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Dhaleshwari River Water Quality Due to Disposal of Tannery Wastes at Savar, Dhaka, Bangladesh

[1] AS Chamon, [2] S Romana, [3] MR Zubaer, [4] WZ Prian, [5] MA Hossain, [6] MN Mondol
[1, 2, 3, 4, 5, 6] Department of Soil, Water and Environment, University of Dhaka, Dhaka-1000, Bangladesh

Corresponding Author: **AS Chamon**

Abstract
To assess the contamination load in Dhaleswari river water samples and its possible human health hazards, heavy metals concentration (Cr, Cd, Cu, Pb, Ni and Zn) in the study area were determined. The highest metal concentration was observed in main disposal point and the decreasing value was observed with the increasing distance in dry and wet season with significant differences among different sampling spots and in most of the cases metal concentration in water crossed the Maximum Permissible Limits (MPL). The DO (mg/L) in various sampling point were ranging from 0.08 to 7.82 and 0.08 to 6.76 mg L^{-1} and TDS from 209 to 7124 and 68.1 to 6,510 mg L^{-1} respectively, in dry and wet season. Chromium (Cr) concentrations in the Dhaleshwari river water and effluent samples were ranged from 0.0384 to 18,809.71 and 0.013 and to 37.68 mg L^{-1} respectively, in dry and wet season. Comparative higher values of heavy metals were found in dry season than wet season. Chromium (Cr) concentrations in river water and waste water/effluent samples at Savar sampling area were ranged from 0.0384 to 18,809.71 and 0.013 and to 37.68 mg L^{-1} respectively, in dry and wet season. Chromium concentrations in the water samples collected from Dhaleswari river in some sampling points, crossed the MAC (Maximum allowable concentration) at Savar study area for drinking (0.05 mg kg^{-1}) (WHO 2004) [20] in dry season. Chromium (Cr) concentrations in waste water in dry and wet season were 18,809 and 37.68 mg L^{-1} and Pb concentrations at main disposal point of Savar tannery area crossed the standard value of effluents for inland surface water (0.1 mg L^{-1}) (CPCB 1995) [4] respectively, which afflict the river water environment and thus lessen ecological balance.

Keywords: Metal Concentration, Waste Water, Tannery Industry, Dhaleshwari River

Introduction
On July 15, 2001, the Honorable High Court (HC), Bangladesh gave the first order to take effective measures against Hazaribagh tannery pollution as well as to shift the tanneries within one year from Hazaribagh to Savar in view of the Buriganga becomes dead, because of dumping of untreated chemical waste. Finally, the HC issued an order to cut down the electricity supply of the Hazaribagh tannery which initiated the relocation of the tannery industries to Savar's Tannery Park (BAPA 2017) [2].

Nearly, 200 acres of land has been acquired for the purpose of establishing an environmentally friendly tannery industrial estate located by the bank of Dhaleshwari River near Dhaka. Plots have been distributed among 155 tannery companies in the acquired area. In the meantime, the majority of tannery companies that have allocated plots, are continuing their relocation process. At present, 2 modules of Central Effluent Treatment Plant (CETP) are operational, and two more are in progress, which is expected to be commissioned soon. But the total waste storage capacity of the entire plant is 25,000 cubic meters. However, the amount of waste will increase after Eid. At present, about 70 tanneries are producing between 12,000-15,000 cubic meters of waste, which are going directly into the Dhaleshwari River without any treatment. It is necessary to reevaluate the efficiency of ETP by examining them scientifically (BAPA 2017, Web. 1-6) [2].

Dhaleshwari pollution is an indispensable issue because there is no way to refine and manage solid waste, salt and chromium. A Chinese Company working on this project has given a proposal to the Government to implement a Solid Waste Management system by 2019. Around 100 factories from Hazaribagh are still not in the list of allotment. Several factories have been continuing their operation in Hazaribagh by taking illegal power connections lines from the nearby households and from dishonest government electricity distributer (LightCastle Partners 2019) [10].

The worst fact is that, the pollution of the Dhaleshwari River would increase to a larger extent after Eid-Ul-Azha. Savar Tannery Park's pollution has been expanding beyond the Buriganga, Dhaleshwari and Kaliganga. While, there is no

confirmation when these factories would run with proper ETP implementation. Despite continuous movement, some issues like poor planning and management, ETP limitations, employment, education and health have not been properly highlighted. Since the CETP of Savar is a biological treatment plant, its efficiency depends on the amount of waste; the time taken for modules to process; and the amount of caustic soda as well as other ingredients, which is either faulty or non-existent (BAPA 2017, Web. 1-6) [2].

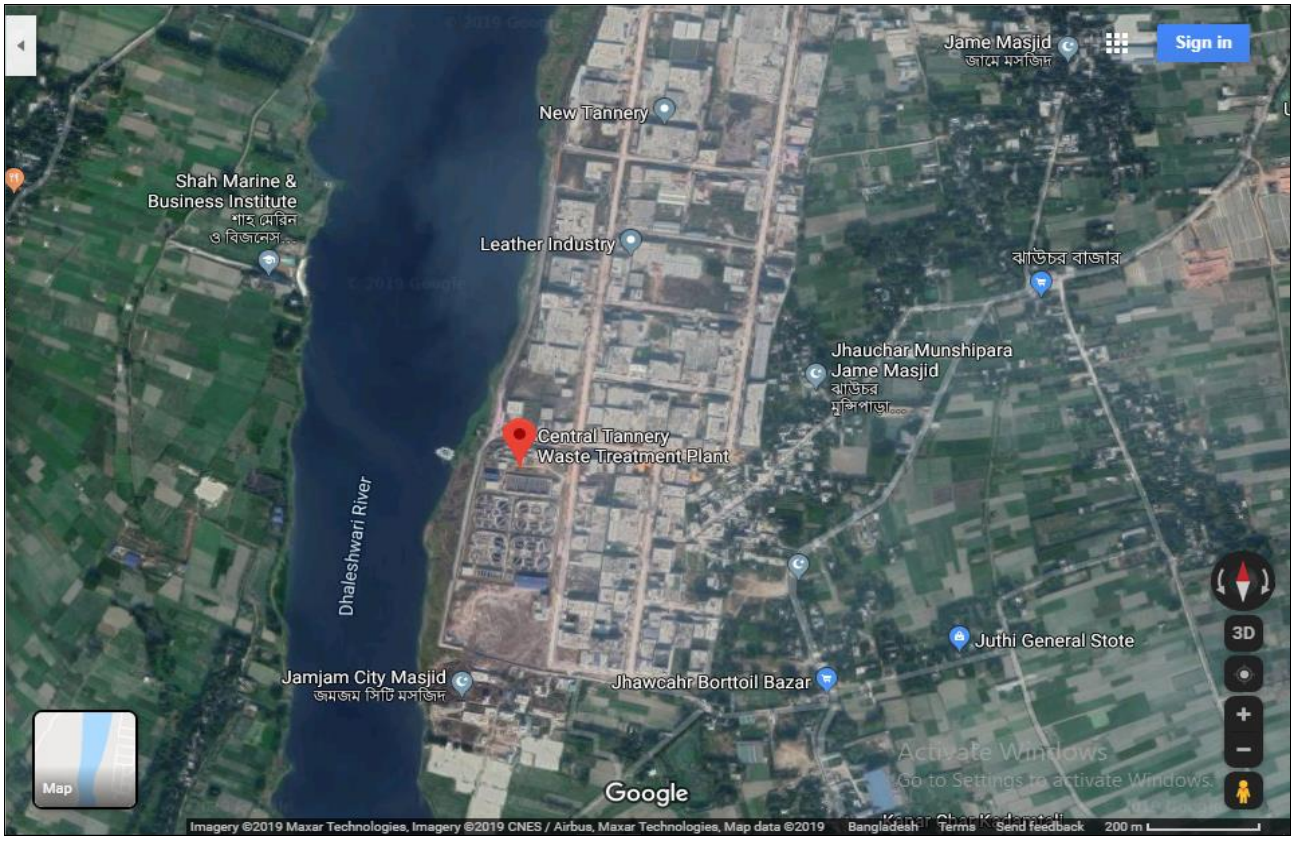
Waste water derived from tannery sludge is extremely colored due to physico-chemical treatments; contain considerable amounts of Toxic metals, tannins and their phenolic derivatives (Vallini *et al.* 1989). Phenols and hydrocarbons are considered common environmental pollutants even in low concentrations (Nuruzzaman *et al.* 1998) [13].

Toxic metals are known to have serious health implications, including carcinogenesis induced tumor promotion, and hence the growing consciousness about the health risks associated with environmental chemicals has brought a major shift in global concern towards prevention of heavy metal accumulation in soil, water and vegetables (Ahmed *et al.* 2009, Mortula and Rahman 2002, Rahman *et al.* 2012) [1, 12, 14]. The aims of the present research work were to study the effect of waste and effluent on the physical, chemical and physico-chemical properties of water in wet and dry seasons.

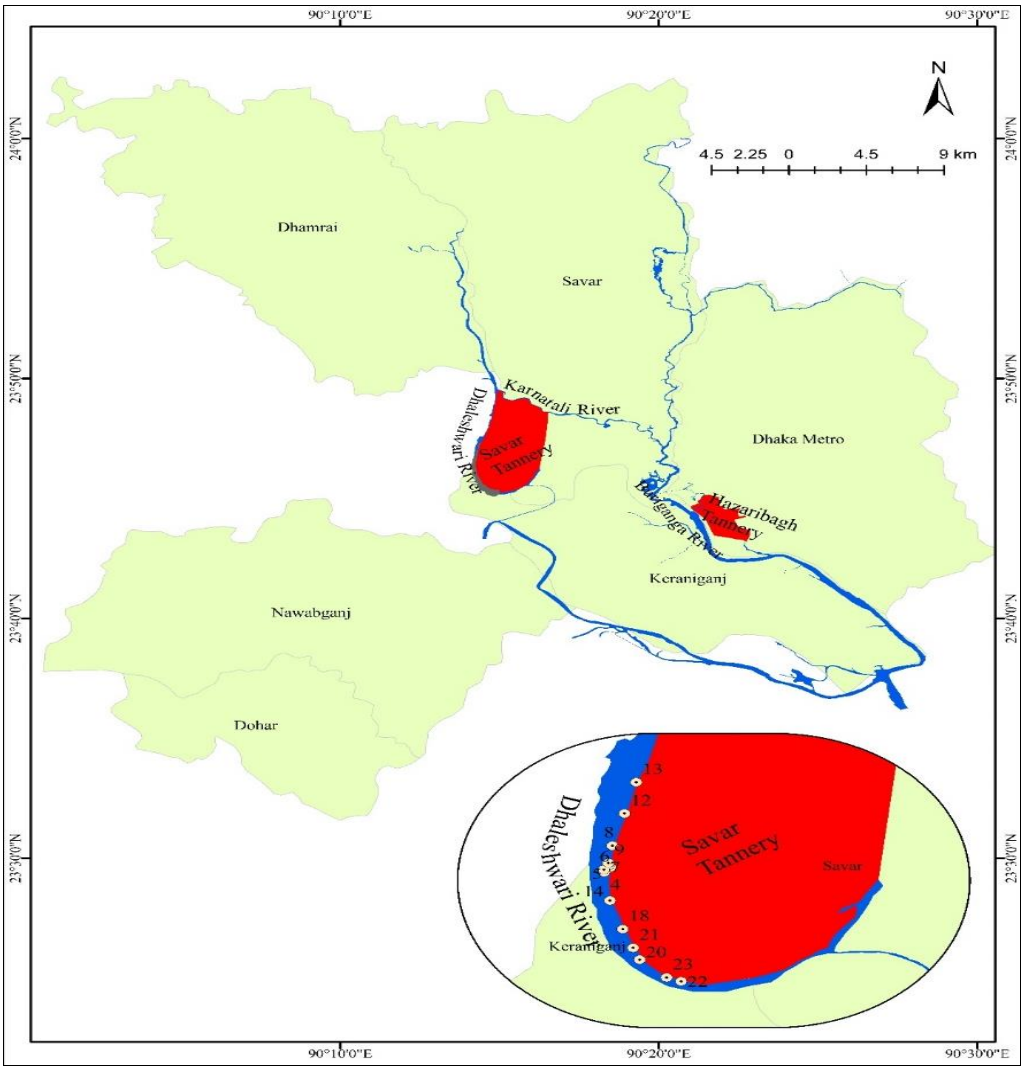
Materials and Methods

A study was conducted (during January 2019-January 2020) to determine the impact of newly relocated tannery wastes and effluents on the environment [(Tanneries were relocated from Hazaribagh to Savar's Horindhara (Hemayetpur), adjacent to the Dhaleswari river, two years ago to save the Buriganga)] (Dhaka Tribune Dec. 26, 2018) [5], (Map 1). To assess the contamination load in the Dhaleswari river water samples, only heavy metal concentration (Cr, Cd, Cu, Pb, Ni and Zn) in the study area were determined.

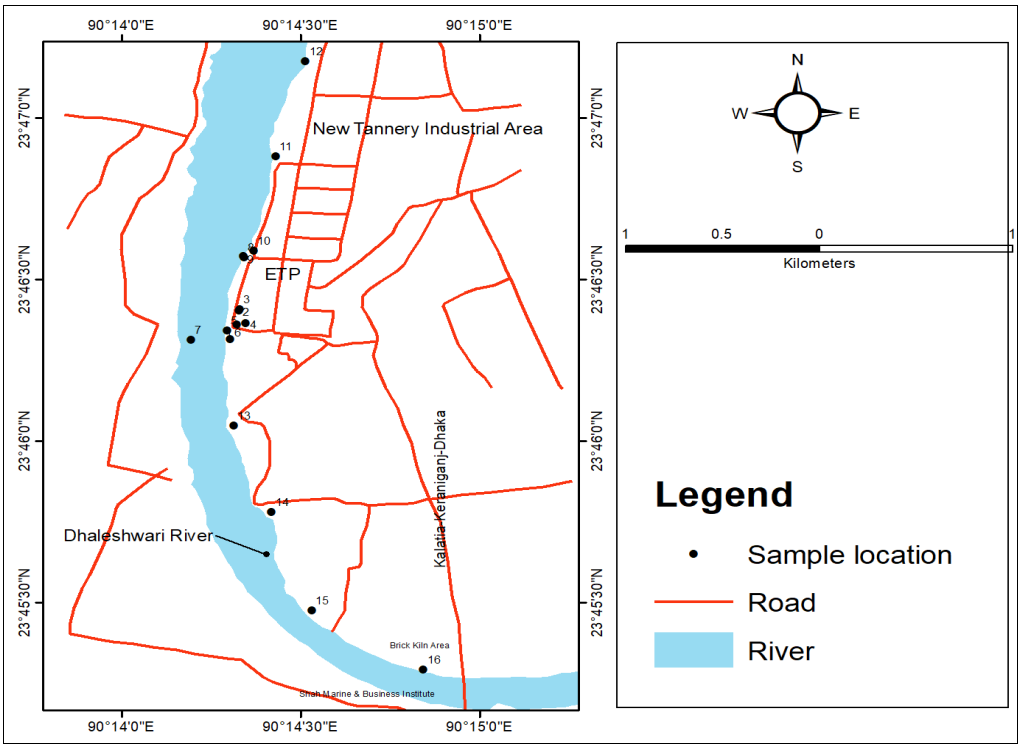
Water/effluent samples were collected from the study area at two phases, February (dry season) and August, 2019 (wet season). Water samples were collected during dry and wet season, from newly established tanneries at Hemayetpur savar upazila (Picture 8 and 9) with 3 replications. Sampling sites were selected according to the main sources of wastes and effluent disposal around CETP to the Dhaleswari river ranging from 1 km upstream and 2 km downstream (Map 1 and 2). The sampling points were geo referenced with GPS (Geographical Positioning System) and marked on the map (Picture 1 and Map 1 and 2, Table 1).



Picture 1: Satellite view of the sampling sites at Savar Tannery areas



Map 1: Sample collection points in dry and wet season around Savar Tanneries



Map 2: Sample collection points in dry and wet season around Savar Tanneries

Table 1: Sample collection points and location details in dry and wet season around Savar Tanneries

Point No	Location details
1	Solid Waste dumping site 1 (Effluent)
2	Solid waste dumping site 2 (Effluent)
3	River bank (before mixing with river (Effluent))
4	River bank (effluent mixing with river (water))
5	Middle of the river (water)
6	Effluent at source point 3
7	Effluent+river water mixed (water)
8	Direct Effluent from ETP pipe
9	Direct Effluent from ETP pipe
10	Effluent Discharge without ETP
11	Beside BG land (water)
12	River Water from 0.5 km upstream
13	River Water from 1.0 km upstream
14	River Water from 0.5 km down stream
15	River Water from 1.0 km down stream
16	River Water from 1.5 km down stream
17	River Water from 2 km down stream

Eleven (11) water, six (6) effluent samples (500 ml) were collected from each site in deionized polyethylene bottles fitted with liquid-tight stopper. Spot 1 is considered the main disposal point and the increasing numbers of the spots indicate increasing distance from the main point mentioning upstream and downstream of the Dhaleswari river. The water samples were immediately acidified with 4 ml of concentrated hydrochloric acid per liter and analyzed within 7 days of collection.

pH: The pH of water was measured using a glass electrode pH meter.

EC.: Electrical conductivity of water was measured using an EC meter.

TDS: Total dissolved solids of water were measured using a portable TDS meter.

TSS: Total soluble salts in water measured gravimetrically by evaporating 20 ml of water sample at 110^{o}C and expressing it in mg/kg.

DO: Dissolved oxygen of water were measured using a portable DO meter

Heavy metals: 10 ml of water/effluent sample was measured and digested with 20 ml conc. HNO_3 (Blum *et al.* 1996) [3]. The digested water and effluent samples were analyzed for heavy metals, e.g., Cd, Cr, Cu, Mn, Ni, Pb, and Zn by atomic absorption spectrophotometer (AAS) at the Department of Soil, Water and Environment, University of Dhaka. The results were statistically evaluated by the DMRT. Different letters were used to signify the statistically different results at 5% level of significance.

Results and Discussion

A breach in the embankment of a pond, used by the Central Effluent Treatment Plant (CETP) for dumping solid waste generated by the Tannery Industrial Estate, savar, is likely worsening the pollution levels in the Dhaleshwari river in Savar (The Daily Star Sept. 17, 2018) [16] (Picture 2). Liquid waste from the Savar Tannery Industrial Estate being dumped into the Dhaleshwari turning the river water black and leaving thick foam on the surface. Solid waste of the Savar Tannery Industrial Estate on the outskirts of the capital being discarded into the temporary dumping station there. But the waste eventually makes its way into the Dhaleshwari river (The Daily Star Sept. 17, 2018, Dhaka Tribune July. 21, 2019) [16, 6].

Picture 2: Dumping liquid waste directly to the Dhalashwari river, generated by the Tannery Industrial Estate, savar.

There was no wide variation in pH values among the dry and wet season effluent/water samples. The maximum pH value was 10.11 recorded during dry season and the minimum value was 6.24 during wet season (Table 2). The EC in water samples at various sampling point were ranged from 418 to 14,233 and 136 to 7,100 µS/cm respectively, in dry season and wet season (Table 2).

Comparative higher values were in dry season than wet season and it might be occurred due to dilution of rain water by monsoon rain or less discharge of tannery effluents from industries at the time of sampling. Total dissolved solids TDS (mg/L) in waste water at various sampling points of savar tannery area were ranged from 209 to 7124 and 68.1 to 6,510 mg L^{-1} for dry and wet season, respectively (Table 2). The variations in the concentrations of TDS in waste water and the Dhaleswari river water were due to discharge of effluents and wastes from the tannery industries (The Daily Star August 03, 2019) [17]. The DO (mg/L) in various sampling point were ranging from 0.08 to 7.82 and 0.08 to 6.76 mg L^{-1} respectively, in dry and wet season (Table 2). In both the seasons minimum DO was observed at sampling point 1 (0.08 mg L^{-1}). The collected Dhaleswari river water had higher DO level in both seasons (>5 mg L^{-1} in dry and wet season, respectively) (Table 2).

Table 2: Seasonal variation in physico-chemical properties of water and effluent samples in Dry season.

Point No	Dry season				Wet season			
	pH	EC (µS/Cm)	TDS (mg/L)	DO (mg/L)	pH	EC (µS/Cm)	TDS (mg/L)	DO (mg/L)
1	10.11 i	14230 m	7120 l	0.09 a	7.66 k	1320 d	6510 k	0.18 b
2	7.81 c	14233 m	7124 l	0.08 a	7.46 j	454 b	224 f	6.65 n
3	8.01 h	1332 g	666 f	4.46 c	7.44 i	137.8 a	67.8 a	6.4 m
4	8.03 h	1324 f	665 f	7.68 k	8.18 l	6830 f	3430 i	0.09 a
5	7.94 fg	1813 j	907 i	7.38 i	7.67 k	7100 g	3560 j	0.08 a
6	8.01 h	1751 h	876 g	7.11 g	7.43 hi	139.5 a	69.3 bc	4.27 e
7	7.83 cd	1334 g	667 f	7.56 j	7.42 h	4520 e	2260 h	1.08 c
8	7.91 ef	418 a	209 a	7.57 j	7.34 g	1010 c	505 g	5.18 h
9	8.01 h	5150 k	2590 j	7.76 l	7.15 e	218 ab	108 e	2.68 d
10	10.07 i	5360 l	2680 k	0.11 b	7.14 e	138.7 a	68.7 ab	4.43 f
11	7.98 gh	1802 i	901 h	5.59 e	nd	nd	nd	nd
12	7.95 fg	1326 f	662 f	7.26 h	6.74 b	143.1 a	70.5 c	5.73 j
13	7.89 de	1303 e	652 e	7.43 i	6.24 a	138.7 a	68.4 ab	5.04 g
14	7.87 de	1281 d	641 d	7.82 m	7.08 d	136.7 a	68.1 ab	6.35 l
15	7.63 a	1269 c	634 c	6.87 f	7.19 f	146.8 a	72.8 d	5.44 i
16	7.62 a	1267 c	633 c	6.86 f	7.15 e	147.5 a	73.6 d	6.76 o
17	7.68 b	1256 b	627 b	5.23 d	7.06 c	148.9 a	74.1 d	5.93 k

Mean values with the same letter (s) in a column do not differ significantly from each other at 5% level by DMRT. nd- not done

The study on the waste water quality near the discharge point of savar tanneries during the dry (February) and wet season (August) revealed that tannery waste water with very low DO level (<5 mg L^{-1}) were found to be added during both seasons into the Dhaleswari river and in future if it continues, no fish and other aquatic life will be found living, up to 500 m downstream around the CETP (Table 1). Many authors (Immamul Huq 1998) [8] reported that a higher amount of waste discharged to the Buriganga river is responsible for the decrease in DO level because of increased microbial activity (respiration).

The test on May 28 (2018) by the Department of Environment (DoE) found that the Biochemical Oxygen Demand (BOD) was as high as 17.6mg per litre against the permissible limit of 5mg; Dissolved Oxygen (DO) was 1.75 mg per litre against the minimum of 5 mg (Dhaka Tribune Dec. 26, 2018) [5].

Heavy Metals Concentration in Water and Effluent Samples at Savar Tannery Area

Chromium (Cr) concentrations in effluent and Water samples (Dry and Wet seasons): Chromium (Cr) concentrations in river water (Figure 1 and 2) and waste water/effluent (Figure 3 and 4) samples at Savar sampling area were ranged from 0.0384 to 18,809.71 and 0.013 and to 37.68 mg L^{-1} respectively, in dry and wet season. Spot/point 1 may be contaminated by various chromium salt that were used in tannery industries or huge amounts of waste water and effluents are now continuously added from CETP (Picture 3) into the Dhaleshwari River (The Daily Star August 03, 2019) [17]. Chromium concentrations in the water samples collected from Dhaleswari river crossed the MAC (Maximum allowable concentration) at savar study area for drinking (0.05 mg kg $^{-1}$) (WHO 2004) [20] (Fig 1) in dry season. In case of wet season samples, Cr concentrations in point no. 1-8, and 11 crossed the MAC (Maximum allowable concentration) at savar study area for drinking (0.05 mg kg^{-1}) (WHO 2004) [20] (Fig 2) and in other points Cr concentrations were below the MAC endorsed by WHO (2004) [20]. The effluent samples also in some sampling points crossed the general standard value for discharge of effluents according to CPCB (1995) [4] (Figure 3 and 4).

Picture 3: Direct Discharge of Partially treated effluents into the Dhaleshwari River (The Daily Star, 2019) [17]

Comparatively lower Chromium (Cr) concentration was observed at the same sampling point in wet season. Significant differences were found among different sampling spots. Chromium (Cr) concentration that was observed in wet season may be occurred due to dilution of chromium (Cr) in water by rainfall (Fig 2).

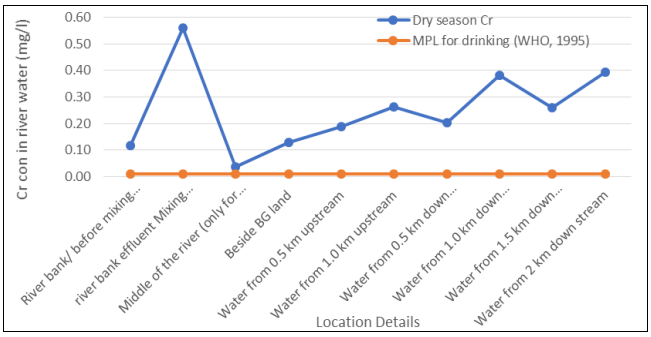


Fig 1: Chromium concentrations in Dhaleshwari river water in dry season

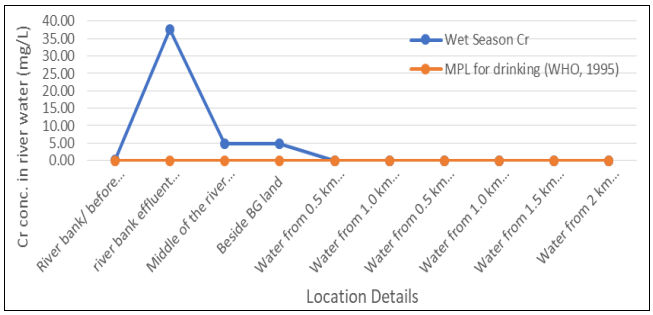


Fig 2: Chromium concentration in Dhaleshwari river water in wet season

Immamul Huq (1998) [8] reported 0.28 ppm Chromium (Cr) concentration in waste water/effluent samples at Hazaribagh area. Similar findings were also reported by Nuruzzaman *et al.* (1998) [13] and Elahi *et al.* (2010) [7]. Chromium (Cr) concentration at 6 sampling points (both dry and wet season) crossed the MAC (Maximum allowable concentration) (at Hazaribagh) for water (0.05 mg kg^{-1}) (WHO 2004) [20] reported by Mondol *et al.* (2017) [11].

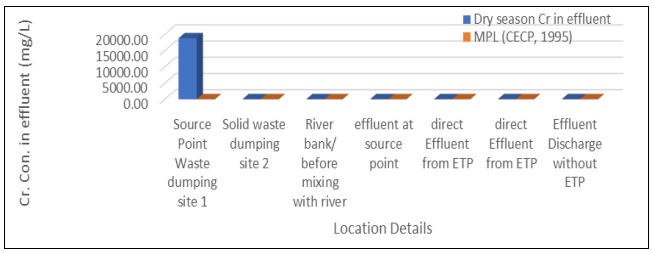


Fig 3: Chromium concentration in effluent samples in dry season

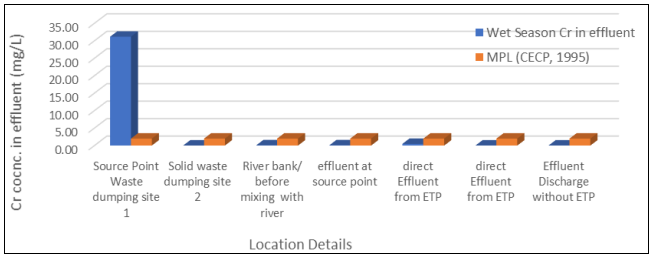


Fig 4: Chromium concentration in effluent samples in wet season

Cadmium (Cd) concentrations in effluent and Water samples (Dry and Wet seasons): Cadmium (Cd) concentrations in water samples from savar sampling area were ranged from 0.00 to 0.0027 mg L^{-1} and 0.005 to 0.035 mg L^{-1} respectively in dry and wet season (Table 3). Cadmium (Cd) concentrations in waste water at savar tannery area in wet season were 0.035 at main disposal point 2 which was significantly different from other spots except few other sampling points and different results were observed in dry season samples collected from the downstream of the river (Table 3). The highest value was observed at point no 7 where tannery effluents are directly mixed with river. The tests of significance of different sampling point were calculated by DMRT at 5% level. Spot 1 may be contaminated by various cadmium salt that were used in tannery industries (Ullah *et al.* 1999) [18].

Cadmium concentration in all samples were below (both dry and wet season) the MAC (Maximum allowable concentration) for drinking water (0.005 mg kg^{-1}) (WHO 2004) [20], as well as the standard value of waste water for in land surface water (2.0 mg L^{-1}) (CPCB 1995) [4].

Table 3: Seasonal variations in Cd, Cu, Ni and Zn concentrations in water and effluent samples.

Point No	Dry Season				Wet Season			
	Cd	Cu	Ni	Zn	Cd	Cu	Ni	Zn
	mg kg^{-1}				mg kg^{-1}			
1	0.00 a	0.50 c	Tr	0.7462 c	0.0028 bcde	0.069 m	0.025 e	0.15
2	0.00 a	0.0575 a	Tr	0.0399 a	0.0035 de	0.011 b	0.077 l	0.00
3	0.00 a	0.02 a	Tr	0.0279 a	0.0032 cde	0.016 e	0.032 f	0.02
4	0.00 a	0.18 b	Tr	0.10 a	0.0026 abcde	0.04 k	0.046 h	0.09
5	0.00 a	0.19 b	Tr	0.036 a	0.001 abc	0.046 l	0.023 d	0.02
6	0.00 a	0.17 b	Tr	0.3195 b	0.002 abcde	0.008 a	0.00 a	0.00
7	0.0027 d	0.03 a	Tr	0.00 a	0.0005 a	0.021 g	0.099 n	0.00
8	0.00 a	0.005 a	Tr	0.039 a	0.0008 ab	0.014 d	0.037 g	0.00
9	0.00 a	0.01 a	Tr	0.1973 a	0.0006 ab	0.016 e	0.077 l	0.00
10	0.00 a	0.16 b	Tr	0.30 b	0.0018 abcde	0.028 j	0.155 o	0.00
11	0.00 a	0.16 b	Tr	0.18 ab	0.001 abc	0.046 l	0.023 d	0.02
12	0.00 a	0.015 a	Tr	0.012 a	0.0032 cde	0.02 f	0.014 c	0.00
13	0.00 a	0.01 a	Tr	0.0714 a	0.0034 e	0.1 n	0.058 i	0.00
14	.0004 b	0.03 a	Tr	0.0172 a	0.0028 bcde	0.012 c	0.012 b	0.00
15	0.00 a	0.01 a	Tr	0.0902 a	0.0028 bcde	0.025 i	0.063 k	0.00
16	0.0018 c	0.01 a	Tr	0.0098 a	0.0023 abcde	0.025 i	0.078 m	0.00
17	0.0004 b	0.00 a	Tr	0.0179 a	0.0013 abcde	0.023 h	0.060 j	0.00

MPL (Max. Permissible Limits)	Cd	Cu	Ni	Zn
Drinking water MPL (mg L^{-1}) (WHO, 1997)	0.01	1.0	0.2**	15.0
Std. for discharge of effluents (mg L^{-1}) (CPCB, 1995) [4]	2.0	3.0	3.0	5.0
Irrigation water MPL (mg/L) (WHO, 1997)	0.0	0.2	0.5	5.0

*WHO, 2004 [20] **Zigham Hassan, 2012

Means followed by same letter (s) in a column do not differ significantly from each other at 5% level by DMRT

Copper (Cu), Nickel and Zinc concentrations in effluent and Water samples (Dry and Wet seasons): Copper, nickel and zinc concentration in all samples were below the MAC (Maximum allowable concentration) for drinking water (1.0, 0.2 and 15.0 mg L^{-1} for Cu, Ni and Zn, respectively) (WHO 1993) [19], as well as the standard value of waste water for in land surface water (3.0, 3.0 and 5.0 mg L^{-1} for Cu, Ni and Zn, respectively) (CPCB 1995) [4] in both dry and wet season (Table 3). Zigzag value of Zn that was observed in dry season may be occurring due to addition of Zn from leather or from other industrial installations (Fig 3). Ullah *et al.* (1999) [18] reported 0.12 mg L^{-1} of Zinc (Zn) concentration in waste water at Hazaribagh area. Similar findings were also reported by Nuruzzaman *et al.* (1998) [13].

Lead (Pb) concentrations in effluent and Water samples (Dry and Wet seasons): Lead (Pb) concentrations in savar tannery sampling area were ranged from 0.00 to 0.04 and 0.00 to 0.05 mg L^{-1} in case of Dhaleshwari river water (Fig 5) and 1.99 and 0.00 to 0.36 mg L^{-1} for effluent/waste water samples, respectively, in dry and wet season (Fig 6).

Lead (Pb) concentrations of waste water, only at the source point at savar tannery area in both seasons i.e., at main disposal point crossed the standard value of effluents for inland surface water (0.1 mg L^{-1}) (CPCB 1995) [4] (Fig 6). No Significant differences were found among other different sampling points. Similar results were also observed in wet season (Fig 6). The tests of significance of different sampling points were calculated by DMRT at 5% level.

Comparatively lower Pb concentration was observed at the same sampling point in wet season may be occurred due to dilution of Pb in water by rainfall. Elahi *et al.* (2010) [7] reported Pd concentration of 0.1023 mg L^{-1} in waste water during dry season at hazaribagh tannery area.

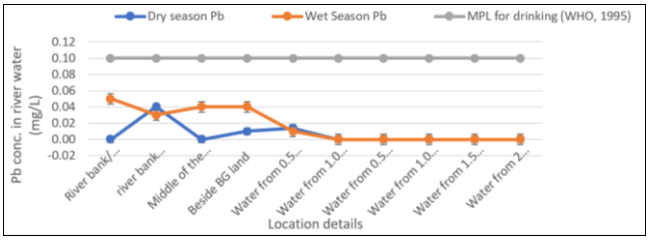


Fig 5: Lead (Pb) concentrations in Dhaleshwari river water samples

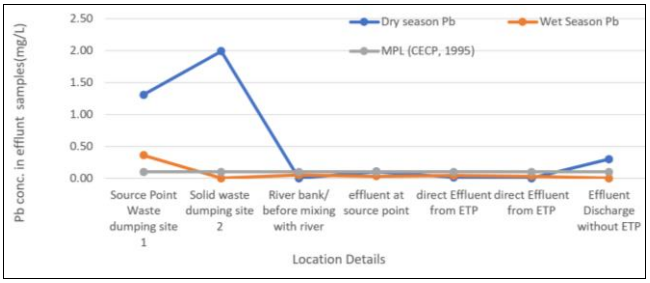


Fig 6: Lead (Pb) concentrations in effluent samples at savar tannery area

High concentration of Pb, Cr and Fe were found also higher than the standard limit at different tannery wastewater canal of Chittagong city in Bangladesh, indicating imperiled state of canal water of the city (Islam *et al.*, 2013).

The dry season had significantly higher metal contamination loads, which were decreased during the monsoon season. Anthropogenic activities, as well as the variation in river water flow during different seasons were the main reasons for this high degree of water pollution of the main rivers around Dhaka city was also reported by Saiful *et al.* (2015) [15] and Islam *et al.* (2015) [9].

Conclusion

In Bangladesh, the tannery industries afflict the river water environment and thus lessen ecological balance. This study has revealed that the tanning activities involve serious environmental hazards. Finally, it could be said that adequate preventive measures should be taken in tannery industrial activities with a view to ensuring safe, sound and healthy environment for the greater benefit of Bangladesh.

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