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Wastewater Effluent - A Case Study- Part-I

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ABSTRACT

The chromium tannery effluent wastewaters are characterized by high salt and high chromium content. In addition, the organic solids and the organic colloids are highly concentrated.
In the present case-study a medium-size tanning workshop, namely "El-Radio", Cairo-Egypt, was selected for investigation. The collected final wastewater effluent is discharged directly into the domestic sewer-network without any treatment.
The aim of the present work is to apply physico-chemical treatment results which was used previously in phase one in treating the final tannery effluent to chromium tannery wastewater effluent, to evaluate the validity of this procedure in reducing the pollution loads as a pretreatment step prior to the recovery of chromium by using membrane separation technique.
Coarse filtration as pretreatment was carried out, then followed by coagulation by using organic polymers. Three kinds of polymers (nonionic, anionic and cationic) were used.
The pretreatment technique achieved low removal efficiencies in SS, COD,and Cr
The average removal efficiencies for SS, COD and Cr are 13%, 14% and 15% respectively.
The chemical treatment by using 2.5 mg/l. nonionic polymer proved removal of pollution load to a great extent. The average removal efficiencies for SS, COD and Cr are 76% , 60% and 66% respectively.
The obtained results has been discussed evaluated and compared with the maximum national limits given by the Egyptian Environmental Law (Decree No. 44/2000) for the discharge of industrial wastewater into domestic sewerage network.

KEYWORDS:

Chromium effluent, treatment, coagulation, polymer

INTRODUCTION

The leather industry includes several processes. Chromium tanning process is one of these processes which resulted toxic wastewater effluent.

Chromium occurs in liquid wastes in two forms, trivalent (Cr III) and hexavalent (Cr VI). Hexavalent chromium is known to be a carcinogenic substance, while trivalent chromium is simply toxic. Hexavalent chromium is responsible for lung cancer[1,2,3]. The whole population dies at 1 ppm Cr[4]. Chromium also affects adversely air and ground quality[5,6].

For pollution control, the effluent containing chromium must be segregated and should not be allowed to mix with other liquid wastes. This keeps the volume of the waste low. The streams can, however, be mixed after chromium has been removed.

Egyptian tanneries face now a variety of problems. One of the main problems facing the leather industry is the chromium salts lost annually in the disposed final effluent creating money losses as well as environmental degradation due to the disposal of chromium ions.

In the present case-study a medium-size tanning workshop, namely "El-Radio" in Cairo-Egypt, was selected for investigation. The collected wastewater effluent resulted from the different processes is discharged directly into the domestic sewer-network without any treatment.

Previously bench scale experiments for treatment of final effluent streams of El-Radio tannery was carried out[7] where nonionic polymer of 2.5 mg/l reduce the high pollution-load to be within the limits of the biological-treatment process, which is covered by the Egyptian Government

The aim of this paper is to apply physico-chemical treatment technique used previously[7] in treating the final tannery effluent to chromium tannery wastewater effluent, to evaluate the validity of this procedure in reducing the pollution loads as a pretreatment step prior to the recovery of chromium by using membrane separation technique.

PROBLEM DESCRIPTION

In tanning operation in El-Radio tannery, the salted hide is loaded in rotary drum, where 7-12 kg of tertiary chromium powder salt (25% Cr_2O_3) is used per 100 kg of hide. Basifying agent (0.5-2%) is added and drum rotation is continued for 6-8 hours. The total amount of solution in the drum during tanning usually 1.5 times the weight of hide, the chrome solution is added gradually to achieve high efficiency for hide adsorption.
A significant amount of chromium is consumed in the tanning of leather (60-80%). The liquor from the chrome tanning bath is discarded periodically as a drag out solution once its efficiency drops below a certain level.
Chromium occurs in liquid wastes in two forms, trivalent (Cr III) and hexavalent (Cr VI). Hexavalent chromium is known to be a carcinogenic substance, while trivalent chromium is simply toxic.

The chromium available in the wastewater often creates a disposal problem.

WASTEWATER CHARACTERIZATION

Six grab samples were collected from effluent of chrome tanning wastewater for El-Radio Tannery (Two grab samples of sheep-hide tanning and four grab samples of cow-hide tanning) to investigate the characterization of the chromium wastewater.
Samples collection, preservation, and analysis were carried out according to the described standard methods given by the APHA-AWWA-WPC, 1992 [8].
The compiled analytical results of the 6 grab samples are presented in table (1).
The chromium effluents are characterized by high salt and high chromium contents dissolved into weakly to moderately acidic medium. In addition, the organic-solids and organic-colloids are highly concentrated too, and could be estimated in the range of ±19000 mg/l. In brief, the chrome effluent is characterized with high pollution loads from organic and inorganic species.

BENCH SCALE EXPERIMENTAL PROCEDURE

Two grab samples of wastewater chrome effluents were collected in order to cover the necessary sampling program, which include filtration and coagulation experiments. The original samples were analyzed before and after filtration and coagulation experiments in order to examine the removal efficiency of suspended solids, COD, and chromium ion.
For each experiment, a sample volume of 10 liters was filtered on a poly acrylic disc under vacuum. This step removed both solids and floating materials (fats & greases) of particle-diameter larger than 100 micron.
The Jar-test experiments were carried out at different operating conditions, and by using organic coagulants. Commercial available polymers (nonionic, anionic and cationic) were used as organic coagulants.
The organic coagulants were used in the following doses; 0.5, 1.0, 1.5, 2.0, 2.5, 3.0 mg/l.
The samples were stirred vigorously to obtain a homogeneous medium, then a volume of 800 ml portion was taken in each of the 6 jar-test containers, and stirred at the maximum speed (120 rpm) during the addition of coagulant doses. All following results were corrected to the 1000-ml volume, normalized for sample density, and expressed in mg/l (= ppm wt/volume). After dosing, the stirring-speed was reduced to 100 rpm for 10 minutes, and then reduced again to 20 rpm for twenty minutes. Finally, the solution left to settle for 30 minutes without stirring. The sludge-volume was recorded by means of a graduated Imhof-cone for the nearest 0.1 ml, then drained, filtered, dried and weighted.

RESULTS AND DISCUSSION OF TREATMENT EXPERIMENTS

The experimental results of coarse filtration and chemical treatment for El-Radio by using organic coagulants are given in Tables 2,3 .
Table 4 summarizes the removal efficiencies after coarse filtration and the optimum doses of the used coagulants, as well as their respective removal efficiencies of SS, COD and chromium ion for both tanneries.

From coarse filtration the average removal efficiencies are (SS = 13%, COD= 14%, Cr= 15%).

From coagulation treatment, the highest mean recorded removal efficiencies (SS = 76%, COD= 60%, Cr=66 %) gained by the nonionic-polymer with 2.5 mg/l dose. The second in order was achieved by the cationic-polymer (SS = 48%, COD= 44%, Cr=38%) with a dose of 2.0 mg/l. The third in order was achieved by the anionic-polymer (SS = 33%, COD= 15%, Cr=20%) with a dose of 2.5 mg/l.

The compiled results of coarse filtration and coagulation are presented in Table 5 are still higher when we compared these results with the maximum national limits given by the Egyptian Environmental Law (Decree No. 09/1989 modified to Decree No. 44/2000) for the discharge of industrial wastewater into domestic sewerage network.

CONCLUSION

The final obtained results for chromium waste effluent (SS,COD,and Cr)are still higher as presented in tables, when we compared these results with the maximum national limits given by the Egyptian Environmental Law (Decree No. 09/1989 which modified to Decree No. 44/2000) for the discharge of industrial wastewater into domestic sewerage network.
So advanced treatment by using membrane separation to recover chrome is necessary.

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Table 1: Compiled Analytical Results of Chromium Effluents, For El-Radio Tannery

ser	Parameter	Batch-A	Batch-B	Batch-C	Batch-D	Batch-E	Batch-F	Mean	Decree No. 44/2000
01	Color	Green	Green	Green	Green	Green	Green	Green	43
02	pH - Value	5.0	3.8	3.5	4.1	5.0	5.0	4.6	6-9.5
03	Oil & Grease, mg/l	74	83	613	75	674	121	273	100
04	BOD-5, mg/l	48	62	79	12	23	46	45	600
05	COD, mg/l	10482	3617	9987	8625	11928	10139	9130	1100
06	Suspended Solids (S S), mg/l	945	712	1429	1214	2479	1637	1403	800
07	Volatile Suspended Solids (VSS), mg/l	1050	438	1213	917	1851	1179	1108	---
08	settleable Solids	42	12	16	11	12	10	17	8 in 10 min. 15 in 30 min.
09	Total Dissolved Solids (TDS), mg/l	50959	44541	44981	52551	68105	51316	52076	
10	Total Kjeldahl Nitrogen (TKN), mg/l	137	42	181	142	84	112	116	100
11	Sodium Ion (Na), mg/l	14358	12678	15018	15983	24139	15088	16211	
12	Calcium ion (Ca), mg/l	19	38	26	43	29	36	32	
13	Total Phosphate Ion (PO_4), mg/l	0.6	0.8	0.4	0.9	0.6	0.9	0.7	
14	Chromium Ion (Cr^6), mg/l	587	251	1966	1834	2321	612	1262	T.H.M <5mg/l.
15	Sulphide Ion (S), mg/l	76	81	51	58	64	48	63	

Table 2 : Bench-Scale Results of SS, COD and Cr Removal Efficiency After Filtration and coagulation For Chrome Effluent- El-Radio Tannery- RUN # I

Initial pH value	S.S Initial influent Mg/l	S.S after filtration mg/l	S.S Removal %	COD Initial influent mg/l	COD after filtration mg/l	COD Removal %	Cr^{6+} Initial influent mg/l	Cr^{6+} after filtration mg/l	Cr^{6+} Removal %
3.83	12950	11073	14.00	7467	6250	16.30	1452	1202	17.20

ANIONIC POLYMER

Dose, mg/l	S.S mg/l	S.S Removal %	COD mg/l	COD Removal %	Cr^{6+} mg/l	Cr^{6+} Removal %
0.5	8610	22.24	6109	2.25	1152	4.16
1.0	7690	30.55	5988	4.19	1103	8.24
1.5	7003	36.76	5800	7.20	1055	12.23
2.0	6784	38.73	5699	8.82	999	16.89
2.5	6746	39.08	5618	10.11	956	20.49
3.0	7310	33.98	6010	3.84	1010	15.97

CATIONIC POLYMER

Dose, mg/l	S.S mg/l	S.S Removal %	COD mg/l	COD Removal %	Cr^{6+} mg/l	Cr^{6+} Removal %
0.5	8000	27.75	5811	7.02	1101	8.40
1.0	6520	41.12	5519	11.70	1012	15.81
1.5	6050	45.36	4998	20.03	956	20.47
2.0	*5883*	*46.87*	*4510*	*27.84*	*882*	26.62
2.5	5087	54.06	3875	38.00	835	30.52
3.0	6249	43.57	4239	32.18	905	24.71

NONIONIC POLYMER

Dose, mg/l	S.S mg/l	S.S Removal %	COD mg/l	COD Removal %	Cr^{6+} mg/l	Cr^{6+} Removal %
0.5	7511	32.17	5622	10.05	942	21.80
1.0	5978	46.01	5109	18.26	790	34.28
1.5	5019	54.67	4500	28.00	620	48.42
2.0	4401	60.25	3990	36.16	549	54.33
2.5	3174	71.33	3350	46.40	413	65.61
3.0	5841	47.25	3600	42.40	485	59.65

Table 3 : Bench-Scale Results of SS, COD and Cr Removal Efficiency After Filtration and coagulation For Chrome Effluent- El-Radio Tannery-RUN # II

Initial pH value	S.S Initial influent Mg/l	S.S after filtration mg/l	S.S Removal %	COD Initial influent mg/l	COD after filtration mg/l	COD Removal %	Cr^{6+} Initial influent mg/l	Cr^{6+} after filtration mg/l	Cr^{6+} Removal %
3.48	15400	11600	12.01	6250	5508	11.87	83	72	13.25

ANIONIC POLYMER

Dose, mg/l	S.S mg/l	S.S Removal %	COD mg/l	COD Removal %	Cr^{6+} mg/l	Cr^{6+} Removal %
0.5	10880	6.21	5250	4.68	69.1	4.03
1.0	10090	13.02	5100	7.41	65.3	9.31
1.5	9410	18.88	4800	12.85	62.2	13.61
2.0	8987	22.53	4650	15.56	59.1	17.92
2.5	8584	26.10	4461	19.01	56.8	20.09
3.0	8811	24.04	4750	13.76	63.2	12.22

CATIONIC POLYMER

Dose, mg/l	S.S mg/l	S.S Removal %	COD mg/l	COD Removal %	Cr^{6+} mg/l	Cr^{6+} Removal %
0.5	10111	12.84	4910	10.86	64.30	10.69
1.0	8812	24.03	4408	19.97	56.20	21.94
1.5	7911	31.80	3843	30.23	51.70	28.19
2.0	7212	37.83	3408	38.13	44.10	38.75
2.5	6844	41.00	2807	49.00	39.60	45.00
3.0	7561	34.82	3101	43.70	50.20	30.28

NONIONIC POLYMER

Dose, mg/l	S.S mg/l	S.S Removal %	COD mg/l	COD Removal %	Cr^{6+} mg/l	Cr^{6+} Removal %
0.5	9911	14.56	4519	17.96	61.01	10.99
1.0	8998	22.43	3608	34.50	51.21	28.88
1.5	6503	43.94	2750	50.07	41.00	43.06
2.0	4655	59.87	1910	65.32	32.01	55.56
2.5	2204	81.00	1487	73.00	24.90	65.42
3.0	3051	73.70	1520	72.40	36.11	49.85

Table 4 Summary of the Bench Scale Experiments For El-Radio Tannery Chromium Wastewater Effluent.

Coagulant & parameter	RUN #I	RUN # II	Mean
Removal Efficiency after coarse filtration:			
SS, %	14.50	12.01	13.26
COD, %	16.3	11.87	14.09
Cr^{6+}, %	17.2	13.25	15.23
Anionic Polymer Coagulant Optimum Dose, 2.5 mg/l			
SS removed, %	39.08	26.10	32.59
COD removed, %	10.11	19.01	14.56
Cr^{6+} removed, %	20.49	20.09	20.29
Cationic Polymer Coagulant Optimum Dose, 2.0 mg/l			
SS removed, %	54.06	41.00	47.53
COD removed, %	38.00	49.00	43.50
Cr^{6+} removed, %	30.52	45.00	37.76
Nonionic Polymer Coagulant Optimum Dose, 2.5 mg/l			
SS removed, %	71.33	81.00	76.17
COD removed, %	46.40	73.00	59.70
Cr^{6+} removed, %	65.61	65.42	65.52

Table 5 : Compiled Results of the Physico- Chemical Treatment.

Parameter	Run # I	Run # II	Average	National Limits
S S, mg/l.				**800 mg/l.**
Initial	12950	11600	12275	
After Treatment	3147	2204	2689	
COD, mg/l.				**1100 mg/l.**
Initial	7467	5508	6488	
After Treatment	3350	1487	1633	
Cr, mg/l.				**T.H.M <5mg/l.**
Initial	1425	72	762	
After Treatment	413	25	219	