Evaluation of some environmental impact indicators of tannery wastewater in Tuul river, Ulaanbaatar, Mongolia

ODGEREL Dalkhjav[1]
Graduate School of Life and Environmental Sciences, University of TSUKUBA

1. Background

Due to Ulaanbaatar city's nowadays population growth and some other reason, Ulaanbaatar citizen's basic drinking water source Tuul river's water quality is decreasing year by year. Namely, Tuul river's water quality sharply polluting just after passed through Ulaanbaatar city [1].

In recent 10 years Tuul river's pollution is increasing due to industrialization, urbanization and lack of the old aged technology of waste water treatment plants. The self purification coefficient of the Tuul river was 6.57 until first pollution point, but that coefficient is decreased till 0.98 at the waste water joining point from the Central waste water treatment plant (CWWTP) [2].

Nowadays research result shows that efficiency of the CWWTP is around 60-70%, because of the lack of technology; it means that 10-20% untreated waste water pouring to the Tuul river and it shows negative effect to river water quality [3].

Except waste water treatment technology innovation and instrument capacity, one of the reasons which couldn't fully treat waste water from the central sewage water treatment plant is about 30 tanning industries which are located in Ulaanbaatar city area. Also, municipal treatment plant has a responsibility to treat tanneries waste water which contains highly amount of toxic elements and transfer to CWWTP, due to out of date technology can not treat tanneries waste water.

Mongolia has a large number (in Ulaanbaatar city 34 tanning industries) of small leather tanneries which process some 30 000 skins per day, for a total output of about 8 million units per year. The tanneries produce wastewater, solid waste and sludge that contain significant amounts of chromium (Cr) and other chemical pollutants.

Particularities of tanneries are their activity is not regular, maximum number of leathers manufactured in autumn season, not much considers about waste management, safety and technology innovation. Due to these factors the chemical properties of the rivers and the drinking water source have been changed, and may impact further on human health and ecosystems in the future. That is why we need to improve monitoring of the waste water discharge to river and do assessment on the chemicals usage and impact on the environment.

2. Material and methods

For the purpose to evaluate Tuul river's pollution, 11 sampling points chosen along the main branch Tuul river from Uu bulan of Terelj till Altanbulag of Tuv aimag, 2 times in year from May 2012 to October 2013. The tanneries and waste water treatment plants are located in Khan-Uul, Songinokhairkhan district of Ulaanbaatar city.

In water samples, pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), oxidity, color, nitrogen, some cations and anions, and heavy metals (lead, cadmium, copper, iron, cobalt, chromium) determined in laboratory of Metropolitan Inspection Agency by using Mongolian National and International standard method .

River water quality assessment was done by 142-352th arrangement "Surface water quality grade" of Ministry of Nature and Environment and Ministry of Health (MOH) in 1997.

3. Result and Discussion

Tuul river water quality assessment by chemical and microbiological parameters

For the purpose to evaluate Tuul river's water quality, 11 sampling points chosen along the Tuul river from Uu bulan of Terelj till Altanbulag of Tuv aimag and was done chemical, microbiological and heavy metal analysis, respectively two times between 2012-2013.

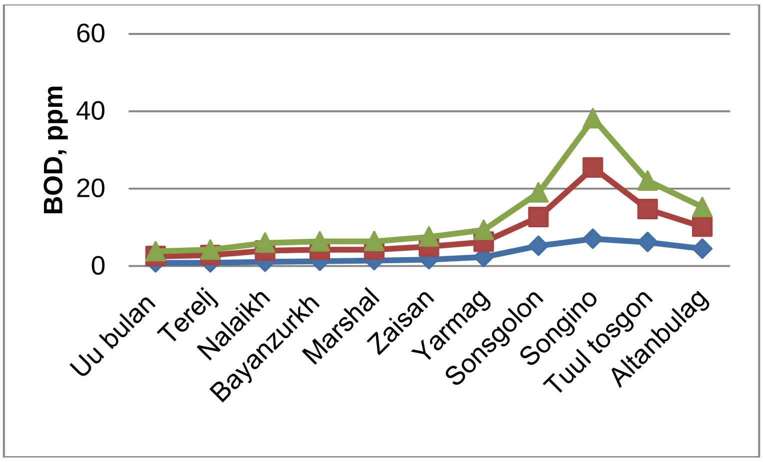


Figure1. BOD concentration in Tuul river water

There are 2 basic indicators of surface water quality, DO and BOD analysis shows that Tuul river water quality is from Uu bulan until Yarmag bridge belongs to class 2, from the Sonsgolon bridge water pollution is increasing and that pollution is getting maximum level at the Songino point, belongs to class 5.

In 2012, by microbiological parameters Tuul river water quality belongs 2 class from Uu bulan to Bayanzurkh bridge, but in 2013 at the second point (Nalaikh waste water joining point) sharply increased and transferred to class 4 (contaminated water).

That continues constantly till Yarmag bridge. At the Songino bridge point observed maximum contamination level 5 (heavily polluted) and further points Tuul tosgon belongs to class 4 (moderately polluted), around Altanbulag point belongs to 3 class (slightly polluted).

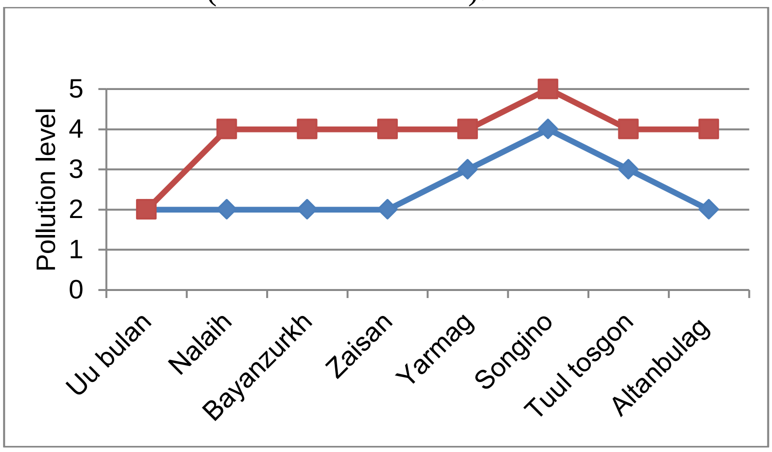


Figure 2. Tuul river pollution level by microbiological parameters

Generally, Tuul river's water quality belongs to class 2 (pure) at the points from Uu bulan till Marshal bridge, belongs to class 3 (slightly polluted) from Zaisan bridge till Sonsgolon bridge, at the Songino point belongs to maximum pollution level, class 5 (heavily polluted), Tuul tosgon and Altanbulag points belongs to 4 (moderately polluted), 3 (slightly polluted) class respectively.

Table 1 . Tuul river pollution level

Year	Season	Uu bulan	Terelj	Nalaikh	Bayanzurkh	Marshal	Zaisan	Yarmag	Sonsgolon	Songino	Tuul tosgon	Altanbulag	**Pollution level**

2012	Spring	2	2	2	2	2	3	3	3	4	3	2	**2.5**
	Autumn	2	2	2	2	2	2	3	3	4	3	3	**2.7**
2013	Spring	2	2	2	2	2	3	3	3	4	4	4	**2.8**
	Autumn	2	2	2	2	3	3	3	4	5	4	4	**3.1**
Average		**2**	**2**	**2**	**2**	**2.2**	**2.8**	**3**	**3.3**	**5.3**	**3.5**	**3.3**	

Tuul river's pollution level is measured at the first point after discharge from CWWTP enters to the river. At the further points the pollution level little bit decreases, but river self-purification process still insufficient.

Heavy metal analysis in river water and sediment

The heavy metal analysis in river water and sediments shows that compare to Mongolian National Standard MNS 4586:1998, not exceeded from the permissible level of chemical variables.

Table 2. Heavy metal concentration in Tuul river, ppm

Points	Pb	Cd	Cr	Fe	Zn
Uu bulan	<2	<0.3	<2.5	30±0.35	150±0.18
Nalaikh	<2	<0.3	<2.5	36±0.32	148±0.12
Bayanzurkh	<2	<0.3	<2.5	30±0.34	152±0.11
Zaisan	<2	<0.3	<2.5	50±0.12	208±0.08
Sonsgolon	<2	<0.3	<2.5	82±0.22	250±0.34
Bio	<2	<0.3	<2.5	190±0.43	1054±0.76
Tuul tosgon	<2	<0.3	<2.5	90±0.17	470±0.33
Altanbulag	<2	<0.3	<2.5	80±0.09	390±0.43

Note: Detection limit of determination of heavy metals by AAS, ppm Pb <2; Cd <0,3; Cr <2,5; Fe <6; Zn <1

However, heavy metal analysis in river sediment shows that in the sampling point in downstream, after the discharge from the CWWTP enters the river contaminated by Cr (39.4 ppm) and Cd (0.43 ppm) (Table 2).

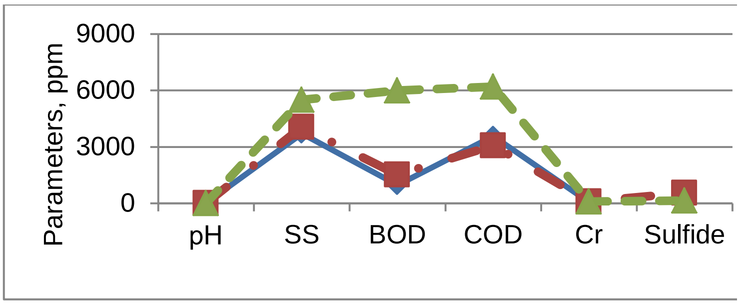
Table 3 . Heavy metal concentration in the Tuul river and sediment

Elements	Tuul river water, ppm	Tuul river sediment, ppm
Zn	0.352±0.030	40.70±0.06
Pb	<0.002	36.50±0.26
Fe	0.074±0.008	6.40±0.10
Cd	<0.0003	**0.43±0.02**
Cr	<0.0025	**39.40±0.32**

Heavy metal analysis shows that in Tuul river water not contaminated by toxic heavy metals but river sediment contains heavy metals such as Cr and Cd which indicates originating from the tanneries waste water. It can be expected that changes from reducing to oxidizing conditions which involve transformations of sulfides that from tannery waste water and shift to more acid conditions were increased the mobility of Cd and Cr [11].

Analysis of tanneries waste water

The main quantity of pH, SS, COD, BOD and Cr of 52 samples of 13 delegations of 13 tanneries were selected on 2012-2013 and were investigated two times. The 15 factories were operated on March 2012 but total 23 factories were operated on 2013.



MPL-max permissible level

Figure 3. Comparison of tanneries waste water quality to MPL

The requirements of waste water of leather factories in Mongolia have been released standard about following as "Water quality. Technical requirement for tannery effluent to municipal treatment plant. MNS 5582:2006". It was shown our results studied 52 samples of waste water of tanneries that the 35 samples (67 %) are the highest values above the permitted level.

For the evaluate tannery waste water quality particularly, we were investigated 3 samples from tanneries, 1 sample from municipal treatment plant and have done heavy metals analysis using ICP-MS (Inductively coupled plasma mass spectrometry) in Hokkaido University, Japan. The analysis result shown in Table 4.

Table 4. Quality of heavy metals in waste water of treatment plant and tanneries

Samples	Heavy metal concentrations, ppb						
	Cr	Fe	Cu	As	Cd	Pb	Hg
Treatment plant	**2632**	619	ND	**2.63**	ND	**25.2**	**1.99**
Mon ireedui Co., Ltd	**28816**	361	ND	**5.55**	ND	**130**	**8.19**
Belon Co., Ltd	231	68.2	ND	ND	ND	**4.66**	**7.74**
Arildii Co., Ltd	75.9	78.4	ND	**0.09**	ND	**5.04**	**1.72**

ND: not detected

The permitted level of these heavy metals in waste water of tanneries in standard of Mongolia is not included, therefore we could not discuss about. However, detection of toxic heavy metals such as Cr, As and Hg in tannery waste water is very interesting in the future research and discussion.

Analysis of waste water after purified in treatment plant

The main quantity of pH, SS, BOD, COD, sulfide and Cr of each 8 samples from sulfide and chromium lines of "Municipal treatment plant" of operating tanneries in Khan-Uul district of Ulaanbaatar city which interflows into CWWTP of water purification and 4 samples of entrance, 8 samples of exit at CWWTP for qualification of waste water were investigated.

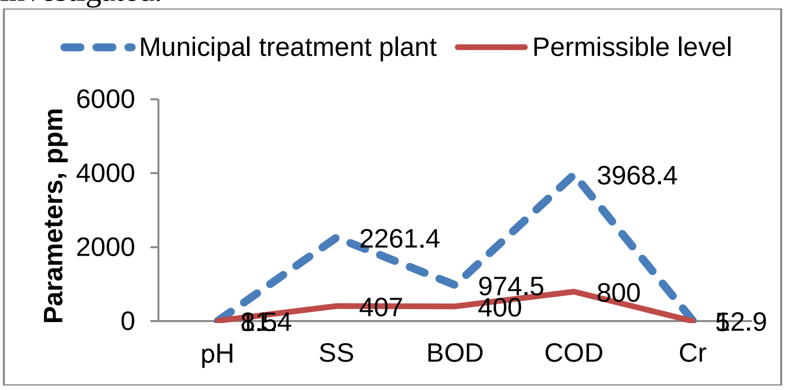


Figure 4. Comparison of Municipal treatment plant's waste water with maximum permissible level

The results of waste water of treatment plant shows that the amount of COD is 4 times, BOD is 2 times, weighing component is 10 times, pH is two times higher than maximum permissible level. In Mongolia, municipal treatment plant's waste water contamination managed by regulation named by "Requirement of the highest level of waste water of factories to Central treatment plant".

The waste water at exit from CWWTP must be lower than the requirement for level of toxic components of Mongolian National Standard "Purified waste water interflows to nature. Technical requirement MNS 4943:201" but in waste water at exit from treatment plant, the amount of BOD is 9, COD is 6 times, SS is 11 times, nitrogen of ammonium is 3 times higher than standard level and the amount of Cr (VI) is 3.9 ppm which is not approved in purified waste water.

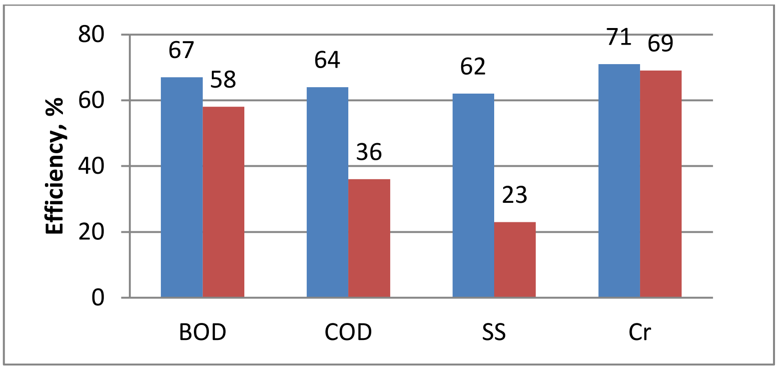


Figure 5. Efficiency of CWWTP

After the evaluated the force of purification of CWWTP for BOD, COD, SS and Cr, the average efficiency were calculated as 66.8 % on 2012 but 49.8% on 2013 which was decreased by 17 %.

Results of correlation analysis

Based on correlation analysis it was clearly showed that, on autumn and spring data of Tuul river water, the following parameters such as [BOD_{spring} = f (BOD_{autumn})], [DO_{spring} = f (DO_{autumn})], [pH_{spring}= f (pH_{autumn})], [$Color_{spring}$= f ($Color_{autumn}$)] are correlated strongly. Calculation of them is shown on the table 5.

Table 5.Seasonal correlation of parameters characterizing river water quality of Tuul river

Parameters	Season	Analyze		Correlation
BOD	spring-autumn	rxy =0.811	tab=0.423	Positive
DO	spring-autumn	rxy =0.518	tab=0.423	Positive
pH	spring-autumn	rxy =0.823	tab=0.423	Positive
Color	spring-autumn	rxy =0.705	tab=0.423	Positive

For tanneries waste water the correlation is formulated as between [COD= f (pH)], [COD = f (SS)] which means DO strongly correlated to SS.

However, elements and parameters of waste water from treatment plants are correlated strongly, [Cr = f (SS)] for water from the "Municipal treatment plant" and [BOD = f (SS)], [Cr = f (SS)], for the water waste pouring directly to Tuul river from CWWTP.

Table 6. Correlation between CWTTP's waste water parameter

	BOD	COD	SS	pH	Ammonia	Cr
BOD	1					
COD	0.597	1				
SS	0.709	0.580	1			
pH	-0.387	0.298	-0.495	1		
Ammonia	0.045	0.027	-0.116	0.290	1	
Cr	0.574	0.383	0.720	-0.229	0.483	1

r_{xy} (α, f)→0.707

Strong correlated

4. Conclusion

The following conclusions are made based on the survey of Tuul river pollution from the tanneries which are located in Khan-Uul district of Ulaanbaatar city:

- The assessment on Tuul river quality by chemical and microbiological characteristics indicates that, the section from Uu-bulan to Marshal's bridge has the second level of pollution (pure), the section from Zaisan bridge to Sonsgolon has third level of pollution (small contamination), the section near the Songino has fifth level of pollution (high contaminated) and pollution is decreasing according to the location how far from Ulaanbaatar, as an example, water pollution in Tuul village is fourth (contaminated) and Altanbulag of Tuv aimag is third level.
- In 2012, when 15 factories were operating near Tuul river, data result shows Tuul river had 2 level of pollution in average. However, in 2013, when number of tanneries had been increased up to 23, average pollution is also increased to the 3 level. Water quality of Tuul river becomes poor in autumns, which overlaps with intensive operating period of leather factories. From the other hand, efficiency of the CWWTP had been decreased 66.8% in 2012 to 49.8% in 2013 by 17 percents.
- Analysis of Cr in river water not detected, however our study shows that Cr concentrated and mobilized in river sediment. That indicates tannery waste water with chromium contamination is polluting the environment.
- Based on the correlation analysis on autumn and spring data of Tuul river water, the following parameters such as [BOD_{spring}= f (BOD_{autumn})], [DO_{spring}= f (DO_{autumn})], [pH_{spring}=f(pH_{autumn})], [$Colour_{spring}$= f ($Colour_{autumn}$)] are correlated directly and moderately and for water waste of leather factories [COD= f (pH)], [COD= f (SS)], which means they are correlated directly. However, elements and parameters of treatment plant's waste water are correlated strongly [Cr= f (SS)], [BOD= f (SS)], [Cr= f (SS)], respectively.

References

1. Altansukh. O. *Surface water quality and modelling///.* Ulaanbaatar., (2010), 2 p
2. Ministry of Nature and Environment. Assessment on environmental issues///. Ulaanbaatar., (2006-2007), 34 p
3. Batmunkh. Sh. *Ulaanbatar city's ecology and disaster condition///.* Ulaanbaatar., (2010), www.irgen.mn
4. Gonchigsumlaa.Ch. *The methodology of protection Ulaanbaatar city's environment///.* Ulaanbaatar., (1999)
5. Janchivdorj. L and others. MAS, *Tuul river: Ecology reform, water management///.* Ulaanbaatar., (2011), 17, 70, 71, 74, 75, 91 p
6. Janchivdorj. L and others. MAS. *The assessment on biggest river basins in Mongolia, study of water ecology///.* Ulaanbaatar., (2007)
7. Munguntsetseg. A. *Selenge river basin hydrochemistry///.* Ulaanbaatar., (2006)
8. Bolormaa. O. Sarangerel. D. *Metrology training material///.* NUM, SCCE. Ulaanbaatar ., (2011), 25, 36 p
9. Oyuntogos. L, Chimedsuren. O, Manfred Dierich. *Chromium exposure assessment///.* Medical science magazine, Ulaanbaatar., (2006), 117 p
10. Enktaivan. J and others. *Structure and variance of Tuul, Kharaa and Eroo river basins///.* Ulaanbaatar., (2007)
11. Ulrich Forshtner, Wolfgang Ahlf, Wolfgang Calmano, Michael Kersten and Wim Salomons. *Mobility of heavy metals in Dredged Harbor Sediments///.* (2009). 7p