IMPACT ASSESSMENT OF TANNERY INDUSTRY ON WATER QUALITY IN TUUL RIVER
Case study of Khan-Uul district in Ulaanbaatar city, Mongolia

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Abstract

This research examines the determine water pollution of the Tuul river around the Tannery industry in Ulaanbaatar city and to identify impact of industry area on environment and residents. Also it aims to identify possibilities of transfer for Tannery industries from Ulaanbaatar city through solving issues in order to find a method for enhancing environment. The research indicates that the Tuul river was not polluted until the Ulaanbaatar city and contamination level spike appears when the river entering the city. The upper reaches of the river maintains relatively good water quality. There are several sources for pollution in the area. Among them, the Tannery industries, Hargia pre-treatment and central wastewater treatment plant are most influential source in the downstream section of the river, recently after 2004s. Pollution at site is strongly dependent effluent treatment levels from the Hargia pre-treatment plant, and it contains a high amount of chemicals that can cause of major degradation of the water quality.

Your research is about the water pollution caused by the Tannery industry nearby Tuul River, Uranbaatr. It will be much better if you include the findings of your research.

Keyword; Tannery industry, water pollution, contamination, Tuul River, Treatment plant

Background

Tanning leather is one of the most important industries in Mongolia. Chromium is widely used in industries for tannery. In Ulaanbaatar city, water resource pollution with wastewater containing chromium from the tannery ~~is~~ has been a serious problem.(Bolortamir and Egashira 2008)

The main and biggest artificial point source of 1 tannery industrial wastewater treatment, 29 tannery industries are located in Khan-Uul district. Pollution at site ~~pollution at sites~~ is strongly dependent on(?) effluent treatment levels ~~from~~ of(?) the Tannery industries and Hargia pre-treatment plant, and it contains a high amount of chemical that can cause ~~of~~ major ~~decrement~~ deterioration of the water quality.

In ~~the~~ tanneries, chromium is used to chemically convert raw hides ~~or~~ and skins into leather. The production processes in a tannery can be split into ~~3~~ three main categories, which shown in the most common, stable and abundant forms of chromium are hexavalent (Cr (VI)) and trivalent (Cr (III)), and Cr (VI) is quite toxic. There are two methods in chromium tanning. In the first method ~~developed~~, the source of the chromium is hexavalent ~~and this is~~ which will be reduced to trivalent ~~for~~ in the tanning process. ~~Here~~ In this way, ~~the~~ tanning can be accomplished within a relatively short period of time. The other method was developed from the first, and uses only trivalent chromium throughout the process. This method does not need to use toxic Cr (VI). The most widely used trivalent chromium as a tanning agent. In both methods, hexavalent chromium is contained in the wastewater. Discharge of solid waste and wastewater containing chromium from tanneries is the main

environmental problem. Chromium is a highly toxic compound and the dumping of chromium containing material is in most countries restricted to a few special dumping grounds. Emissions into the air are primarily related to energy use, but also the use of organic solvents and dyes causes emissions into the air.

Mongolia has a capacity to produce 7-8 million hide and skins per year, out of which 52.4% is sheep skin, 26.2% goat skin, 7.1% cattle hide, 4.7% horse hide and 4.8% skin from other animals. Because of the implementation of the "Hide and Leather" sub-program by Government, the production of the sector increased and reached 28.1 billion MNT at current prices, which was 0.6% of the total industrial output in 2012. At present, there are about 29 tanneries with a total capacity of processing 9.2 million of hide and skins per year and about 200 entities producing end product only three of them are located in provinces and all the others in Ulaanbaatar. There werelin total: Livestock-based industries are key economic driver in Mongolia. (MIA 2012)

- 24 tanneries primary processing,
- 5 tanneries deep processing,
- 4 fur entities,
- 8 footwear,
- 180 leather and garment,
- 4 dressing and dying of fur industries
- One research and preproduction center

Table 1, Tanneries processing company (Source: GASI)

	Tannery company	Location	Capacity, m^3	Type
1	Mon-it-buligaar	47°53‘34.56"N, 106°53‘38.58"E	5000 pieces of leather processing a week, 1325 m^3	Deep processing
2	Mongol shevro	47°53‘38.67"N, 106°53‘40.70"E	5000 pieces of leather processing a week, 1325 m^3	Deep processing
3	Belon	47°53‘35.70"N, 106°53‘38.10"E	6000 pieces of leather processing a week, 1590 m^3	Primary processing
4	Shandast Argamag	47°53‘36.21"N, 106°53‘41.17"E	5000 pieces of leather processing a week, 1325 m^3	Primary processing
5	MLTJ	47°53‘36.21"N, 106°53‘36.54"E	1000 pieces of leather processing a week, 265 m^3	Primary processing
6	Yarmag	47°53‘33.81"N, 106°53‘27.15"E	5000 pieces of leather processing a week, 1325 m^3	Primary processing
7	Eiltfrut	47°53‘37.29"N, 106°53‘41.47"E	5000 pieces of leather processing a week, 1325 m^3	Primary processing
8	Lider-Arena	47°53‘32.11"N, 106°53‘40.24"E	5000 pieces of leather processing a week, 1325 m^3	Primary processing
9	Ikh-Ergelt 1	47°53‘40.42"N, 106°53‘40.95"E	6000 pieces of leather processing a week, 1590 m^3	Primary processing
10	Ikh-Ergelt 2	47°53‘39.55"N, 106°53‘40.79"E	4000 pieces of leather processing a week, 1060 m^3	Primary processing
11	Eruult international	47°53‘34.87"N, 106°53‘45.79"E	1000 pieces of leather processing a week, 265 m^3	Primary processing
12	Monireedui	47°53‘33.15"N, 106°53‘35.38"E	8000 pieces of leather processing a week, 2120 m^3	Deep processing
13	Midelmen	47°53‘36.49"N, 106°53‘32.78"E	6000 pieces of leather processing a week, 1590 m^3	Primary processing
14	Sodontsuurai	47°53‘35.76"N, 106°53‘26.38"E	50 pieces of leather processing a week, 60 m^3	Deep processing

15	Tumensor	47°53‘36.74"N, 106°53‘26.06"E	50 pieces of leather processing a week, 60 m^3	Primary processing
16	Ikh-Asar 1	47°53‘41.87"N, 106°21‘94.80"E	5000 pieces of leather processing a week, 1325 m^3	Primary processing
17	Ikh-Asar 2	47°53‘41.49"N, 106°53‘18.92"E	5000 pieces of leather processing a week, 1325 m^3	Primary processing
18	Shuudriin hundii	47°53‘39.46"N, 106°53‘31.95"E	50 pieces of leather processing a week, 60 m^3	Primary processing
19	Erdene chandmani	47°53‘40.34"N, 106°53‘27.56"E	50 pieces of leather processing a week, 60 m^3	Primary processing
20	Yalman	47°53‘33.74"N, 106°53‘31.71"E	50 pieces of leather processing a week, 60 m^3	Primary processing
21	Sutain devshil	47°53‘39.02"N, 106°53‘46.76"E	100 pieces of leather processing a week, 265 m^3	Primary processing
22	Uy impecs	47°53‘37.72"N, 106°53‘45.81"E	50 pieces of leather processing a week, 60 m^3	Deep processing
23	Altain-Khargia	47°53‘31.68"N, 106°53‘38.51"E	4000 pieces of leather processing a week, 1060 m^3	Primary processing
24	Khatan tugul	47°53‘33.35"N, 106°53‘41.26"E	50 pieces of leather processing a week, 60 m^3	Primary processing
25	Arildii	47°53'29.76"N, 106°53‘37.80"E	9000 pieces of leather processing a week, 2800 m^3	Primary processing
26	Fuchir holding	47°53'29.76"N, 106°53‘37.80"E	1-000 pieces of leather processing a week, 3120 m^3	Primary processing
27	Munkhshine-Od	47°53‘37.23"N, 106°53‘19.92"E	50 pieces of leather processing a week, 60 m^3	Primary processing
28	Batdembee	47°53‘33.79"N, 106°53‘44.76"E	50 pieces of leather processing a week, 60 m^3	Primary processing
29	Khanpiwon	47°53‘36.05"N, 106°53‘19.86"E	1000 pieces of leather processing a week, 265 m^3	Primary processing

In 2012, the tanning, dressing of leather industry used 0.1 million m^3 water. The Regional Development program estimates the annual growth rate of the sector at 6.9%, which means that in 2021 water demand of the sector will reach 0.2 million m^3. (Report of MEGD, 2012)

Not only Tanneries, wool and cashmere industries use over 30 chemical substances for their processing which is likely to cause further serious water pollution. Usually in Ulaanbaatar tanneries, wool and cashmere industries use water from the central system and discharge wastewater to the wastewater treatment plant (WWTP) in Khargia.

Current situation of Tanning process in Mongolia

Table 2

№	Name of the WWTP	Activity time /year/	Capacity	Current treatment capacity of amount for wastewater
1	Central wastewater treatment plant	1964	230,0 мянган $м^3$	160.0 мянган $м^3$
2	Bayangol treatment plant	1978	400 $м^3$	450-500 $м^3$ /summer season /, 350-400 $м^3$ /winter season/
3	Nisekh treatment plant	1972	1000 $м^3$	3000 $м^3$
4	Bio combinat treatment plant	1990	600 $м^3$	200 $м^3$
5	Baga-khangai treatment	1974	200 $м^3$	200 $м^3$

	plant			
6	Khargia pre-treatment plant	1972	13000 м^3	15000-20000 м^3
7	Baganuur treatment plant	1991	17000 м^3	6000 м^3
8	Nalaikh treatment plant	1976	1450 м^3	1600-2300 м^3

Figure 1

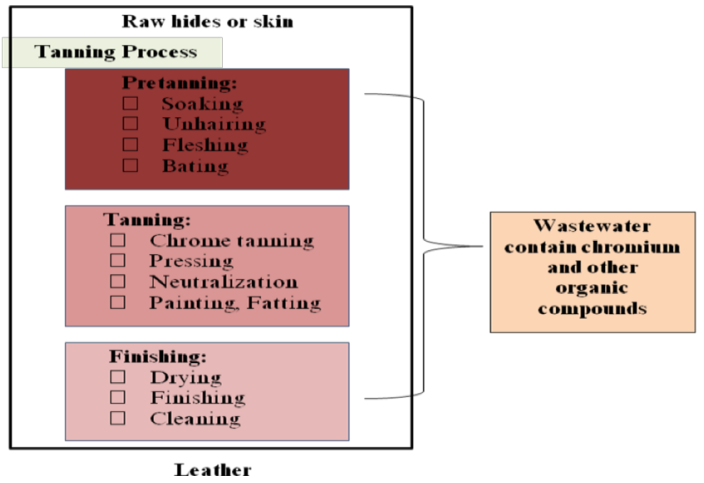
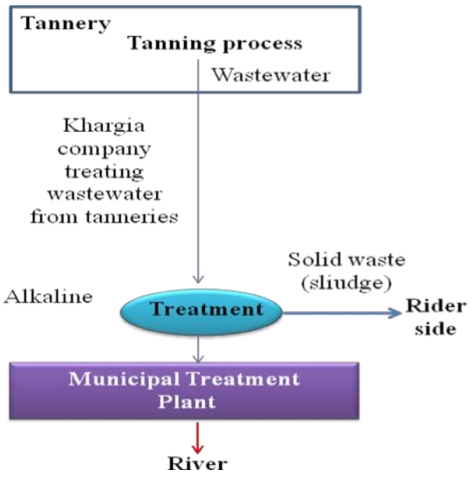


Figure 2



In the tannery, chromium is used to chemically convert raw hide or skin into leather. The production processes in a tannery can be split into 3 main categories, which is shown in figure1.

Research statement

All of tannery industries are located near the Tuul River, which mainly contributes to the pollution of the river. In Mongolia, all of the tanneries don't have their own treatment plant. The Khargia Company is the only government-owned company to treat wastewater from tanneries.

Literature review

The literature review regarding pollution industries in the Tuul River can be divided into four conceptual areas each area using a method to evaluate the level of pollution in the river. These four methods are namely chemical method, biological method, Leather tannery effluent method and water quality method.

2.1 Quality studies using chemical method

- Tuvaanjav, G in 1978, chemical analysis in the Tuul river and its tributaries and found out the following conclusions; the Tuul river belongs to hydro-carbonate class and contains 78.9% calcium, 15.8% sodium, magnesium, total mineralization is between 28.1-634.7 mg l^{-1}. Upper reach of the river and its tributaries contain high amount of sulphate than chlorine. Mineralization, pH and ammonia concentration increase along the Selbe and the Uliastai Rivers [Tuvaanjav, 1978].
- In a research report written by Munguntsetseg, A and et all, they estimated that the river is totally self-purified along 170 km of downstream after wastewater from CWTP pours into river [Munguntsetseg et al., 1982].
- A researcher Davaa, G in 1996 in 12 points along the Tuul River and its tributaries and noted that total mineralization increases along the river, because of, soil type changes, precipitation degredation and evaporation increase [MNE, 1997a].

2.2 Quality studies using biological method

- MNE hydro-biological research in the Tuul River and estimated 170 aqua insects. Moreover, the team assessed water quality by using those fauna [Munguntsetseg, 1987].
- N.Soninhishig in 1998, she defended an MSc degree in Mongolia by thesis titled as "Algae in the Tuul River". She was exploring algae fauna in river and was assessed the following water quality index by algae fauna [Soninhishig, 1998].

2.3 Issue studies using industries

- A research of Removal of Hexavalent Chromium from Model Tannery Wastewater by Adsorption Using Mongolian Natural Zeolite has done. They applied Mongolian natural zeolite adsorptive removal of hexavalent chromium contained in tannery wastewater. At first, characterization was carried out for various kinds of natural zeolite obtained from Tsagaan Tsav and Urgon deposits in Dornogovi province, southeast part of Mongolia.(Bolortamir and Egashira 2008)

2.4 Model studies using water quality

- Mcgraw, 2001, David Bullard, Thomas Kuchnicki, Jason, Water Quality Assessment and Modeling of the California Portion of the Truckee River Basin They 1) established recommended reductions in sediment loads for designated reaches and sub-basins in the upper basin of the Truckee River; 2) developed a GIS-based watershed model capable of simulating erosional and sediment transport processes over multiple physiographic settings; 3) use the calibrated model to estimated sediment conditions under various land-use scenarios
- O. Altansukh, (2000), Surface water pollution of Ulaanbaatar city, 43 pp, National University of Mongolia, Ulaanbaatar. He is assessment of surface water quality for natural river water, and Duflow Modeling system was then used as the tool for modeling of the river water quality. Water flow simulations were performed using hydraulic datasets between 2005 and 2006.
- 2004, Unumandakh Namkhai, Integrated approach of GPR and GIS for groundwater study of Tuul river basin, Mongolia. He is identified groundwater of the Tuul River in near the Ulaanbaatar city.

Research objective

1. Identify pollution of tannery industries inside of industry area.
2. Identify the impacts of tannery industries surrounding area on environment and residents.
3. Find possible solution of transfer for tannery industries.

Research question

The research aims to answer the following question;

1. How do tannery industries determine impact on environment and residents living in near the industry area?

Research Hypothesis

Study by the environmental and residents to determine the real impact of tannery industries.

Research area

Location of fieldwork area:

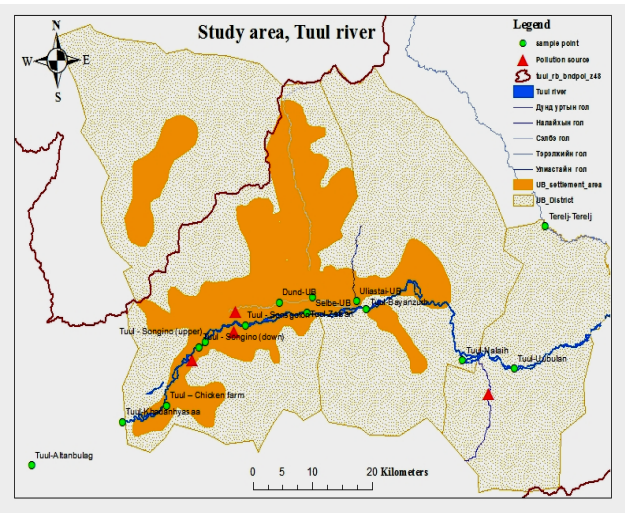
Total area is 64 hectares; our of which Tannery industries-22.5 ha, Khargia tannery WWTP-4.6 ha and Household-37.6 ha

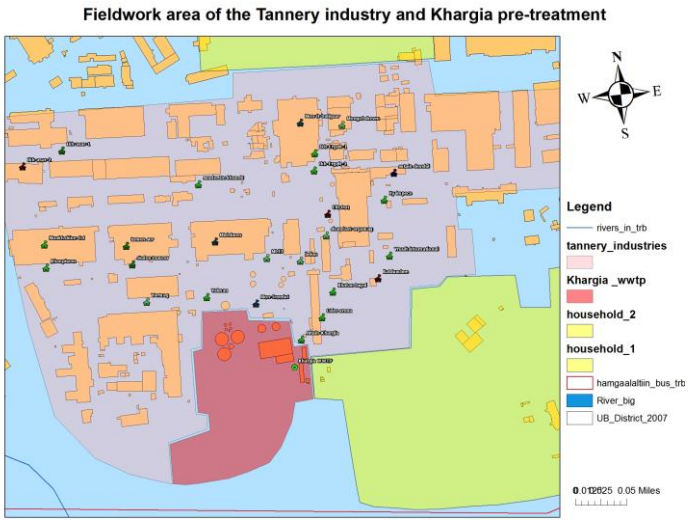
Community people: 750 household, 2250 people

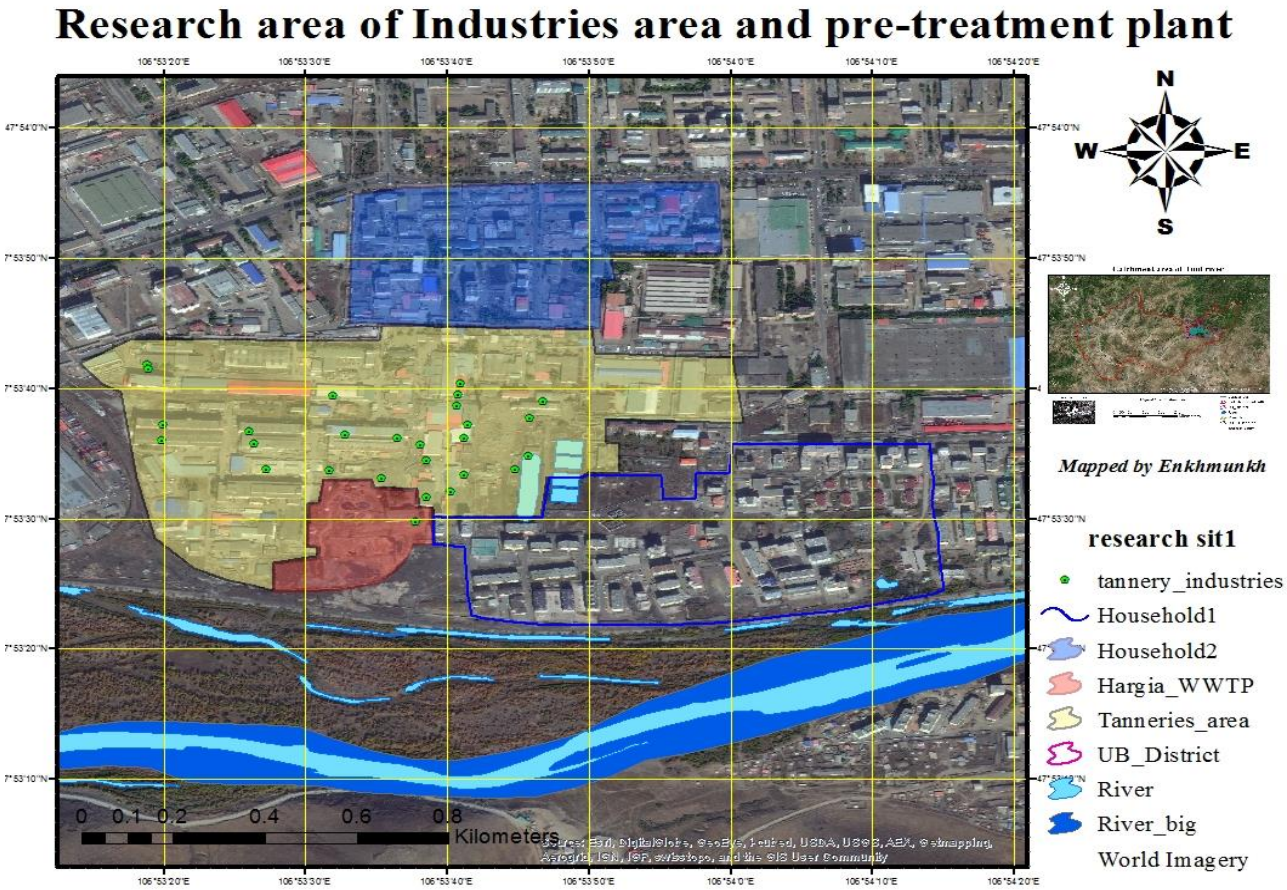
Location: 47°53'29. 76"N, 106°53‘37.80"E

Situation: Than 1 tannery industrial wastewater treatment, 29 tannery industries are located in Khan-Uul district, Ulaanbaatar city.

Figure 3







According to an estimate currently 29 leather-processing factories are operational in the City, emitting polluted water and waste near the tanneries area.

Field survey;

-Collect data and interview

-Therefore, to take questionnaire and sample of wastewater during field survey.

Data analysis;

In this stage, all data, which are collected and measured during fieldwork, are assessed and classified using surface water quality indices.

Map visualization:
Maps for research area are visualized using ARCGIS software.

Data
This step consist of gathering the available data such as topographic map, hydro-chemical datasets from previous years, hydraulic variable, physical parameter and climatic data from different organization in Mongolia.

Table 3. Data source

N	Data	Source
1	Literature	Keio university, internet, SCLM, Academic library of NUM and others
2	Dataset	CLEM, NAMNEM and others
3	Map	Administration of land affairs, Geodesy and Cartography
4	Documents (standard, book)	MNGD, NWCG, GASI, MASM, Tuul River Basin Authority
5	Field equipment	GASI, KEIO
6	Software	ARCGIS
7	Laboratory	CLEM, GASI

Monitoring data from Laboratory of GASI

Table 4

Sampling point	Ph	BOD mg/l	COD-Mn mg/l	HCO3 mg/l	NH4-N mg/l	NO3-N mg/l	Cr /VI/mg/l
Uu bulan	7.1	2.05	3	30.7	0.12	0.37	0.002
Nalaikh	7.2	2.45	3.45	36.6	0.17	0.37	0.001
Bayanzurkh	7.2	2.67	3.88	-	0.15	0.3	0.004
Zaisan	7.7	2.21	4.41	-	0.13	0.4	0.003
Sonsgolon	7.7	2.23	3.97	-	0.13	2.31	0.003
Songino-Deed	7.6	3.09	3.9	-	0.2	0.87	0.001
Songino-Dood	7.5	79.42	11.8	96.2	14.6	0.96	0.005
Hadan hysaa	7.4	14.03	5.49	89.6	4.17	1.43	0.003
Altanbulag	7.4	12.11	4.6	76.26	2.25	1.32	0.003

Result of research

Result of chemical data

Water quality differences along the Tuul River show that river water from Bayanzurkh till Sonsgolon Bridge is less polluted and then up to Songino is very much polluted and the self-purifying capacity of the river is completely lost within this reach. The macro invertebrate community dynamics along the sites of Tuul River show an aquatic environment, which is completely lost at Songino. According to the Biotic index, river water is polluted from “less” to “very much” with a grade of 5.01.

Figure 4, Result of measurement for collected data at the Tuul River

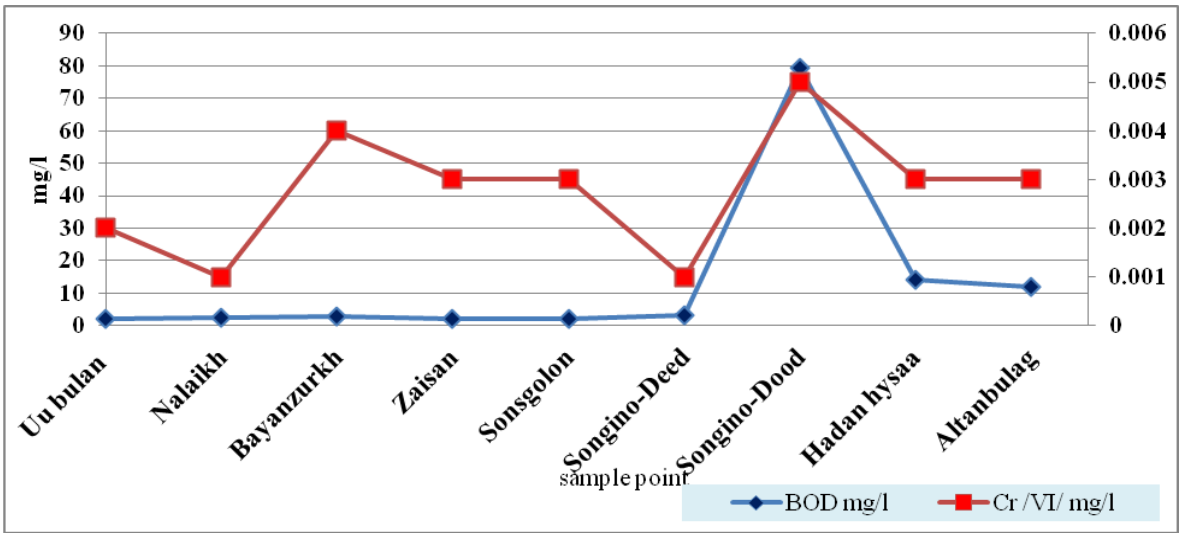
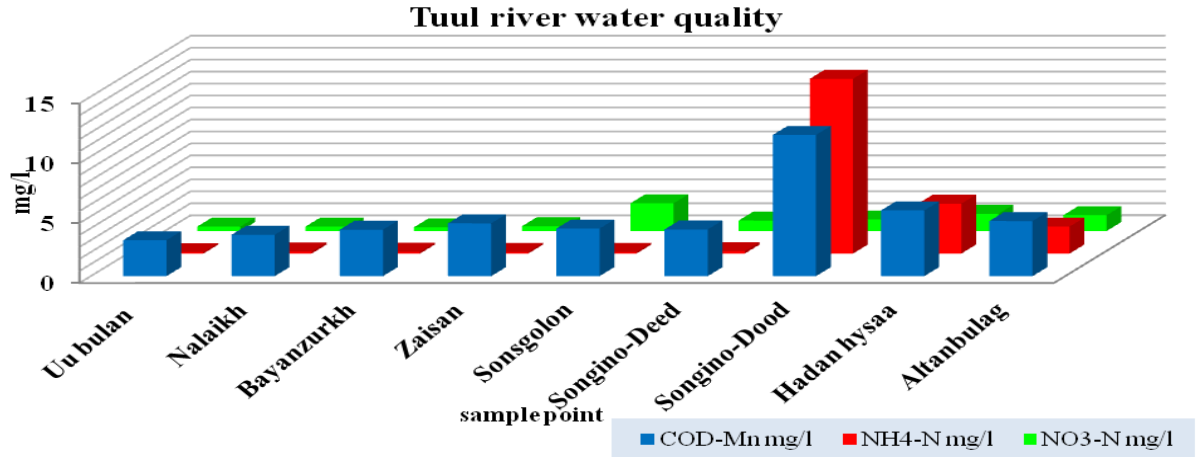


Table 5, Location of sample point

N	Name of sites	Latitude	Longitude	Selection
1	Tuul - Uubulan	47°48'26.40"N	107°22'50.30"E	Base load
2	Tuul - Nalaih	47°49'14.00"N	107°15'56.40"E	Discharge from local WTS
3	Tuul – Bayanzurh	47°53'28.10"N	107°03'04.70"E	Inflow to city
4	Tuul – Zaisan	47°53'19.40"N	106°55'05.70"E	Centre of city (near the Tannery industry)
5	Tuul – Sonsgolon	47°52'28.70"N	106°46'50.10"E	Outflow from city
6	Tuul-Songino (upper)	47°51'17.80"N	106°41'23.20"E	Upper reach of CWTP
7	Tuul-Songino (down)	47°50'51.70"N	106°40'29.70"E	Lower reach of CWTP
8	Tuul–Chicken farm	47°46'21.00"N	106°35'59.20"E	Discharge from bio-industry
9	Tuul- hadanhyasaa	47°45'08.90"N	106°30'02.60"E	Indicator of self-purification and inflow to town
10	Tuul - Altanbulag	47°41'53.40"N	106°17'40.60"E	Indicator of self-purification

Figure 5



As can be seen from figure 5 the concentration of ammonium exceeded the 'much polluted' category of the standard of surface water at Songino and Khadan Khyasaa points. The concentration of ammonium and chemical oxygen demand in increased when compared Bayanzurkh Bridge, Songiono and Altanbulag points. Because Songino point located Central wastewater treatment plant wastewater discharges into Tuul River. Aquatic animal and plant residency will degrade if increasing amount of ammonium ion and chemical oxygen demand continues in the future.

Figure 6, at the part of discharge into Tuul River for Central wastewater treatment plant

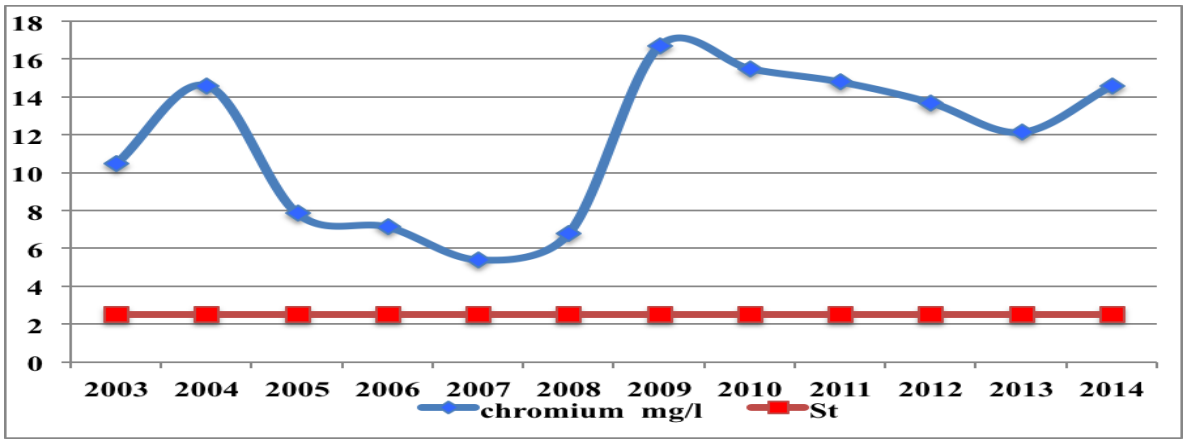


Table 6. Result of measurement for Hargia WWTP at part of collect wastewater from tanneries

№	Indicator of challenge		Measuring unit	2013 year /mean/	2014 year /mean/
1.	Chemical oxygen demand /XXX/	мг/л	6200.0	**9392.7**	**8538,16**
2.	Suspended matter	мг/л	5500.0	**5762**	3204,72
3.	pH	-	9	**11.89**	**9,92**
4.	sulfate	мг/л	150	125.1	56,77

igure 7, Result of measurement for Tannery industries

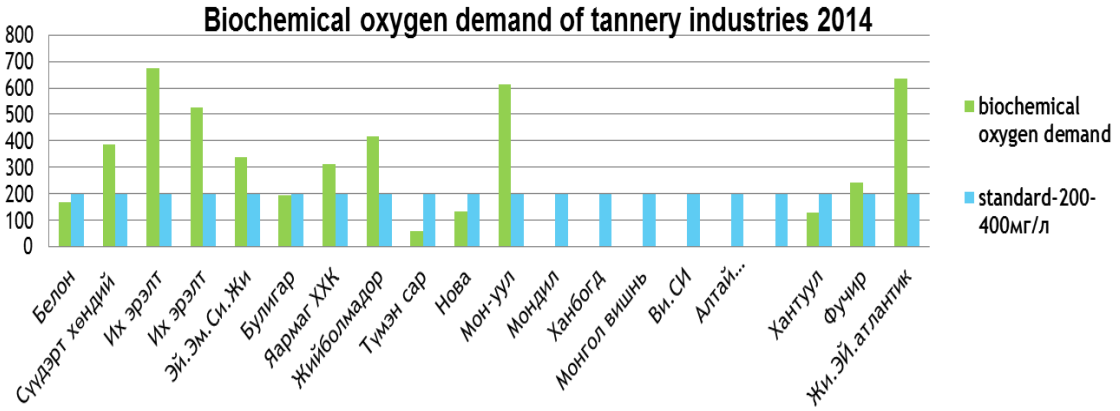
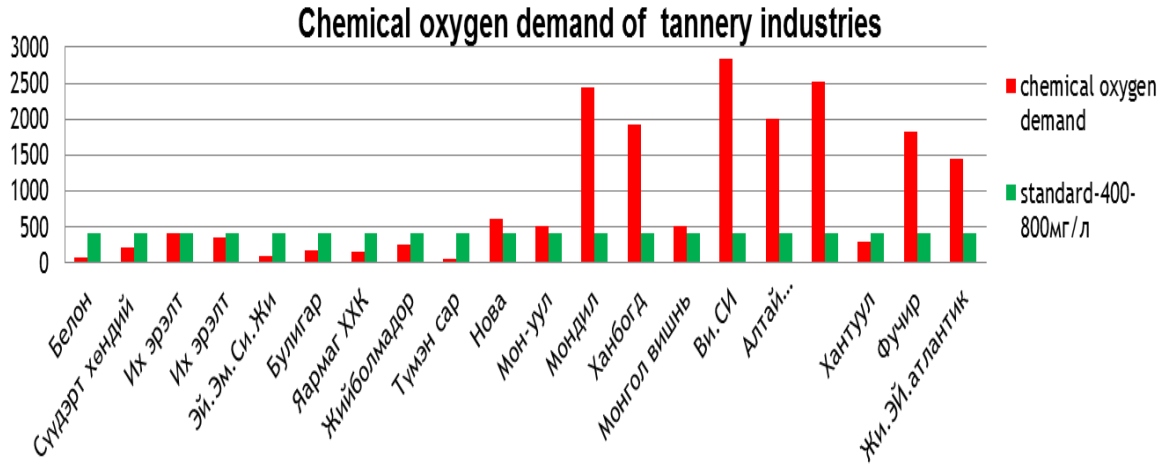
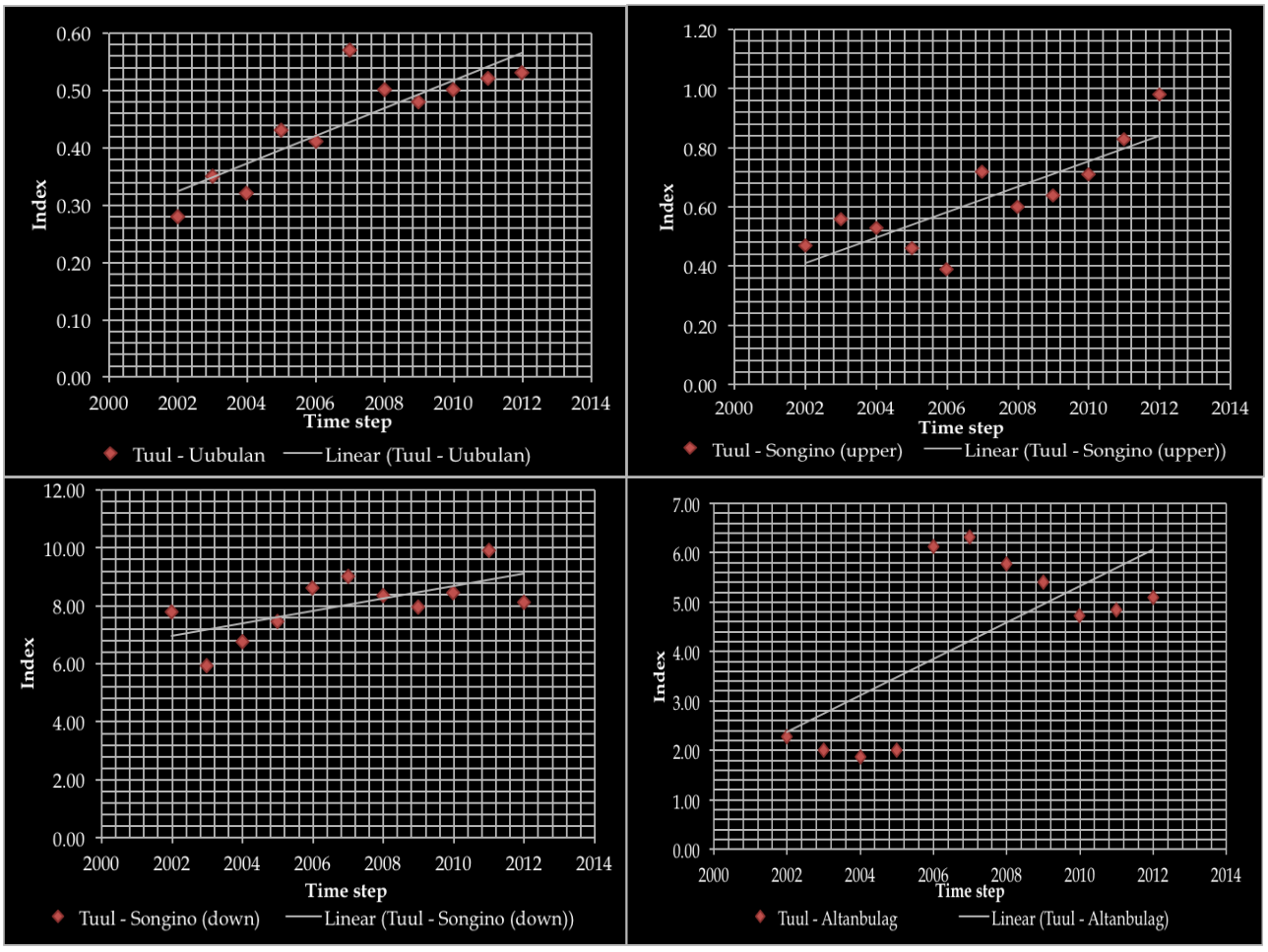


Figure 8, Result of measurement for Tannery industries



Result of samples had been chemical oxygen demand is plus by 1.5 folds, suspended matter is plus 1.04 folds, pH is plus 1.32 folds in 2013. But this year chemical oxygen demand is plus 1.37 folds, pH is plus 1.1 folds, another indicator normal.

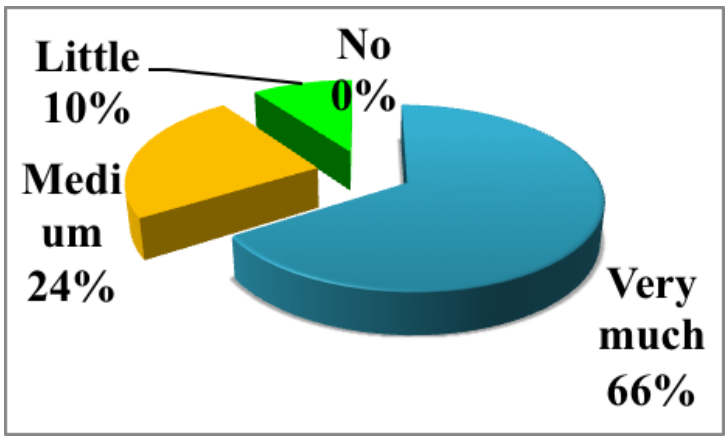
Result of water quality index in the Tuul River



In-depth interview result from local people near the Tannery industry

I have taken over 80 questionnaires from local people near the Tannery industries and part of wastewater discharge into Tuul River from CWWTP

Q 1. Do you smell the tannery industry and wastewater treatment of contamination?



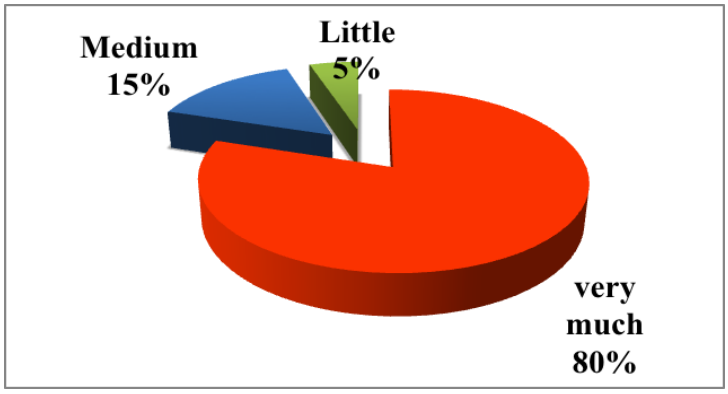
Q 2. How do you feel about the pollution on the Tuul River?

- ✓ Have changed the color of river water
- ✓ To rising the morbidity for babies
- ✓ Have dying a lot of fish in the every spring

Q 3. Do you think your livestock drink from the Tuul River? /Biocombinate/

- ✓ If no, Why? Please write down the reason
- ✓ Last few year rising to the livestock diseases

Q 4. How does the smell affect in your living area?



Please write:

- ✓ Can not open the window
- ✓ Can not take baby out in living area
- ✓ Can not walk outside
- ✓ Have a headache and nausea by smell
- ✓ Some people moved to summer house at the every spring and summer

Conclusion

1. In Mongolia, large or famous tannery companies use the trivalent chromium, but still some small companies illegally use the hexavalent chromium. Furthermore, a private facility that treats all of the wastewater from the above tanneries has already deteriorated and needs to be improved. These facts lead to the serious water pollution, such as in Tuul River, around Ulaanbaatar, recently.

2. The river system still remains highly vulnerable to pollution. With expansion of settlement area and industrialization in the future, it is recommended that the Water Authority of Mongolia should estimate vulnerable zone and protection distances from both river banks and to restrict any future activities, which may have a negative impact on river ecological system. Furthermore, the Mongolia Government should improve the efficient equipment of the Tannery industries and Hargia WWTP in order to reduce the negative

impact on surface waters. Perhaps should be transfer for Tannery industries from settlement area in Ulaanbaatar city.

3. From upper Songino after wastewater discharge to the Altanbulag Bridge river water is not suitable for livestock and resident use.

4. Under-refine or completely unrefined wastewater from industries and enterprises in the Ulaanbaatar city discharging into Tuul River and capital wastewater network is the basic reason of river water pollution.

5. Contamination indicators are increasingly higher than standards in the last few years, due to the expansion of population and Tannery industry in Ulaanbaatar.

Policy

1. Private facility, which treats all of the wastewater from the above tannery industries, has already deteriorated and needs to be improved.

2. Promote investment and financing opportunities in Tannery industry sector, encourage public-private partnership and cooperative investment through governmental policy.

References

(2010). "Associations of Fertility and Pregnancy Outcomes with Leather Tannery Work in Mongolia." International Journal of Occupational and Environmental Health **16**(1): 60-68.

Bolortamir, T. and R. Egashira (2008). "Removal of Hexavalent Chromium from Model Tannery Wastewater by Adsorption Using Mongolian Natural Zeolite." JOURNAL OF CHEMICAL ENGINEERING OF JAPAN **41**(10): 1003-1009.

Javzan, C., et al. (2004), Study of Tuul river contamination, *Geo-ecology in Mongolia, 04*, 213-219.

Ministry of Environment and Green development of Mongolia, report on state of Environment 2011-2012.

O. Altansukh, (2000), Surface water pollution of Ulaanbaatar city, 43 pp, National University of Mongolia, Ulaanbaatar.

Bolortamir, Ts. And R. Egashira: "Remove of Hexavalent Chromium from Model Tannery Wastewater by Adsorption Using Mongolian Natural Zeolite" Journal of Chemical Engineering of Japan, (October, 2008).

Vera Jones, "Water quality modeling as a tool for assessing new water resource management options" the case of the River Stour, Kent, 2009.

C.Neal et al, "Water Quality of Treated Sewage Effluent in Rural Area of the Upper Thames Basin, Southern England, and the impact of Such Effluents on Riverine Phosporus Concentrations," Journal of Hydrology, Vol. 304, No. 1-4, 2005, pp. 103-117