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Characterization of effluents of leather industries in Hazaribagh area of Dhaka city

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Abstract

This study was conducted at leather industries of Hazaribagh, Dhaka to evaluate the tannery effluent quality. The samples of effluent were taken from seven leather industries and three places around the area of leather industries. The pH, Temperature, Colour, Odour, Electrical Conductivity (EC), Total Dissolved Solid (TDS), Cl^-, NO_2^-, Alkalinity, Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), chromium ion (Cr^{3+}), Suspended Solid (SS), phosphorous, sulphate (SO_4^{2-}) were analyzed .The odour of the samples were more or less pungent. The colour of the samples was blackish blue, violet, brown, black etc. The values of pH, temperature, EC, alkalinity, DO, COD, BOD, Cl^-, Cr^{3+}, SS, TDS, NO_2^-, NO_3^-, phosphorous and SO_4^{2-} of the samples were found in the range of 3.00-9.10, 26.4-30.27 ^oC , 897-1084 µs/cm, 275-1410 mg/L, 0.34-4.10 mg/L, 510-2555 mg/L, 220-1010 mg/L, 820-1930 mg/L, 1.02-20.32 mg/L, 1310-2010 mg/L, 2910-3740 mg/L, 0.74-3.15 mg/L, 6.31-23.49 mg/L, 7.45-9.35 mg/L and 125-510 mg/L respectively.

Keywords: Tannery effluent; Electrical conductivity; Alkalinity; Biological oxygen demand; Total dissolved solid

Introduction

Over the years, large number of polluting industries has developed all over the greater Dhaka area. The tannery industries at Hazaribagh (23º 43´ N, 90º 21´ E), Dhaka, are one of the major polluting industries (Saha and Ali, 2001). Particularly, water pollution of Hazaribagh area has reached alarming level. The situation in Bangladesh demands major thrust in water pollution first. Water pollution refers specially to degradation of water quality as measured by physical, chemical and biological criteria (Keller, 1985).

Hazaribagh tanning industrial zone constitutes 90% of the total 270 tanneries in the country. Various kinds of chemicals are required in different steps of leather manufacturing process for processing good quality leather. Over 95% of all leather manufactured in Bangladesh is chrome tanned. No treatment plant, recycle of chemical and reuse of water system exist in Hazaribagh area. Waste water from the tannery industries typically contains chromium, dissolved lime, hydrogen sulphide, dyes oils, organic matter, suspended solid etc. (Saha and Ali, 2001). The tanning process requires huge amount of chromium powder and liquor (Gain, 2002, Islam *et al*., 2004, Nath *et al*., 2009) especially in the blue green section of the industry. Waste water containing a significance quantity of chromium from the tannery industries is discharged through open drain into waste water pond/lagoon which is finally discharge into river Buriganga and Turag which are major sources of water supply for agricultural, livestock and fishing activities (UNIDO, 2000, Saha JC, 2008). An estimated result reveals that 15800 m^3/day of waste water with a BOD load of 17600 kg/day and high chromium concentration is discharged from the tannery industries at Hazaribagh (BKH, 1995). Bioaccumulation of this heavy metal on human body is numerous such as cancer, brain damage kidney damage etc. (Srinath *et al.,* 2002). But in Bangladesh few research works is done in this field and in some cases proper documentation is also not done. So the objective of this work was to make the pollutants trend slope down to learn the application of suitable technology for environmentally sound and friendly production system. For that reason this study was conducted to evaluate various environmental parameters of effluents such as ionic load, physico-chemical parameters.

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Materials and methods

This study was carried out at Hazaribagh tannery area which is situated in the western side of Dhaka City. Effluent samples were taken from seven industries and three places around the tanneries to analyze different parameters and their contamination level which was discharge to the environment.

Table I. Identification of samples

Sample ID	Name of the Industry
S:1	M/S Mukti Tannery
S:2	Ruma Leather Industry
S:3	Dhaka Skin and Hide Industry
S:4	Jomila Tannery
S:5	Phoenix Leather Industry
S:6	Samina Leather Industry
S:7	Aiub Brother Tannery Ltd.
S:8	Point-1, Gaznabi, Hazaribagh
S:9	Point-2, Gaznabi, Hazaribagh
S:10	Point-3, Beri Badh Channel in Rayerbazar

Sampling

For collecting sample 1000 mL plastic bottles were used. The collection and record keeping procedures were maintained as per standard technique (ASTM D 510). All samples were directly transported to IFRD, BCSIR Dhaka, Bangladesh, in transport box within 4 hours of sample collection. Each sample was given an identification number (Table I). Starting of measurement of different parameters of water by electronic meter was done in the laboratory within 4 hours of sample collection.

Physicochemical Parameters

Physicochemical parameters included pH, TDS, EC, alkalinity, DO, BOD, COD etc. DO was measured by DO meter (Model No. D 8120 Weilheim Oxi 42). EC was measured by digital conductivity meter (Model No. DDS-307) and pH was measured by pH meter (PH 2601). COD was measured by titrimetric method, (75 mL of conc. H_2SO_4 was added to 25 mL of 0.25N $K_2Cr_2O_7$ solutions then reflux it for two hours. The excess dichromate was then titrated with 0.25N ferrous ammonium sulphate solution using phenanthroline ferrous sulphate indicator). BOD was measured by BOD_5 day test (APHA-AWWA-WPCF, 1989). TDS was measured by a digital water quality checker, alkalinity (as bicarbonate) was measured by titrimetric method (100 mL of the sample was titrated with standard 0.143N HCl solution using methyl orange as indicator). Colour and odour was determined by visual observation, temperature was measured by direct reading using thermometer.

Phosphorous was measured by molybdo-vanado phosphoric acid method (ASTM D 515). UV-visible spectrophotometer was used. Absorbance was measured at 400 nm against a reagent blank solution. Cr^{3+} was analyzed by ASTM D1687 method. NO_2^- and NO_3^- was measured by colorimetric method using UV-Visible spectrophotometer at very low pH (2.0-2.5). Absorbance was measured for NO_2^- at 543 nm and for NO_3^- at 220 nm respectively. Cl^- was measured by silver nitrate titrimetric method using potassium chromate as indicator (APHA-AWWA-WPCF, 1989). SO_4^{2-} was estimated by using UV-Visible spectrophotometer after formation of precipitation of $BaSO_4$ (in CH_3COOH medium with $BaCl_2$). Absorbance was measured at 420 nm.

Results and discussion

Table II shows the results of the variations of physical parameters such as colour, odour and temperature of the samples. Colour of the liquid effluent cuts off the sunlight

Table II. Observed physical parameters of different samples of tannery effluents

Sample ID	Colour	Odour	Temperature (°C)
S:1	Blackish blue	Pungent	27.30
S:2	Dark violet	Pungent	26.40
S:3	Black	High Pungent	28.10
S:4	Reddish violet	Pungent	29.20
S:5	Dark violet	Pungent	27.30
S:6	Reddish violet	Pungent	27.10
S:7	Almost brown	High Pungent	28.15
S:8	Blackish blue	High Pungent	29.75
S:9	Blackish blue	High Pungent	30.00
S:10	Black	High Pungent	30.27

required for photosynthesis. The result shows that colour of the effluents of various leather industries of the point sources are dark, navy blue, blackish blue, violet etc. and odour of all of the effluents were more or less pungent. Temperature is basically an important factor for its effects on chemical and biological reaction. From the industrial effluent quality standard for Bangladesh, we find that temperature of the effluent is 40 ^{o}C. Here the temperature of all the effluents were low (Table II) with respect to standard value.

not desirable because it increases density of water and reduces solubility of gases like oxygen. The value of EC (Fig. 3) was found 10840 µs/cm in S:9 which was 9 times higher than standard value (1200 mg/L) for Bangladesh. The highest value of alkalinity (Fig. 4) was found 1410 mg/L in S:9 which was about 5 times higher and the lowest value 275 mg/L was almost 2 times lower than the standard value set by DoE (500 mg/L). Higher or lower value of alkalinity is harmful for aquatic life .The highest value of total SS (Fig.

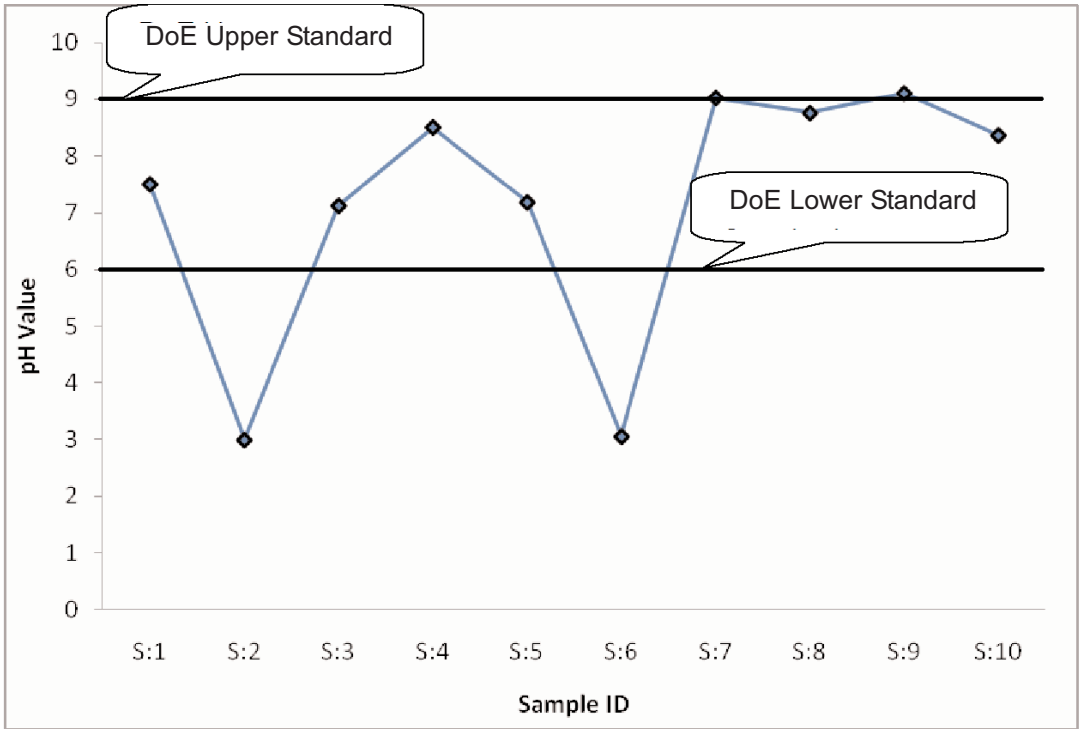

Fig. 1. pH values of different tannery effluent samples vs. DoE standard value

The result of physico-chemical parameters shows that the examined samples contain pH (Fig. 1) in the range of 3.00 to 9.10. Department of Environment (DoE), Bangladesh standard pH value for waste from industrial units or projects is in between 6-9. Most of the samples pH were within the range but S:2 and S:6 were very much lower *i.e.* in acidic state. So these are sensitive for fish and plant life. In this study highest TDS (Fig. 2) value was found 3740 mg/L in sample S:4 which was 1.7 times higher than standard value of industrial waste water permitted by DoE (2100 mg/L) and the lowest TDS value was 2910 mg/L in sample S:1 which was also higher than standard value. High TDS value in the effluent

5) in effluent sample was found 2010 mg/L in the sample S:6 and lowest value was found 1310 mg/L in S:1. Both were very much higher than standard value set by DoE (150-500 mg/L). The highest value of DO (Fig. 6) was found 4.10 mg/L S:1 and lowest value was found 0.34 mg/L in S:5. Both values were lower than standard value permitted by DoE (4.5-8.0 mg/L). Lower value of DO means that oxygen unavailability of oxygen which is a threat to aquatic life. The investigations also reveals that COD (Fig. 7) value was very high 510-2555 mg/L which was very high as compared to standard value set by DoE (200 mg/L for inland surface water and 400 for irrigated land). COD represents chemically

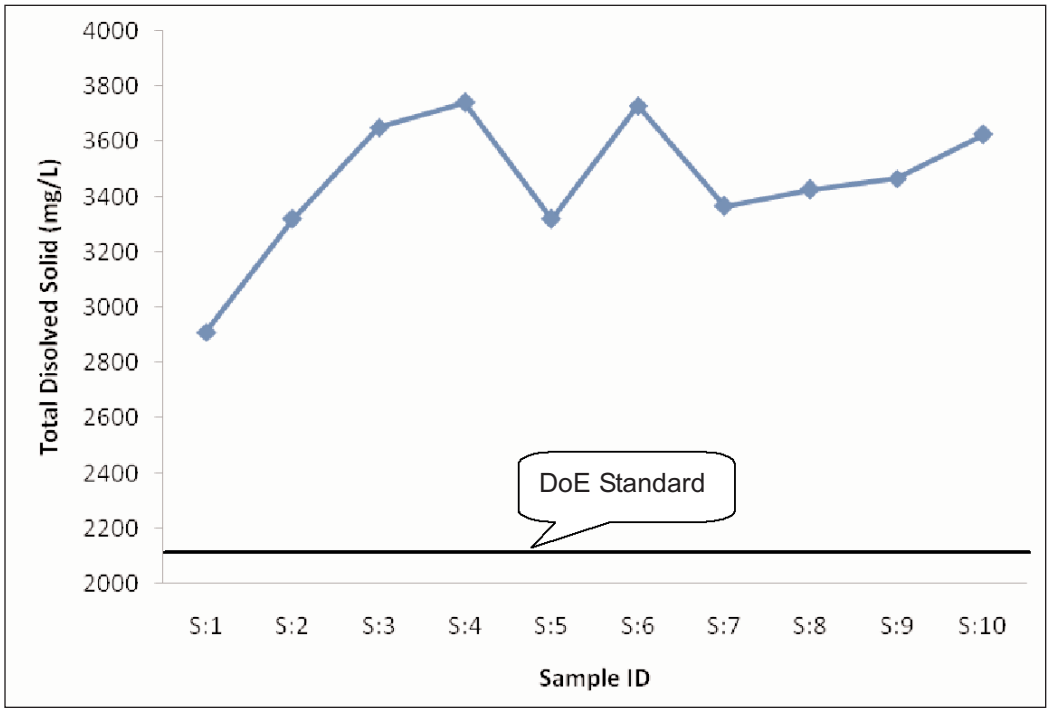

Fig. 2. TDS values of different tannery effluent samples vs. DoE standard value

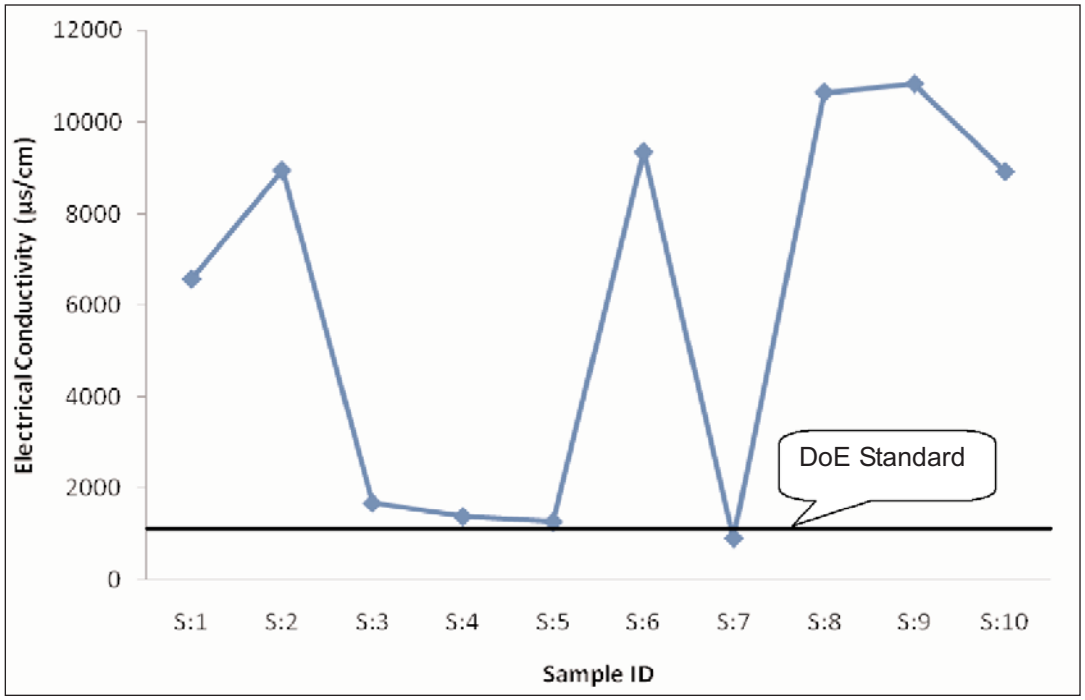

Fig. 3. EC values of different tannery effluent samples vs. DoE standard value

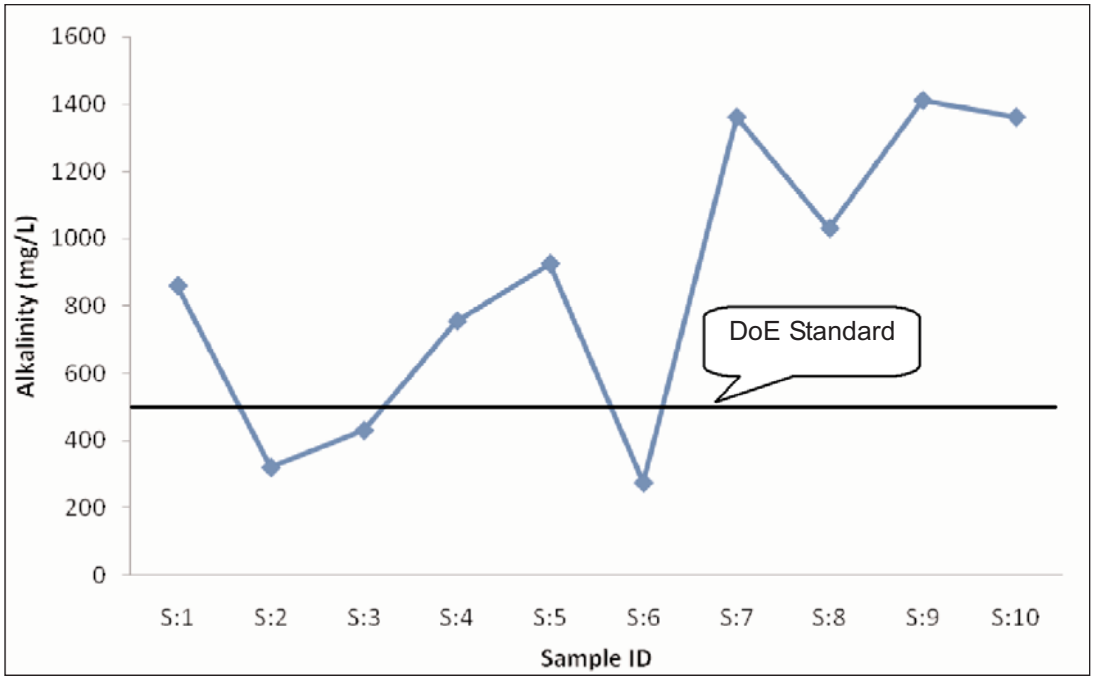

Fig. 4. Alkalinity of different tannery effluent samples vs. DoE standard value

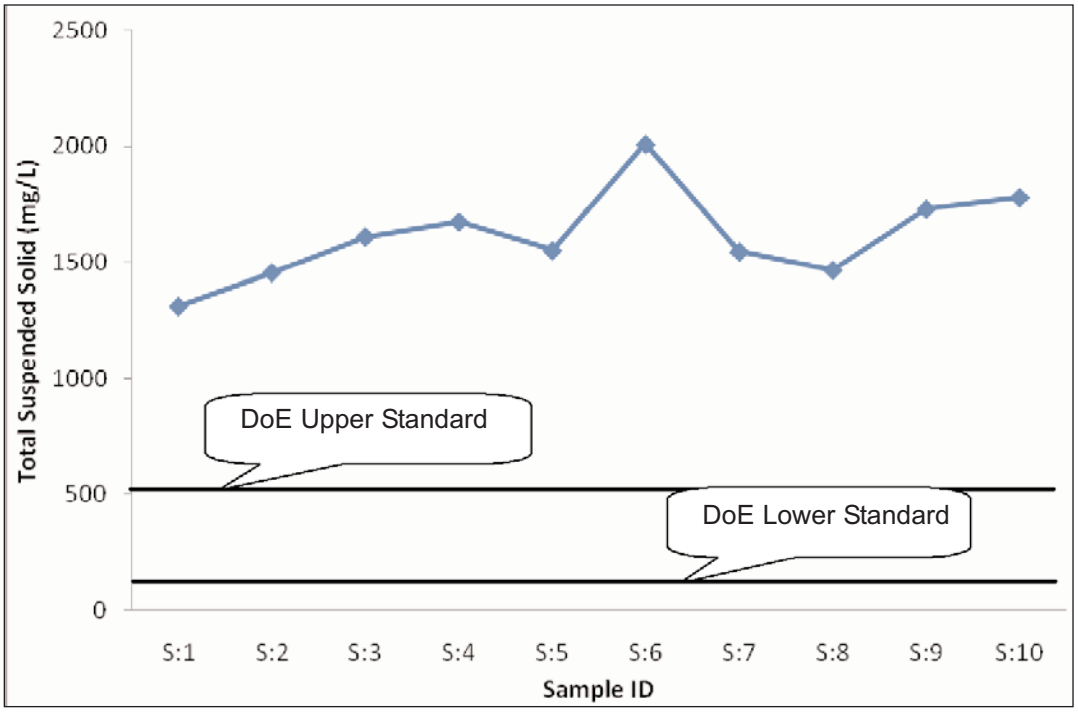

Fig. 5. TSS of different tannery effluent samples vs. DoE standard value

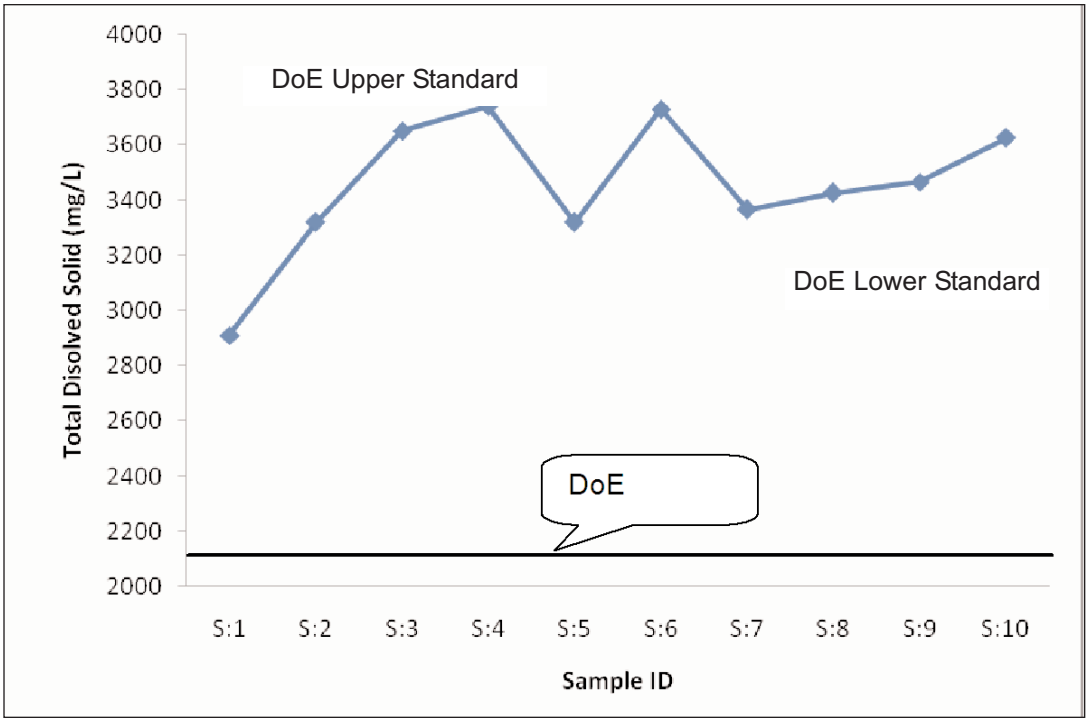

Fig. 6. DO of different tannery effluent samples vs. DoE standard value

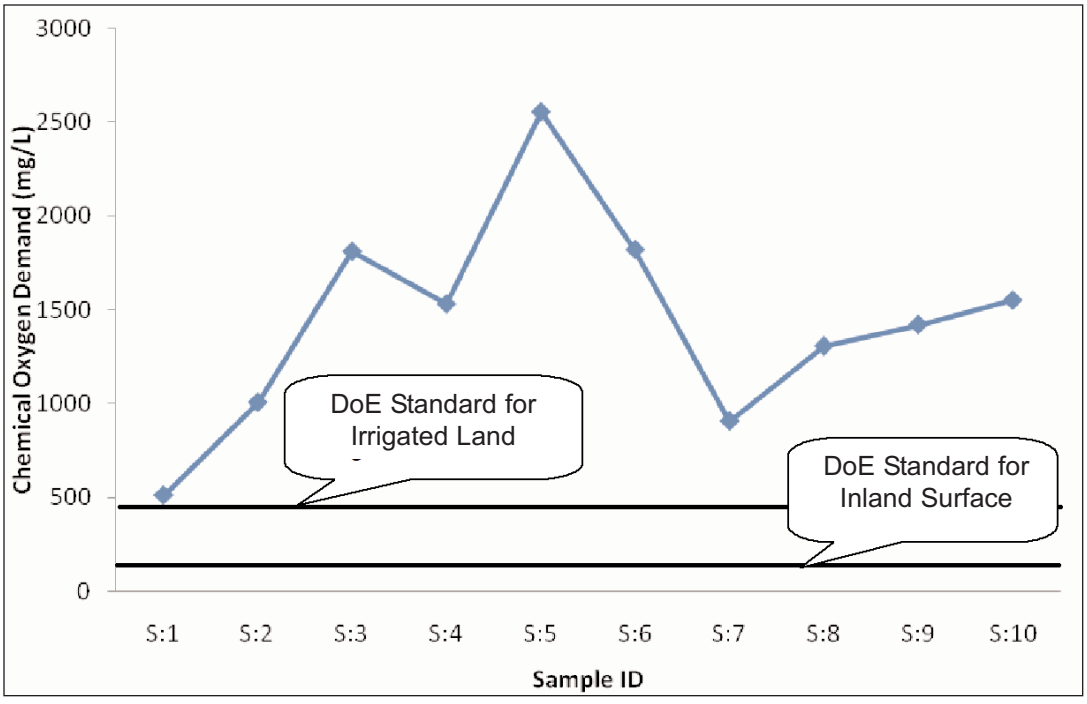

Fig. 7. COD of different tannery effluent samples vs. DoE standard value

oxidizable load of receiving water indicating the high strength of organic matter and low DO. So in the higher COD the aquatic life cannot exist. The investigation also shows that BOD value (Fig. 8) was high. The highest value of BOD was 1010 mg/L in S:5 and lowest BOD value was 220 mg/L in the S:1. The highest value was 4 times higher than standard value permitted by DoE (250 mg/L for public sewerage system connected to treatment at second stage).

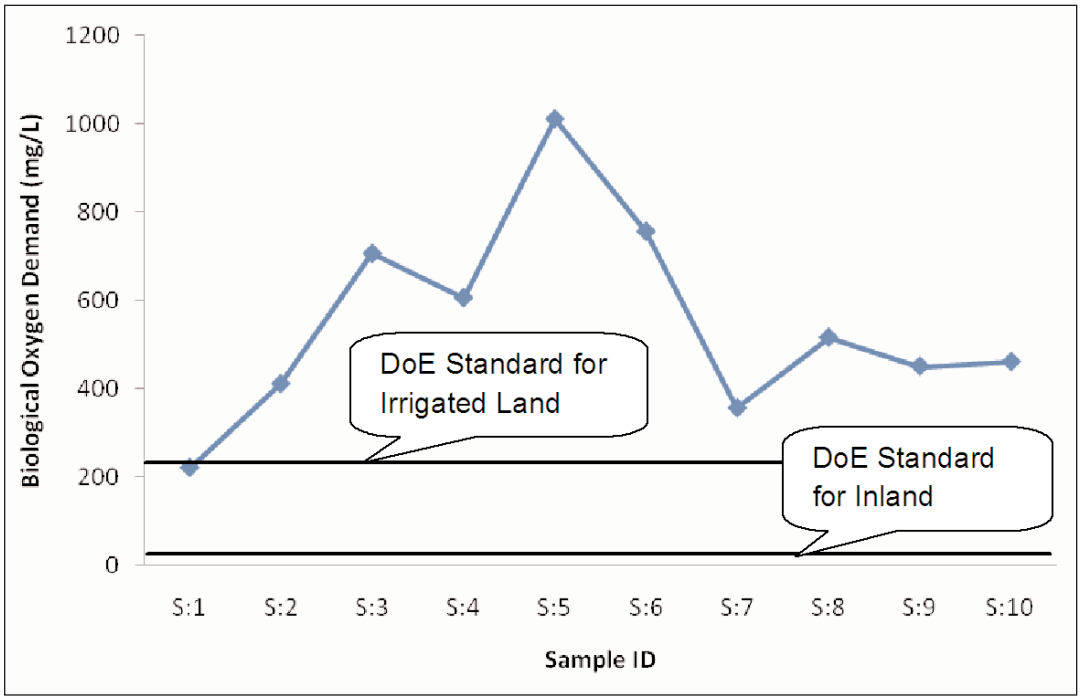

Fig. 8. BOD_5 of different tannery effluent samples vs. DoE standard value

Fig. 9 shows experimental value of Cr^{3+} in the effluent samples. The effluents contain high amount of Cr^{3+} which may sometimes be totally or partially converted into Cr^{6+}. Cr^{6+} is very toxic and carcinogenic. Experimented value shows that all the sample contain high amount of Cr^{3+} specially sample ID S:3, S:5, S:8, S:9 and S:10 contain extremely high amount of Cr^{3+} as compared to standard value of total chromium (0.5 -1.0 mg/L) set by DoE, Bangladesh.

The results of experimented value of phosphorous was 9.35 mg/L (Fig. 10) in sample ID S:5 and the lowest phosphorous value was 7.45 mg/L found in sample S:1. All other sample contains higher value of phosphorous than standard value set by DoE (8.0 mg/L for public sewerage system connected to treatment at second stage). Phosphorous is a nutrient for plant growth. As phosphorous concentration increase, it will increase the algal growth. A massive growth of aquatic plant can change the water quality significantly. The highest value of Cl^- was 1930 mg/L in S:9 and the lowest value was 820 mg/L found in S:6 shows in Fig. 11. Both were higher than the standard value of waste water (600 mg/L) permitted by DoE. Increase in concentration of Cl^- increase the EC of water and increase corrosiveness. The results also show that the highest value of NO_2^- (Fig. 12) was 3.15 mg/L found in S:5 and the lowest value of nitrite was 0.74 mg/L found in S:1. The highest value of NO_3^- (Fig. 13) was found 23.49 mg/L in S:9. Most of the samples contain higher value of NO_3^- than the standard value permitted by DoE (10.00 mg/L). The highest value of SO_4^{2-} (Fig. 14) was found 510 mg/L in S:2 and the lowest value was found 125 mg/L in S:5. Table III shows the average values of pH, temperature, EC, alkalinity, DO, COD, BOD, Cl^-, Cr^{3+}, SS, TDS, NO_2^-, NO_3^-, phosphorous and SO_4^{2-} and the standard values for Bangladesh.

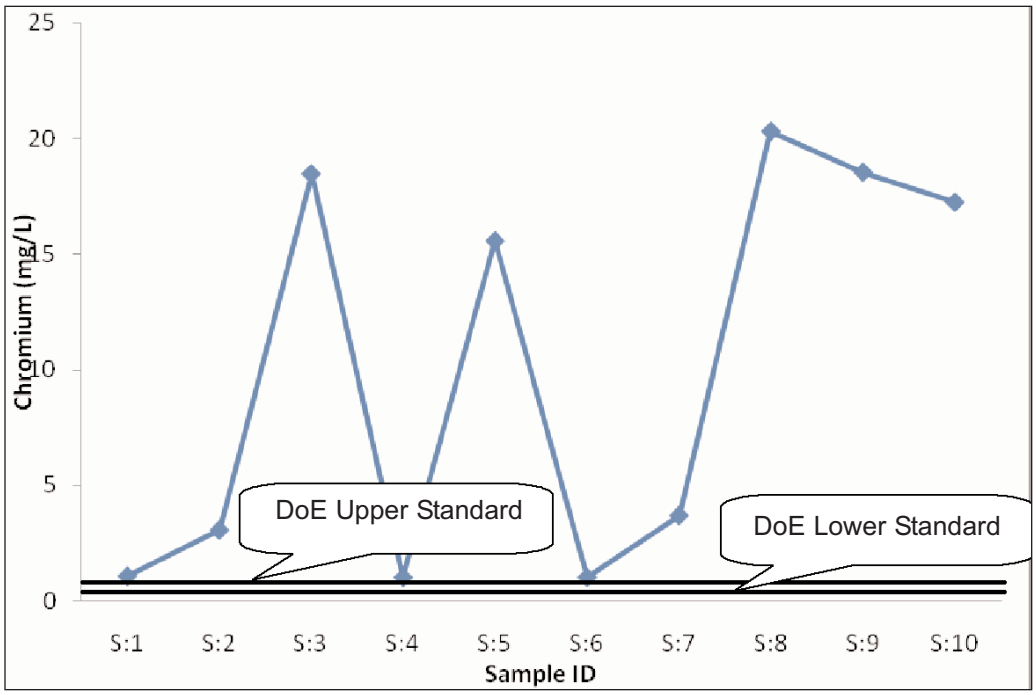

Fig. 9. Chromium of different tannery effluent samples vs. DoE standard value

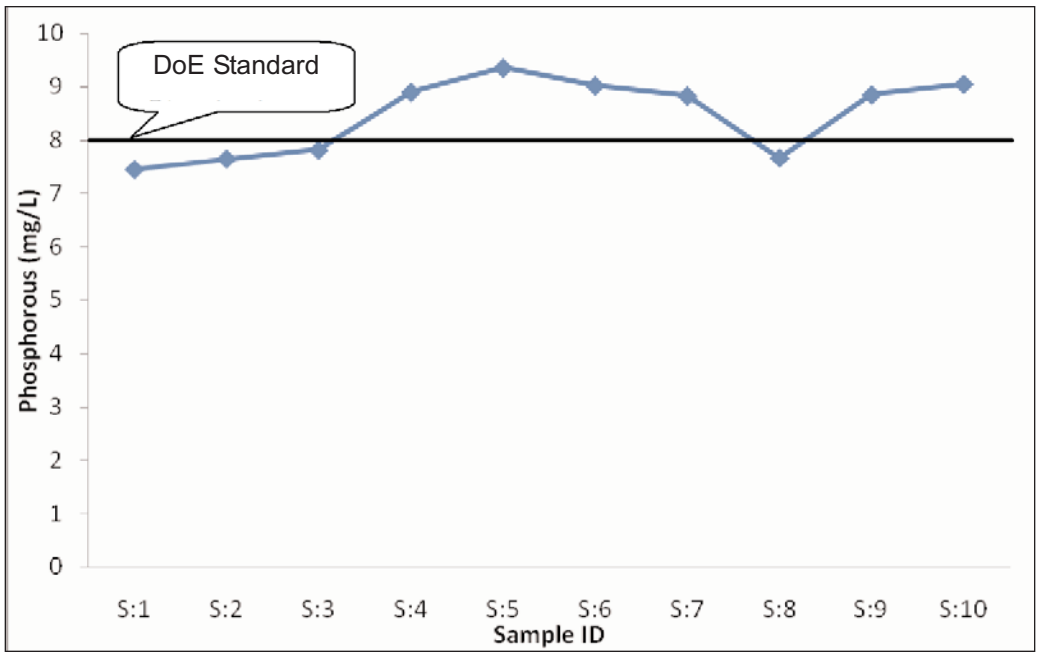

Fig. 10. Phosphorous of different tannery effluent samples vs. DoE standard value

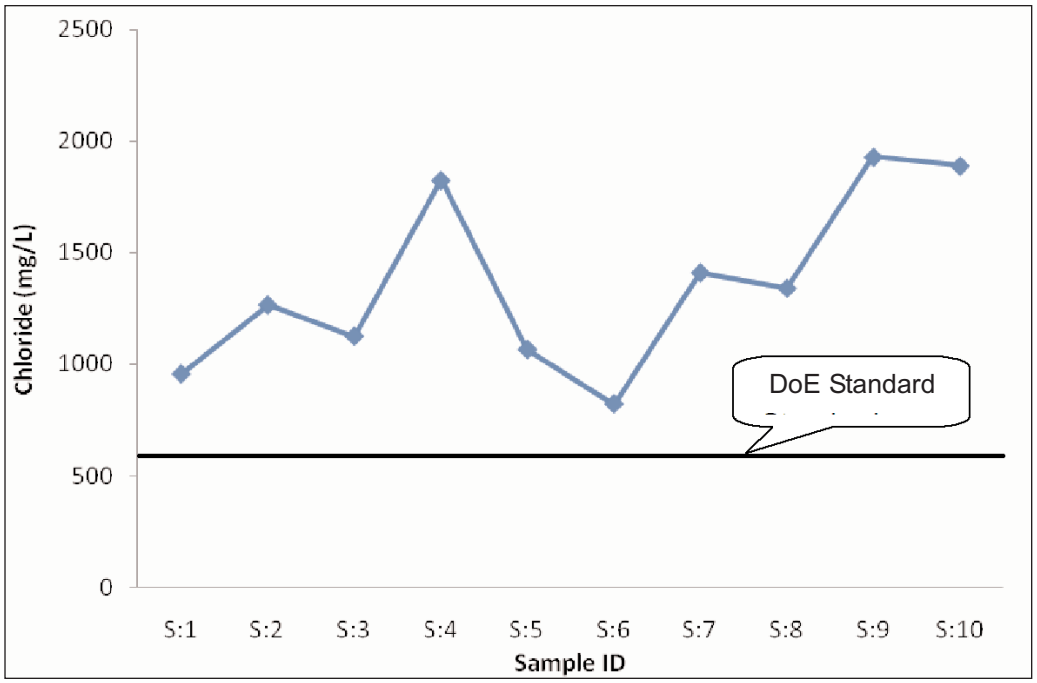

Fig. 11. Chloride of different tannery effluent samples vs. DoE standard value

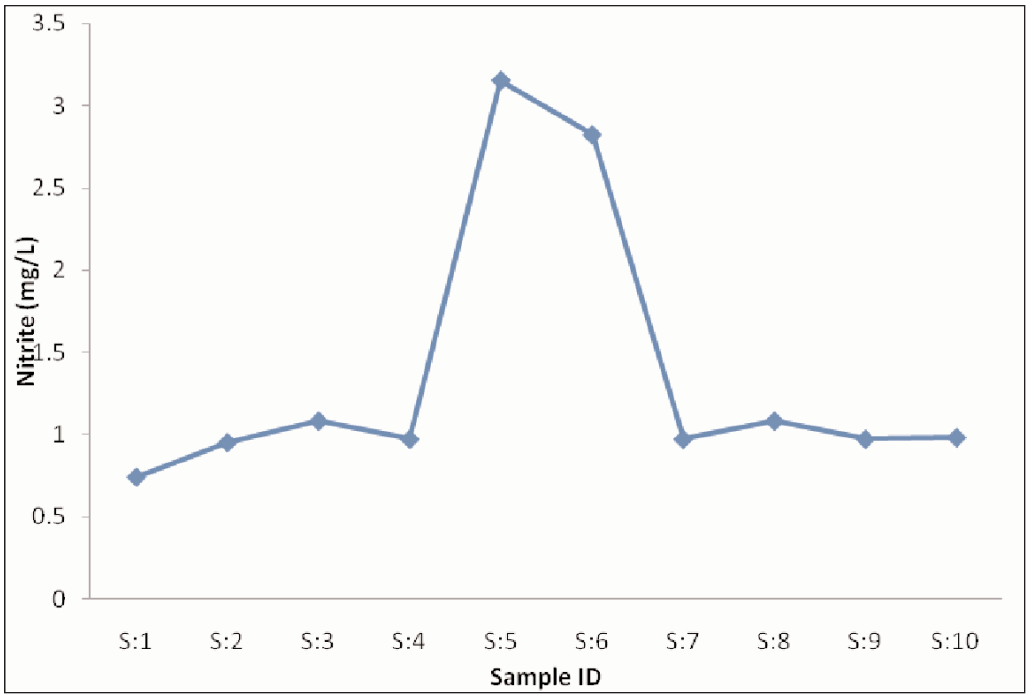

Fig. 12. Nitrite of different tannery effluent samples vs. DoE standard value

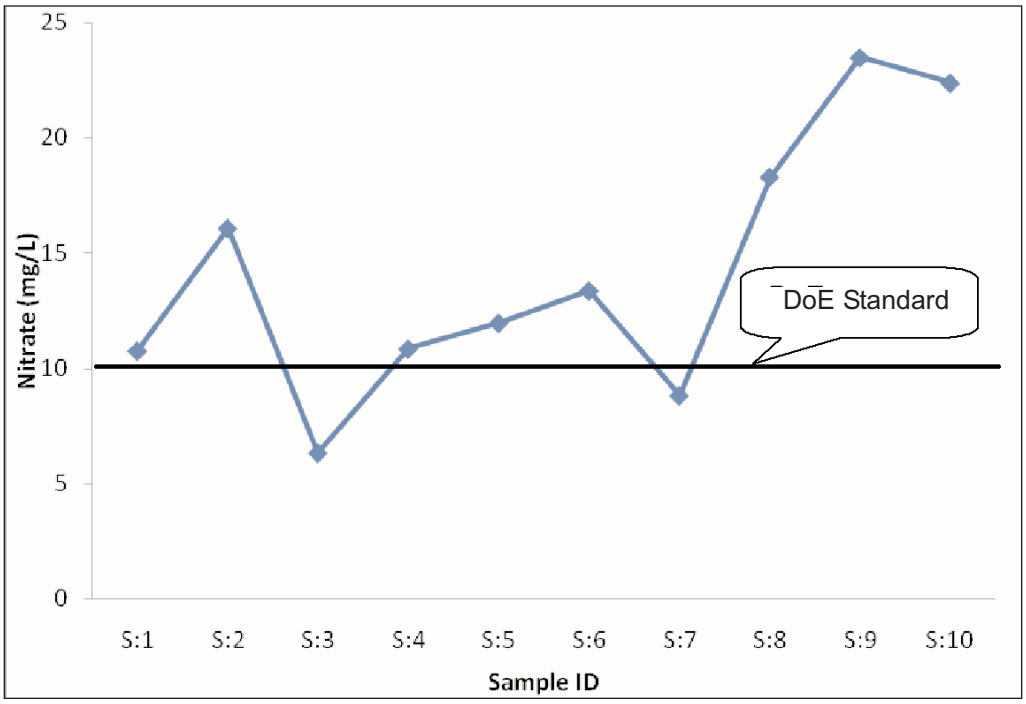

Fig. 13. Nitrate of different tannery effluent samples vs. DoE standard value

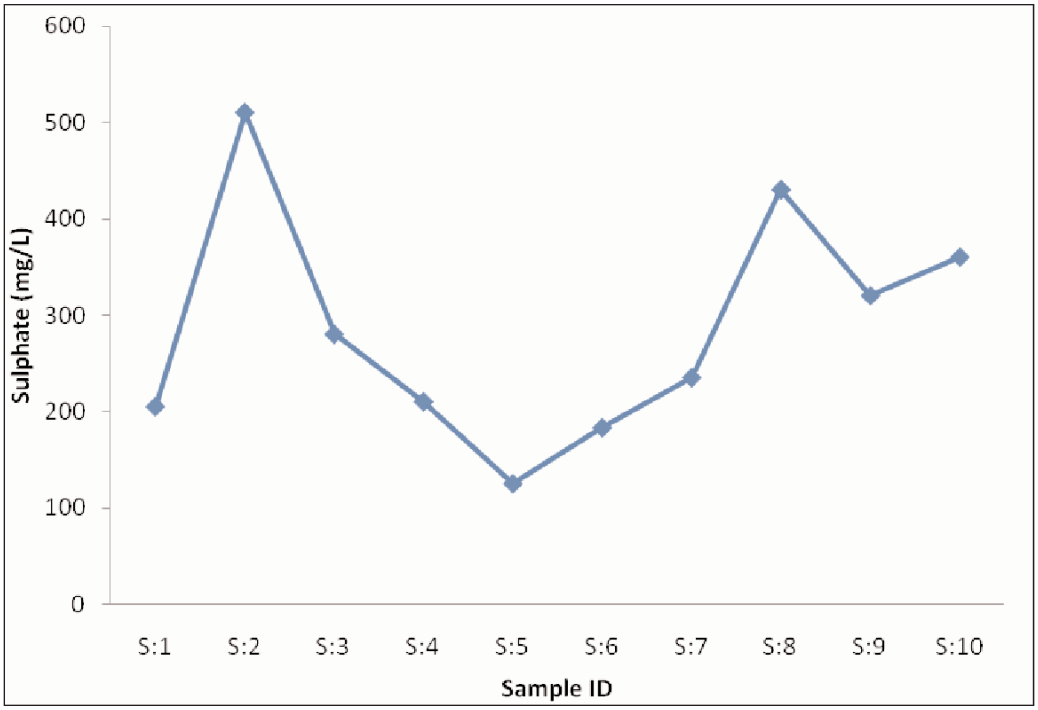

Fig. 14. Sulphate of different tannery effluent samples vs. DoE standard value

Table III. Average experimental value and the standard value for Bangladesh

Parameter	Unit	Experimental average value	Standard value
Temperature	^oC	28.38	40
pH	-	7.16	6-9
EC	µs/cm	6048.40	1200
Alkalinity	mg/L	872.50	500
DO	mg/L	1.74 (4 times lower)	4.5-8
BOD at 20 ^oC	mg/L	548.50	50 (inland surface) - 250 (irrigated land)
COD	mg/L	1441	200 (inland surface) - 400 (irrigated land)
Chromium (total)	mg/L	10.009	0.5-1.0
Phosphorous	mg/L	8.459	8-15
Cl^-	mg/L	1362.60	600
NO_3^-	mg/L	14.23	10
SO_4^{2-}	mg/L	285.80	-
TSS	mg/L	1613	150 - 500
TDS	mg/L	3455	2100
NO_2^-	mg/L	0.98	-

Conclusion

Based on the results of this study it is clear that the tannery effluents at Hazaribagh and the surrounding area are heavily polluted and threatens the environment seriously. Chromium content was found up to 20 times higher and the average value was ten times higher than the standard value. It is clear from the present study that the average values of other water parameters such as pH, EC, alkalinity, DO, BOD, COD, Cl^-, SS, TDS, NO_2^-, NO_3^- phosphorous and SO_4^{2-} are also very high from the national standard value for discharge into surface water bodies. As a result it can be concluded that by these effluents of different tanneries, human life, aquatic life, plant life and the environment are being affected adversely. Lastly we can conclude that the quality of leather effluents should have positive influence on the aquatic ecology of the nearby river and on environment. Therefore, attention should be made to check the quality of the tannery effluents at regular intervals and to take necessary special treatment measures where necessary. Thus it will help to make our environment free from pollution.

References

APHA-AWWA-WPCF (1989), Standard methods for the examination of water and wastewater, American Public Health Association, New York

ASTM D 510 (1988), Methods of Sampling Industrial Water

ASTM D 515 (1982), Test Methods for Phosphorus in Water

ASTM D1687 (1992), Standard Test Methods for Chromium in Water

BKH (1995), BKH Consulting Engineers, Consulting Engineering Services (India) Pvt. Ltd., AQUA Industrial Control Management, Bangladesh, GOB, ADB.

Gain P (2002), Bangladesh Environment: Facing the 21st century, Society for Environment and Human Development (SEHD), Dhaka, Bangladesh.

Islam MS, Chowdhury MTH, Rahman MM and Hossain MA (2004), Urban and peri-urban aquaculture as an immediate source of food fish: Perspectives of

Dhaka City, Bangladesh, *Urban Ecosystems.* **7**: 341-359.

Keller (1985), Pollution and Control in Textile Industry, London Noys Data Corporation.

Nath K, Singh D, Shyam S and Sharma YK (2009), Phytotoxic effects of chromium and tannery effluent on growth and metabolism of Phaseolus mungo Roxb, *J. Environ. Biol*. **30**: 227-234.

Saha GC and Ali MA (2001), Ground water contamination in Dhaka City from Tannery Waste, *Journal of Civil Engineering.* **29**(2): 151-165.

Saha JC (2008), Survay and mapping of environment pollution from industries in greater Dhaka and preparation of strategies for mitigation. 1.

Srinath T, Verma T, Ramteke PW and Garg SK (2002), Chromium (VI) biosorption and bioaccumulation by chromate resistant bacteria, *Chemosphere.* **48**(4): 427-35.

UNIDO (2000), Regional program for pollution control in the tanning industry in South East Asia: Chrome balance in leather processing.

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