SR12	07.02	0.212	5.857	24.44	211.411	169.482	1.303	5.406	401.925	0.45
SR13	07.02	1.535	0.035	3.374	24.71	328.726	0.582	3.015	13.682	0.789
SR14	07.02	1.203	0.021	3.242	21.913	338.481	0.532	3.148	17.07	0.785

Table 18. Heavy Metal Result in Russian part, 2009

Stn	Date	As (μg/L)	Pb (μg/L)	Fe (μg/L)	Cd (μg/L)	Cr (μg/L)	Cu (μg/L)	Mn (μg/L)	Zn (μg/L)	Ni (μg/L)	Co (μg/L)	Ag (μg/L)
SR-1	07.28	0.114	0.113	47.769	0.041	0.453	1.276	0.761	14.871	0.785	0.225	0.005
SR-2	07.28	1.146	1,161	20,440	1,086	8.78	24,700	54,470	50,130	592	1,021	0.394
SR-3	07.28	0.134	0.327	101.262	7.485	0.414	15.669	404.576	232.723	6.561	6.988	0.028
SR-4	07.29	0.939	0.115	73.761	0.076	0.477	2.173	3.584	10.554	0.951	0.108	0.012
SR-5	07.29	0.977	0.128	76.371	0.063	0.49	1.828	3.782	9.662	0.935	0.09	0.01
SR-6	07.29	0.939	0.083	76.436	0.053	0.525	1.573	2.796	6.383	0.993	0.064	0.008
SR-7	07.30	1.222	0.12	98.51	0.024	0.439	1.661	3.831	16.382	1.151	0.118	0.009
SR-8	07.30	1.201	0.123	105.156	0.03	0.448	1.593	4.269	16.696	1.101	0.128	0.006
SR-9	07.30	1.268	0.104	92.932	0.026	0.439	1.535	6.174	14.236	1.17	0.147	0.006
SR-10	07.30	0.466	0.09	189.617	0.033	0.381	1.089	93.951	10.554	0.979	0.217	0.006
SR-11	07.30	1.023	0.103	95.976	0.028	0.469	1.254	11.575	18.716	0.986	0.101	0.006

Table 19. Organic matter and nutrients Analysis Result in Mongolian site, 2009

Stn	Date	COD (mg/L)	T-N (mg/L)	T-P (mg/L)	PO4-P (mg/L)	NO3-N (mg/L)	NO2-N (mg/L)	NH3-N (mg/L)
SM-1	07.27	7.0	2.35	0.44	0.43	0.7	0.0035	1.36
SM-2	07.27	17.5	3.0	0.47	0.5	2.3	0.03	0.6
SM-3	07.28	21.0	23.65	2.44	2.41	11.35	0.814	9.86
SM-4	07.28	11.0	4.2	0.55	0.53	3.2	0.02	0.5
SM-5	07.28	31.0	10.9	1.42	1.42	5.1	0.26	4.2
SM-6	07.28	14.5	5.6	0.43	0.4	2.9	0.0167	0.28
SM-7	07.28	2.5	5.4	0.38	0.4	2.1	0.015	1.0
SM-8	07.29	11.0	2.1	0.47	0.46	0.1	0.0205	0.25
SM-9	07.29	69.5	57.1	0.54	0.56	26.45	0.4795	1.2
SM-10	07.29	52.5	3.15	1.12	1.02	1.3	0.1065	1.45
SM-11	07.29	14.5	18.5	0.92	1.95	15.25	0.936	0.61
SM-12	07.29	16.5	0.4	0.42	0.41	0.1	0.01	0.1
SM-13	07.30	0.8	0.3	0.3	0.32	0.05	0.003	0.25
SM-14	07.30	22.5	4.35	0.5	0.53	0.04	0.0175	2.58
SM-15	07.30	155.0	26.5	2.8	1.98	0.4	0.0655	20.96
SM-16	07.30	15.5	0.75	0.28	0.25	0.05	0.007	0.35
SM-17	07.30	48.5	18.7	1.62	1.42	0.15	0.102	17.4
SM-18	07.31	6.0	1.0	0.23	0.23	0.9	0.008	0.1
SM-19	07.31	8.0	1.3	0.2	0.18	0.04	0.005	0.75

Table 20. Organic matter and nutrients Analysis Result in Russian site, 2009

Stn	Date	COD (mg/L)	T-N (mg/L)	T-P (mg/L)	PO4-P (mg/L)	NO3-N (mg/L)	NO2-N (mg/L)	NH3-N (mg/L)
SR-1	07.28	10.0	1.0	0.22	0.23	0.23	0.0035	0.3
SR-2	07.28	7.0	1.9	0.25	0.24	0.3	0.1585	1.5
SR-3	07.28	4.0	3.5	0.25	0.24	0.63	0.0085	1.05
SR-4	07.29	14.5	0.2	0.2	0.2	0.1	0.019	0.3
SR-5	07.29	22.5	3.9	0.19	0.185	0.1	0.0105	1.0
SR-6	07.29	17.0	0.6	0.18	0.18	0.1	0.0035	0.4
SR-7	07.30	17.5	0.8	0.27	0.24	0.2	0.014	0.6
SR-8	07.30	11.0	1.9	0.32	0.27	0.2	0.0205	1.0
SR-9	07.30	10.5	0.2	0.12	0.12	0.1	0.0135	0.1
SR-10	07.30	11.0	0.7	0.18	0.19	0.17	0.019	0.35
SR-11	07.30	10.0	0.8	0.2	0.19	0.1	0.02	0.7

Table 21. Chemical water quality analysis in Mongolian part, mg/l, 2007

Sample	pH	CO3	HCO3-	Cl-	SO4--	NO2 -	NO3 -	Na++K +	Ca++	Mg++	NH4+	Mineralization [mg/l]	Hardness [mg-eq/l]
SM-1	8.3	3.00	176.90	7.10	7.00	0.00	0.00	12.57	38.08	10.94	0.00	255.6	2.80
SM-2	8.6	3.00	143.35	7.10	14.00	0.00	0.00	5.49	34.07	12.16	0.05	219.2	2.70
SM-3	8.2	3.00	155.55	5.33	35.00	0.00	0.00	8.59	51.10	7.30	0.10	266.0	3.15
SM-4	8.3	1.50	164.70	5.33	37.00	0.00	0.00	14.28	53.11	4.86	0.00	280.8	3.05
SM-5	8.0	1.50	170.80	3.55	27.00	0.18	2.00	12.43	40.08	12.16	0.15	269.8	3.00
SM-6	8.3	3.00	338.55	24.85	110.0	0.0	1.5	39.4	76.2	38.30	0.05	631.8	6.95
SM-8	8.1	15.0	292.80	31.95	300.0	0.0	1.0	23.3	134.3	57.76	0.05	856.1	11.45
SM-9	8.5	9.00	173.85	14.20	15.00	0.00	0.00	9.10	40.08	17.63	0.30	279.2	3.45
SM-10	7.7	0.00	134.20	30.18	30.00	0.80	45.00	41.56	30.06	13.38	0.20	325.4	2.60
SM-11	8.2	0.00	67.10	3.55	4.00	0.00	0.00	7.28	14.03	3.04	0.30	99.3	0.95
SM-12	8.2	0.00	134.20	5.33	17.30	0.00	0.00	13.91	30.06	7.30	0.10	208.2	2.10
SM-13	8.3	0.00	146.40	3.55	14.00	0.00	1.00	8.10	33.07	9.73	0.10	215.9	2.45
SM-14	8.6	0.00	115.90	3.55	15.00	0.10	0.00	7.11	25.05	9.12	0.10	175.9	2.00
SR-1	8.2	0.00	134.20	3.55	18.00	0.00	0.00	15.53	28.06	7.30	0.00	206.6	2.00
SR-2	8.2	0.00	158.60	3.55	17.00	0.04	0.50	2.60	38.08	12.77	0.00	233.1	2.95
SR-3	8.3	0.00	115.90	7.10	17.00	0.02	0.00	4.45	28.06	10.34	0.20	183.1	2.25
SR-4	8.3	0.00	61.00	5.33	4.00	0.00	1.00	12.51	10.02	2.43	0.10	96.4	0.70
SR-5	8.5	0.00	100.65	4.26	6.00	0.00	1.00	16.23	16.03	4.86	0.10	149.1	1.20
SR-6	8.4	0.00	112.85	5.33	12.00	0.01	1.00	10.34	27.05	5.47	0.30	174.4	1.80
SR-7	8.4	0.00	88.45	5.33	8.00	0.01	1.00	13.15	17.03	4.26	0.20	137.4	1.20
SR-8	8.5	0.00	103.70	5.33	17.00	0.01	0.00	18.50	22.04	3.65	0.00	170.2	1.40
SR-9	8.5	0.00	109.80	3.55	10.00	0.01	0.00	10.42	25.05	4.86	0.10	163.8	1.65
SR-10	8.5	0.00	112.85	3.55	6.00	0.01	0.00	10.93	24.05	4.86	0.00	162.3	1.60
SR-11	8.4	0.00	115.90	3.55	8.00	0.01	0.00	7.29	24.05	7.90	0.00	166.7	1.85
SR-12	8.5	0.00	112.85	3.55	7.00	0.01	0.00	10.13	23.05	6.08	0.10	162.8	1.65
SM-27	8.4	0.00	262.30	24.85	25.00	0.03	1.00	20.80	62.12	18.24	0.60	414.9	4.60

Table 22. Chemical water quality analysis in Mongolian part, mg/l, 2008

Sample	pH	CO3	HCO3-	Cl-	SO4--	NO2-	NO3-	Na++K+	Ca++	Mg++	Mineralization [mg/l]	Hardness [mg-eq/l]
SM-1	0.0	36.6	8.88	6.00	0.01	0.40	4.18	10.2	2.43	0.2	68.72	0.70
SM-2	0.0	231.8	46.15	61.00	0.02	0.60	55.27	40.8	20.67	5.0	460.59	3.70
SM-3	0.0	32.7	7.1	9.00	0.01	0.00	6.36	12.02	2.43	0.2	79.83	0.80
SM-4	0.0	298.9	81.65	67.15	0.00	0.80	104.8	50.1	12.16	10.0	625.56	3.50
SM-6	0.0	61	10.65	35.00	0.01	0.00	25.34	15.03	1.82	0.5	149.35	0.90
SM-7	0.0	42.7	12.43	36.00	0.01	8.00	20.73	12.02	4.86	0.5	137.25	1.00
SM-8	0.0	146.4	14.2	35.00	0.00	0.00	18.94	40.08	8.51	0.1	263.2	2.70
SM-9	0.0	164.7	8.88	49.00	0.00	2.00	32.02	32.06	12.16	0.2	301	2.60
SM-10	0.0	195.2	12.43	17.0	0.00	0.2	25.47	36.07	12.16	0.2	298.5	2.80
SM-11	0.0	231.8	42.6	36.00	0.00	0.00	53.79	31.06	22.5	0.2	417.95	3.40
SM-12	0.0	225.7	39.05	20.05	0.00	0.30	40.51	30.06	23.71	0.2	379.6	3.45
SM-13	0.0	259.25	56.8	135.00	0.01	0.20	68.73	49.1	38.91	0.5	608.5	5.65
SM-13-1	0.0	231.8	39.05	98.83	0.00	1.00	72.77	40.08	21.89	0.2	505.62	3.80
SM-14	3.0	201.3	39.05	96.55	0.00	0.00	43.96	52.1	24.32	0.0	460.28	4.60
SM-15	0.0	231.8	10.65	26.00	0.00	0.00	35.46	40.08	13.38	0.0	357.37	3.10
SM-16	0.0	323.3	14.20	30.0	1.00	0.20	56.09	38.08	24.32	0.2	487.4	3.90
SM-17	0.0	115.9	35.5	16.00	0.02	4.00	31.65	30.06	2.43	4.0	239.56	1.70
SM-18	0.0	30.5	7.1	6.00	0.00	0.00	13.23	4.01	0.61	0.0	61.45	0.25
SM-19	0.0	103.7	5.33	16.00	0.00	0.00	20.32	14.03	7.3	0.0	166.68	1.30
SM-20	0.0	79.3	3.55	7.00	0.00	0.00	5.65	14.03	7.3	0.0	116.83	1.30
SM-21	0.0	170.8	10.65	35.00	0.00	6.00	21.68	40.08	10.94	1.5	296.65	2.90
SM-22	18.0	366	28.4	42.00	0.00	0.20	68.371	58.116	29.184	0.1	610.37	5.30
SM-23	0.0	146.4	21.3	29.35	0.02	0.80	50.915	20.04	4.864	0.2	273.89	1.40

Table23. Chemical water quality analysis in Mongolian part, mg/l, 2009

Sample	pH	CO3	HCO3-	Cl-	SO4--	NO2-	NO3-	Na++K+	Ca++	Mg++	Mineralization [mg/l]	Hardness [mg-eq/l]
SM-1	0.00	247.05	8.88	8.00	0.00	0.10	28.79	52.10	7.30	0.30	352.52	3.20
SM-2	0.00	317.20	26.63	200.00	0.02	0.21	23.34	115.23	38.91	2.80	724.34	8.94
SM-3	0.00	183.00	31.95	50.00	0.76	1.22	26.58	52.10	7.90	10.30	363.81	3.25
SM-4	0.00	311.10	26.63	140.00	0.00	0.89	6.66	102.20	40.13	1.65	629.26	8.40
SM-5	0.00	204.35	31.95	280.00	0.27	1.23	20.46	128.26	29.79	6.65	702.96	8.85
SM-6	0.00	314.15	23.08	80.00	0.01	0.10	33.77	81.16	23.71	0.00	555.98	6.00
SM-7	18.00	262.30	17.75	150.00	0.01	0.47	17.75	98.20	34.66	0.20	599.34	7.75
SM-8	0.00	195.20	10.65	20.00	0.00	0.15	37.24	39.08	4.26	0.00	306.58	2.30
SM-9	30.00	802.15	79.88	120.00	0.45	33.80	179.51	142.28	55.33	0.00	1443.4	11.65
SM-10	0.00	213.50	10.65	25.00	0.05	0.46	30.06	42.08	10.94	0.40	333.14	3.00
SM-11	0.00	137.25	35.50	50.00	0.94	1.26	40.55	31.06	12.16	0.35	309.07	2.55
SM-12	9.00	158.60	10.65	12.00	0.01	0.11	14.10	38.08	10.94	0.20	254.30	2.80
SM-13	0.00	97.60	28.40	20.00	0.00	0.07	6.10	33.07	5.47	8.15	198.86	2.10
SM-14	0.00	85.40	17.75	20.00	0.01	0.16	24.15	20.04	1.22	3.05	171.78	1.10
SM-15	0.00	268.40	67.45	45.00	0.00	0.27	69.45	51.10	9.12	16.60	527.39	3.30
SM-16	0.00	45.75	3.55	7.00	0.00	0.09	4.80	10.02	2.43	0.1	75.70	0.70
SM-17	0.00	289.75	31.95	25.00	0.01	0.24	64.40	42.08	6.69	13.05	473.17	2.65
SM-18	0.00	61.00	8.88	10.00	0.30	0.33	9.00	16.03	3.04	0.40	108.98	1.05
SM-19	0.00	42.70	3.55	7.00	0.00	0.10	5.69	10.02	2.43	0.00	71.49	0.70
A	0.00	122.00	3.55	15.00	0.00	0.06	19.86	20.04	5.47	–	188.58	1.45
B	0.00	109.80	5.33	12.00	0.00	0.07	15.23	22.04	3.65	0.00	176.32	1.40
C	0.00	247.05	7.10	20.00	0.00	0.13	22.67	44.09	17.02	1.25	359.31	3.60
D	0.00	149.45	5.33	25.00	0.00	0.11	5.25	40.08	8.51	–	237.22	2.70

Appendix 2. Expert Survey Questionnaire

Survey for M/R Water Management System on SRB

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Survey for M/R Domestic Water Management System on Selenge River Basin

As the Partnership Project of Network of Institutions for Sustainable Development (NISD) under UNEP-ETB, Korea Environment Institute (KEI), Institute of Geoecology, Mongolian Academy of Science(IGMAS) and Baikal Institute of Nature Management, Siberian Branch of the Russian Academy of Science(BINM) have been conducting a joint research project "Integrated Water Management Model(IWMM) on the Selenge River Basin" for three years from 2007.

The overall objective of this project is to develop the IWMM for sustainability of SRB in national and international level. Therefore, joint research team tries to identify the needs and expectations of major actors and stakeholders of Mongolia and Russia to develop the potential domestic & transboundary water management system on SRB in addressing common water environmental issues.

Your answer will be only used for the analysis and development of Domestic Water Management System on SRB in this joint research project. We have a favor you to answer all of questions in this survey paper for SRB sustainability.

Thank you.

Project Manager

Korea Environment Institute

2010. 6

※ Information collected from the following questionnaire is used solely for the classification and statistical purposes.

Name		Contact	
Email			
Address	(Korea/ Mongolia/Russia) ( )city/province ( )town/province		
occupation	☐ 1) government position(public servant/government subsidiary) ☐ 2) Professor ☐ 3) Researcher ☐ 4) Water resource related company ☐ 5) others		
	Name of Institution		
	Are you involved in M-R Transboundary Joint Working Group Meeting or Government Representative Meeting? ☐ Yes ☐ No		

Ⅰ. Recognition of the Domestic Water Isssues in SRB

Please indicate to which extent you would agree or disagree with the following statements.

1-1 There are several domestic water issues of SRB that need to cope with by integrated water management system in Mongolia and Russia (hereinafter M&R).

1.___	agree	2.___	Slightly agree	3.___	Neutral	4.___	Slightly disagree	5.___	Disagree

(Additional Comment:)

1-2 The domestic water issues of SRB will go on increasing and become significant domestic issues of M&R.

1.___	agree	2.___	Slightly agree	3.___	Neutral	4.___	Slightly disagree	5.___	Disagree

(Additional Comment:)

1-3 Please choose two of the most significant, CURRENT domestic water issues of M/R in SRB, and rank them in order.

First		Second	

1. Water resources shortage
2. Water quality deterioration
3. Heavy metal pollution
4. Drinking Water quality issue
5. Improvement Water Supply system
6. Ecosystem deterioration/Biodiversity loss
7. Natural disaster (Flood etc.)
8. Development of river basin (Dam construction etc.)
9. Others (please specify)

1-4 Please choose two of the most significant, FUTURE domestic water issues of M/R in SRB, and rank them in order.

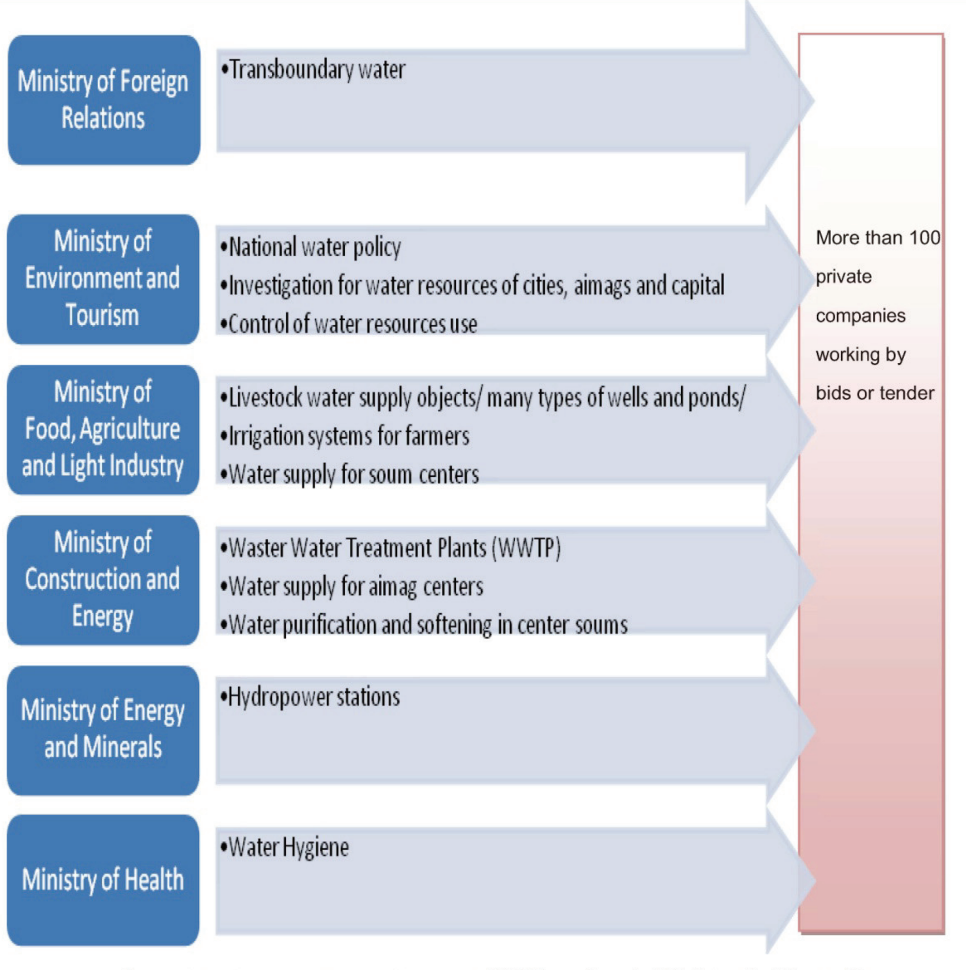
First		Second	

1. Water resources shortage
2. Water quality deterioration
3. Heavy metal pollution
4. Drinking Water quality issue
5. Improvement Water Supply system
6. Ecosystem deterioration/Biodiversity loss
7. Natural disaster (Flood etc.)
8. Development of river basin (Dam construction etc.)
9. Others (please specify)

Ⅱ. Evaluation of the Current Water Management Policy of M/R on SRB

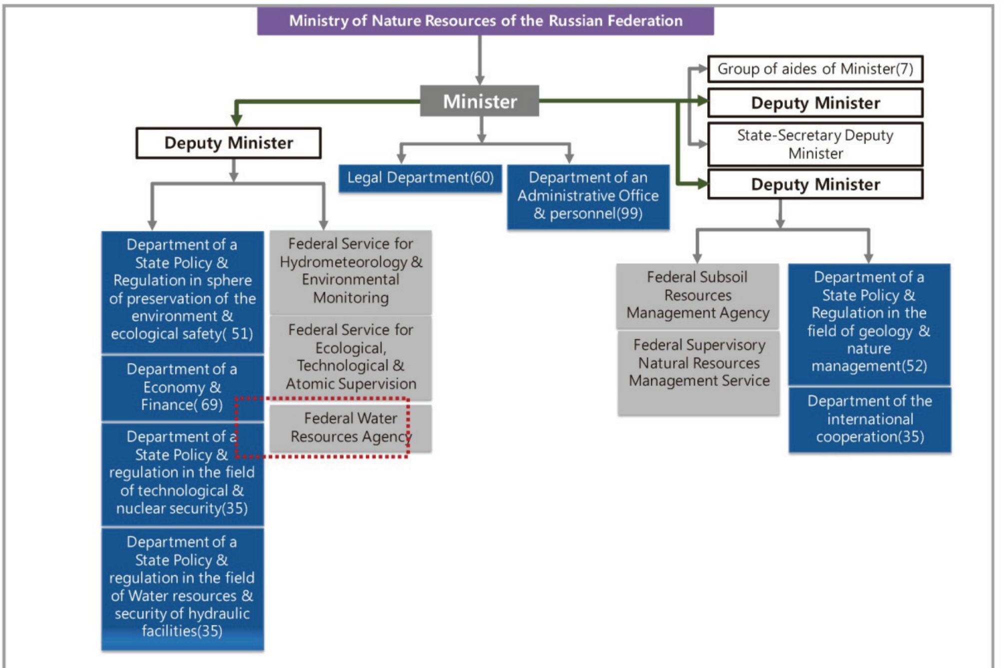
Please indicate to which extent you would agree or disagree with the following statements.

Current Water Management System of Mongolia

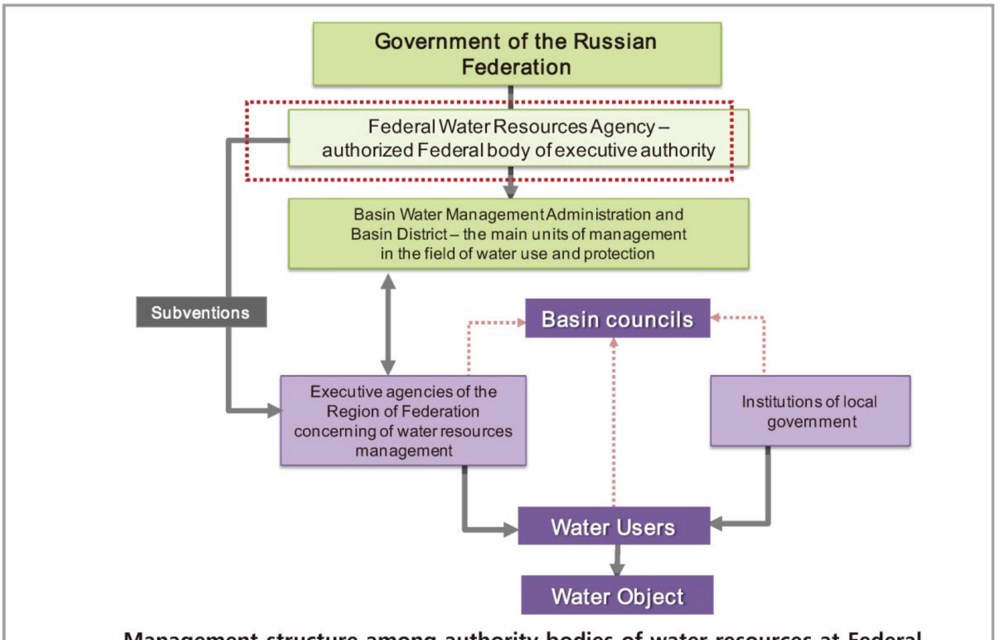


Current water management responsibilities of each Ministry in Mongolia

Current Water Management System of Russia



Structure of the Ministry of Nature Resources of the Russian Federation



Management structure among authority bodies of water resources at Federal, Regional and Municipal levels

2-1 The domestic water management policies of M/R have been known well among major actors and stakeholders of relevant organizations in two countries

1.___	Agree	2.___	Slightly Agree	3.___	Neutral	4.___	Slightly Disagree	5.___	Disagree

(Additional Comment:)

2-2 The current water management policies of Mongolia/Russia produced positive outcomes in addressing rational use and protection of water of SRB.

1.___	agree	2.___	Slightly agree	3.___	Neutral	4.___	Slightly disagree	5.___	disagree

(Additional Comment:)

2-3 Please choose two of the most important domestic water management policies of M/R in current water management system, and rank them in order.

First		Second	

1. Laws of water management
2. Environmental Impact Assessment system
3. Environmental protection plan(program)
4. National water management plan(program)
5. Water use fee and wastewater emission charge system
6. Water quality standard and pollutant emission standard
7. Regulations of water resources and river basin development
8. Others (please specify)

2-4 Please choose two of the most serious limitations or weak points in domestic water management policies of M/R in current water management system, and rank them in order.

First		Second	

1. Insufficient recognition of water issues
2. Insufficient recognition of the integrated management necessity of each government on water issues
3. Different interests in water issues among relevant departments and stakeholders
4. Lack of institutional arrangement and detail policy instruments
5. Lack of coordination and harmony the differences and disputes among policies and interests
6. Lack of administrative and financial capacity
7. Lack of public awareness and participation
8. Others (please specify)

Ⅰ. Recognition of the Domestic Water Isssues in SRB

Please indicate to which extent you would agree or disagree with the following statements.

1-1 There are several domestic water issues of SRB that need to cope with by integrated water management system in Mongolia and Russia (hereinafter M&R).

1.___	agree	2.___	Slightly agree	3.___	Neutral	4.___	Slightly disagree	5.___	Disagree

(Additional Comment:)

1-2 The domestic water issues of SRB will go on increasing and become significant domestic issues of M&R.

1.___	agree	2.___	Slightly agree	3.___	Neutral	4.___	Slightly disagree	5.___	Disagree

(Additional Comment:)

1-3 Please choose two of the most significant, CURRENT domestic water issues of M/R in SRB, and rank them in order.

First		Second	

1. Water resources shortage
2. Water quality deterioration
3. Heavy metal pollution
4. Drinking Water quality issue
5. Improvement Water Supply system
6. Ecosystem deterioration/Biodiversity loss
7. Natural disaster (Flood etc.)
8. Development of river basin (Dam construction etc.)
9. Others (please specify)

1-4 Please choose two of the most significant, FUTURE domestic water issues of M/R in SRB, and rank them in order.

First		Second	

1. Water resources shortage
2. Water quality deterioration
3. Heavy metal pollution
4. Drinking Water quality issue
5. Improvement Water Supply system
6. Ecosystem deterioration/Biodiversity loss
7. Natural disaster (Flood etc.)
8. Development of river basin (Dam construction etc.)
9. Others (please specify)

3-7 A integrated water management system on SRB should be established for SRB sustainability.

1.___	agree	2.___	Slightly agree	3.___	Neutral	4.___	Slightly disagree	5.___	disagree

(Additional Comment:)

3-8 A couple of special policy alternatives such as special law or special management zone are needed for the efficient water management of Selenge River Basin.

1.___	agree	2.___	Slightly agree	3.___	Neutral	4.___	Slightly disagree	5.___	disagree

(Additional Comment:)

3-9 What do you think is the most important issues in the water environment management?

First		Second	

1. Limited water resources
2. Quality of drinking water
3. River ecosystem
4. Social infrastructure for the flood/drought
5. Civil involvement in water resources management
6. Others (please specify)

3-10 What do you think is the most important issue related to the use of water resources?

First		Second	

1. Increase in the demand for water for domestic use due to population growth and rising living standard
2. Increase in industrial demand for water
3. Increase in demand in the agricultural sector
4. Water resources issues between the upstream and downstream within the river basin
5. Others (please specify)

3-11 The policy related water resources consists of constructional approach, such as building a dam, or non-constructural approach. What is your priority in the following non-constructural approaches?

First		Second	

1. Effective management of existing facilities
2. Developing a supplementary water resources
3. Demand control
4. Public relation and education emphasizing the economical use of water
5. Others(please specify)

3-12 If a couple of special policy alternatives is needed for the efficient water management of Selenge River Basin, what do you think are the most important issues?

First		Second	

1. Water quality & ecosystem management
2. Developing Water resource
3. Managing waterworks & Sewage
4. Disaster management
5. Others (please specify)

3-13 If a couple of special policy alternatives are needed for the efficient water management of Selenge River Basin, what do you think are the most important policies?

First		Second	

1. Introduction of special law for water management on SRB
2. Establishment of special management zone on SRB \
3. Establishment of independent SRB agency
4. Establishing a comprehensive plan for the Selenge River Basin
5. Designating a target water quality level for the SRB
6. strengthening the regulation related to the water management of SRB
7. Restructuring the system of management
8. More civil involvement in the process of policy-making
9. Others (please specify)

3-14 Among the following policy options for pollution source control, what do you think are the most important for effective management measures?

First		Second	

1. Designating control or protection area/zone
2. Pollution source location control
3. Allowable discharge standard
4. Regulation of total effluence
5. Enforcing EIA
6. Enforcing Inspection system
7. Others (please specify)

3-15 For promoting the water reuse, what do you think are the most rational policy options?

First		Second	

1. Realistic water fee
2. Tax benefit
3. Technological development
4. Investment aid
5. Others (please specify)

3-16 What do you think are the most important policy options for the systematic development and utilization of groundwater?

First		Second	

1. Renewing the legislations and policies related to groundwater
2. Designation of water reserve
3. Specialized governmental organization in charge of groundwater management
4. Investment aid
5. Data collecting and monitoring on the groundwater
6. Others (please specify)

3-17 What do you think are the most important policy measures for flood/drought management?

First		Second	

1. Establishing a comprehensive disaster management plan
2. System of acquiring and managing the information on the condition of river
3. Prediction and alarm system
4. Water resource development
5. Disaster restitution and community support
6. Others (please specify)

3-18 Please make any additional comments of suggestions for developing integrated management system on SRB

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Survey for Transboundary Water Management System on Selenge River Basin

As the Partnership Project of Network of Institutions for Sustainable Development (NISD) under UNEP-ETB, Korea Environment Institute (KEI), Institute of Geoecology, Mongolian Academy of Science(IGMAS), Baikal Institute of Nature Management, Siberian Branch of the Russian Academy of Science has been conducting a joint research project "Integrated Water Management Model(IWMM) on the Selenge River Basin" for three years from 2007.

The overall objective of this project is to develop the IWMM for sustainability of SRB in national and international level. Therefore, joint research team tries to identify the needs and expectations of major actors and stakeholders of Mongolia and Russia to develop the potential transboundary water management system on SRB in addressing common water issues.

Your answer will be only used for the analysis and development of Transboundary Water Management System on SRB in this joint research project. We have a favor you to answer all of questions in this survey paper for SRB sustainability.

Thank you.

Project Manager

Korea Environment Institute

2010. 6

※ Information collected from the following questionnaire is used solely for the classification and statistical purposes.

Name		**Contact**	
Email			
Address	(Korea/ Mongolia/Russia) ( )city/province ( )town/province		
occupation	☐ 1) government position(public servant/government subsidiary) ☐ 2) Professor ☐ 3) Researcher ☐ 4) Water resource related company ☐ 5) others		
	Name of Institution		
	Are you involved in M-R Transboundary Joint Working Group Meeting or Government Representative Meeting? ☐ Yes ☐ No		

Ⅰ. Recognition of the Transboundary Water Isssues in SRB

Please indicate to which extent you would agree or disagree with the following statements.

I-1. There are several transboundary water issues of SRB that need to cope with by cooperation activities between Mongolia and Russia.

1.___	Agree	2.___	Slightly Agree	3.___	Neutral	4.___	Slightly disagree	5.___	Disagree

(Additional Comment:)

I-2. The transboundary water issues of SRB will go on increasing and become significant transboundary issues between Mongolia and Russia.

1.___	Agree	2.___	Slightly Agree	3.___	Neutral	4.___	Slightly disagree	5.___	Disagree

(Additional Comment:)

I-3. Please choose two of the most significant, CURRENT transboundary water issues in SRB, and rank them in order.

First		Second	

1. Water flow allocation
2. Water resources shortage
3. Water pollution(transboundary water pollution)
4. Heavy metal pollution
5. Ecosystem deterioration/Biodiversity loss
6. Climate change/Natural disaster (Flood etc.)
7. Development of river basin (Dan construction etc.)
8. Others (please specify)

I-4. Please choose two of the most significant, FUTURE transboundary water issues in SRB, and rank them in order.

First		Second	

1. Water flow allocation
2. Water resources shortage
3. Water pollution(transboundary water pollution)
4. Heavy metal pollution

5. Ecosystem deterioration/Biodiversity loss
6. Climate change/Natural disaster (Flood etc.)
7. Development of river basin (Dan construction etc.)
8. Others (please specify)

Ⅱ. Evaluation of the Transboundary Water Management System on SRB

Please indicate to which extent you would agree or disagree with the following statements.

2-1. The bilateral agreements for rational use and protection of water in SRB between Mongolia and Russia as transboundary water management system have been known well among major actors and stakeholders of relevant organizations in two countries

1.___ Agree 2.___ Slightly Agree 3.___ Neutral 4.___ Slightly disagree 5.___ Disagree

(Additional Comment:)

2-2. The activities under bilateral agreements produced positive outcomes in addressing rational use and protection of water of SRB in Mongolia and Russia.

1.___ Agree 2.___ Slightly Agree 3.___ Neutral 4.___ Slightly disagree 5.___ Disagree

(Additional Comment:)

2-3. Please choose two of the most important cooperation activities under bilateral agreements for rational use and protection of water in SRB between Mongolia and Russia as transboundary water management system, and rank them in order.

First		Second	

1. Monitoring the quality of water
2. Monitoring the sanitary status and epidemiological control on water
3. Studying impact of Mongolia mining factories in SRB to the water status
4. Providing of natural migratory condition of fishes and other water animals in water
5. Treating the scheme of using and protecting water
6. Operating emergent accident reporting system
7. Researching with other scientific organizations for rational use of water
8. Others (please specify)

2-4. Please choose two of the cooperation activities that produced positive outcomes in the water state of SRB under bilateral agreements, and rank them in order.

First		Second	

1. Monitoring the quality of water
2. Monitoring the sanitary status and epidemiological control on water
3. Studying impact of Mongolia mining factories in SRB to the water state
4. Providing of natural migratory condition of fishes and other water animals of water
5. Treating the scheme of using and protecting water
6. Operating emergent accident reporting system
7. Researching with other scientific organizations for rational use of water
8. Others(please specify)

2-5. Please choose two of the concrete achievements through cooperation activities under bilateral agreements, and rank them in order.

First		Second	

1. Establishment of cooperation bodies and dialogue channel
2. Proliferation of cooperation necessity between two countries
3. Improvement of Understanding of water states in various aspect
4. Understanding of water management policies of two countries each other
5. Strengthening of water management policies and investments of two countries
6. Improvement water state including water quality etc.
7. Water management awareness promotion in two countries
8. Others(please specify)

2-6. Please choose two of the most serious limitations or weak points in transboundary water management system for addressing rational use and protection of water of SRB, rank them in order.

First		Second	

9. Insufficient recognition of transboundary water issues
10. Insufficient recognition of the cooperation necessity of each government on transboundary water issues
11. Different interests in transboundary water issues between countries
12. Different interests in transboundary water issues in relevant stakeholders of each country
13. Lack of implementation scheme in national level of each country
14. Lack of relevant policies and investment in national level of each country
15. Lack of human/financial resources and institutional arrangement of cooperation bodies
16. Lack of cooperation projects and activities
17. Lack of public awareness of two countries
18. Absence of leading country and competitive to take initiative
19. Absence of legal binding mechanism to each country behavior

20. Others(please specify)

Ⅲ. Development of the Transboundary Water Management System on SRB

Please indicate to which extent you would agree or disagree with the following statements.

3-1. The transboundary water management system of SRB should be strengthened like other transboundary river management cases for addressing rational use and protection of water in two countries

1.___ Agree 2.___ Slightly Agree 3.___ Neutral 4.___ Slightly disagree 5.___ Disagree

(Additional Comment:)

3-2. The principle of water use, protection and management of SRB should be applied through agreement between Mongolia and Russia based on the water states and interests of two countries and relevant stakeholders.

1.___ Agree 2.___ Slightly Agree 3.___ Neutral 4.___ Slightly disagree 5.___ Disagree

(Additional Comment:)

3-3. In the long term, Current bilateral agreement need to develop a legal binding treaty by stages for join water management on SRB between two countries.

1.___ Agree 2.___ Slightly Agree 3.___ Neutral 4.___ Slightly disagree 5.___ Disagree

(Additional Comment:)

3-4. In near future, Current government meeting of transboundary water management system need to develop a permanent joint management organization by two countries.

1.___ Agree 2.___ Slightly Agree 3.___ Neutral 4.___ Slightly disagree 5.___ Disagree

(Additional Comment:)

3-5. Other countries or international organizations need to participate to the cooperation bodies for promoting cooperation activities and developing transboundary water management system and relevant activities

1.___	Agree	2.___	Slightly Agree	3.___	Neutral	4.___	Slightly disagree	5.___	Disagree

(Additional Comment:)

3-6. Please choose two priority issues that should be addressed in transboundary water management system in future.

First		Second	

1. Fair and proper water flow allocation
2. Mitigation and settlement of water resources shortage
3. Protection of water pollution(transboundary water pollution) and improvement of water quality
4. Protection of Heavy metal pollution and insurance of human health
5. Conservation of ecosystem deterioration/Biodiversity loss
6. Climate change/Natural disaster (Flood etc.) mitigation and adaptation
7. Development and use of river basin (Dan construction etc.)
8. Others(please specify)

3-7. Please choose two priority activities for emission reduction and water quality protection in transboundary water management system in future, rank them in order.

First		Second	

1. Strengthening policies dialogue on the emission charge and management system
2. Establishment of joint monitoring and data exchange system
3. Strengthening of emergent environment accident transmission system
4. Adaptation of common water quality standard and pollutant emission standard
5. Financial assistance and technology transfer cooperation between two countries
6. Promotion of international cooperation with other countries and international organization
7. Others (please specify)

3-8. Please choose two important activities for river basin development in transboundary water management system in future, rank them in order.

First		Second	

1. Strengthening policy dialogue in the process of river basin development
2. Joint implementation process of EIA
3. Protection of water resources and potential development capacity
4. Pre notification system on emission facility construction and river basin development
5. Financial assistance and technology transfer cooperation between two countries
6. Promotion of international cooperation with other countries and international organization
7. Others (please specify)

3-9. Please choose two of the priority options in institutional and financial arrangements for promoting transboundary water management system in future, rank them in order.

First		Second	

1. Strengthening the legal binding force of bilateral agreement between two countries
2. Improving the current governmental meeting into more high level official meeting such as Ministry meeting
3. Setting up the transboundary water issues as a priority cooperation agenda between two countries
4. Establishment a new and permanent joint management organization
5. Establishment and strengthening the implementation scheme in national level of two countries
6. Extension of financial investment and human resources
7. Extension and conduct of join activities in the fields and sizes
8. Systematic and efficient management and organization extension of current cooperation bodies
9. Promotion of international cooperation with other countries and international organization
10. Others(please specify)

3-10. Please make any additional comments of suggestions for developing transboundary water management system on SRB.

국문요약 (Abstract in Korean)

셀렝게유역 통합물환경관리모델 개발사업 III

셀렝게강은 몽골의 항가인산맥에서 발원하여 러시아연방 부리야티아 공화국의 바이칼호수로 유입되는 월경성 국제하천으로, 이 강의 상류에 위치한 몽골의 수자원이용 및 수질관리가 하류에 있는 부리야티아 공화국의 물 환경에 직접적인 영향을 미치게 된다. 몽골은 오래 전부터 강수량 부족으로 물 공급에 제한을 받고 있으며, 광산업의 성장과 급속한 경제개발로 인한 수질오염도 점차 심각해지고 있다. 한편 부리야티아 공화국은 몽골과는 달리 풍부한 수자원을 보유하고 있지만, 대부분의 물 공급 및 수처리 시설들이 낙후되고 비효율적이어서 물 관리에 어려움을 겪고 있다. 이처럼 국제공유하천은 자연적으로는 단일하천과 단일유역이지만, 이를 공유하고 있는 국가들의 현황과 요구 등이 상이하게 나타난다. 따라서 이를 효율적이고 체계적으로 관리하기 위해서는 국가들의 이해관계를 통합할 수 있는 관리방안이 필요하다.

본 연구는 셀렝게강 유역의 통합 물 관리 모델을 개발하기 위해 시작되었다. 이번 보고서는 3차년도에 해당하며, 1) 수환경과 수자원, 2) 국내 통합 물 관리 모델, 3) 공유하천 물 관리 체계, 4) 국제 공유하천유역 물 관리를 위한 국제적 협력을 포함하고 있다.

본 보고서는 기존의 연구 문헌 및 자료를 조사·분석한 선행연구와 현지조사 및 담당자 면담 등을 통해 경제사회현황, 수자원 및 수질현황을 조사한 1, 2단계 연구내용을 바탕으로 3단계의 현장조사를 통해 수질 및 수환경, 사회경제적 여건을 분석하여 몽골과 러시아의 셀렝게강 유역 주요 8개 대도시 및 광산도시를 Hot Spot areas (HSAs) 라고 명명하였다. 우선, 주요 오염원인 이 지역의 위치를 정확히 파악하고 현 관리체계를 분석했다. 그후 수질을 악화시키는 압력조건 개선에 대한 효율성을 확인하여 관리 옵션과 접근방식에 대해 분석하는 DPSIR 접근방식을 이용하였다. 이 조사결과를 근거로 몽골과 부리야티아 공화국의 셀렝게강 유역 전반에 대한 현황을 DPSIR 접근방법을 통해 분석하고 물 관리 체계에 대한 주요 문제점 및 물 관련 이슈들을 도출하였다. 이를 근거로 몽골, 러시아의 전문가들을 대상으로 가중치 조사를 실시하고 이 결과를 mDSS 모델을 이용하여 분석하여 정책우선순위를 도출하였다. mDSS 소프트웨어를 이용하여 주요 문제의 우선 순위, 가중치 값을 표준화하였고, mDSS 모델의 설계 과정에서

데이터베이스(DB) 분석, 이상적 포인트 방식 (TOPSIS) 과정을 거쳐, borda 규칙에 의해 우선순위 정책대안을 얻었다. 3단계연구 수행을 위해 국제워크숍, 작업반회의가 몽골에서 개최되었고 셀렝게강 유역 현지조사가 실시되었다.

mDSS 모델링 이외에, 전문가 설문 조사를 수행했다. 이 설문 조사를 통해 몽골, 러시아의 현행 수질관리제도가 충분하지 않으며, 효과적이지 않다는 결론을 얻게 되었다. 따라서 수질오염원에 따른 수질 관리 정책이 마련되어야 하며, 제도, 인프라, 정부대안의 세 가지 요소가 모두 필요하다.

그리고 전문가 설문조사 이외에 제시된 정책 옵션들이 몽골과 러시아에서 실행가능한지 아닌지를 분석하는 실행가능성 분석이 실시되었다. 대부분의 정책대안들이 행정상으로는 실행가능성이 높게 평가되었으나, 경제적으로는 실행가능성이 낮다고 평가되었다. 각 국가에서 셀렝게강 유역의 통합 물 관리는 장기적 목표이기 때문에 즉시 도입하기 힘들어 보일 수도 있다. 그러나 점차적으로 각 국가의 관련 국내정책을 추진하는 것이 필요하다. 따라서 이 보고서는 통합 물 관리의 필요성과 물 관련 지표의 지속적인 관리가 통합 물 관리 계획에 포함되어야 한다는 내용을 포함하고 있다.

또한 이 보고서는 공유하천의 물 관리에 대한 협력 연구 사례 및 이론을 포함하고 있으며, 몽골과 러시아의 입장을 파악하기 위한 전문가 설문을 실시하여 이를 바탕으로 셀렝게강 물 관리 시스템의 기본설계를 제안했다. 주요 내용은 첫째, 현 정부 대표회의에서 위원회를 구성하여 협력사업을 체계적으로 진행하는 것이다. 둘째, 전문가 그룹을 조직하고 관리시스템을 추진하기 위해 프로젝트의 범위를 확장하는 것이다. 셋째, 각 나라의 수질과 수자원에 대한 공동감시 네트워크 및 정보 공유 시스템 구축이 필요하다. 넷째, 국가 수준의 실행 제도 구축 및 재정 투자를 통해 실행 가능성을 높여야 한다. 다섯째, 전략적 장기적 대화 채널 구축을 통해 물 관리 시스템 담당 조직을 신설해야 한다.

마지막으로 이 연구는 셀렝게강 유역의 통합 물 관리 정책을 실행하기 위한 한국–몽골–러시아 환경협력 프로젝트를 제안했다. 제안된 환경협력 프로젝트는 1) 몽골, 러시아 대도시의 하수 처리 수 재이용, 2) 몽골, 러시아의 지하수 이용 합리화, 3) 수자원 사업개발 4) 환경 역량강화 프로젝트이다. 이 보고서는 또한 환경협력사업 실행 이전에 광산 지역의 산업폐수 처리기술 이전을 제안하고 있으며, 마지막으로 한국과 다른 나라와의 환경협력 프로젝트 체계를 포함하고 있다.