

Treatment of Electroplating Effluent

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(Receive 17th April 2007, revised 8th June 2007)

Summary: Effluent samples were collected from electroplating industry at Kot lakhpat Lahore. The samples were physically and chemically analyzed for different parameters and metals concentrations. The concentrations of all metals including chromium, cadmium, nickel, manganese and iron were higher than threshold limit. Chromium is environmentally hazardous and carcinogenic. The electroplating effluent with high Chromium concentration has been treated through chemical precipitation (CP). The treatment of chromium is pH dependent. The experiment results showed that CP process has successfully eliminated chromium from electroplating effluent. The percentage removal is 95 % chromium leaving less than 0.10mg/ L Cr (VI) in filtrate.

Introduction

Our industries are one of the main culprits to pollute environment by discharging their effluents without any prior treatment. Probably, that is the reason why Pakistan has been declared as "polluter's paradise" [1]. Among all industries electroplating industries are actively participating in degrading the environment. In Pakistan a number of large and small electroplating units are working. Several chemicals are used in electroplating processes and are being discharged untreated effluent rich in metals like Chromium, Zinc, Copper, Cobalt, and Iron etc. All of these substances used in electroplating processes are either acidic or alkali solutions with very high and low pH, toxic metals and solvents present in the waste water either come through rinsing of the product or from spillage and dumping of process bath. No serious attention has been paid so far towards electroplating wastes only by throwing them into nearby water channels, to poison the land areas and affecting the health of local habitants. Some people had also complained of reduced crop yields irrigated with industrial effluent [2]. A report had indicated that the land irrigated with industrial effluent made the soil unproductive with no vegetation.

Accidental and deliberate releases of chromium especially hexavalent to streams and municipal waste treatment plants have shown catastrophic results [3]. It is necessary to reduce the toxicity of hexavalent chromium. Numerous methods are available in literature for treatment of Chromium in wastewater [4-5]. Activated Carbon has been used for the recovery of Chromium from

industrial effluent [6]. In another method, metals were chemically precipitated prior to discharge [7]. Chemical precipitation has proven to be one of the most effective ways of removing heavy metals from Industrial waste water [8-9]. In this study a simple method has been used to treat electroplating effluent which meets the effluent guidelines. For the purpose model experiments were conducted and designed in the laboratory.

Results and Discussion

Characterization of Effluent

The data in Table -1 shows the chemical analysis of electroplating effluent. The parameters studied were compared with National Environmental Quality Standards (NEQs) [10]. This study has pointed out that the concentration of metals was significantly higher than the threshold limits [10]. Chromium concentration was 22.0 mg/ L in selected untreated effluent. Chromium was taken as target metal for treatment process. Synthetic solution (1), containing same chromium concentration was also run along with sample solution (2). Characteristics of synthetic wastewater before and after treatment are illustrated in Table-2.

Treatment of Effluent

Generally in chrome plating chromium is present as chromates, dichromates and chromic acid. The hexavalent chromium ions in waste are highly toxic and need to be almost completely removed before discharge to the environment. The

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Table-1: Characteristics of Electroplating Waste Water before Treatment.

Sr. No.	Parameters	E-I	E-II	E-III	NEQS
1.	Colour	Light Green	Sea Green	Yellowish Green	-
2.	Conductivity (us)	2660	6250	7650	-
3.	pH	6.49	4.50	5.20	6-10
4.	Temperature C°	30.7	30.0	29.5	40
5.	Cadmium (mg/ L)	0.51	0.10	0.31	0.1
6.	Chromium (mg/ L)	30.0	22.0	40.0	1.0
7.	Iron (mg/ L)	1.50	2.35	1.96	2.0
8.	Manganese (mg/ L)	2.0	1.0	1.50	1.50
9.	Nickel (mg/ L)	95.0	82.5	80.0	1.0

most effective and economical way of treatment involves reduction of hexavalent to trivalent state and subsequent precipitation with an alkali. Reduction to trivalent chromium takes place most effectively in acidic solution. Ferrous ions were used to reduce chromate quantitatively in acidic solution. Fig. 1 illustrates the sequence of steps involved in the treatment process.

Experiments were conducted to study the effect of pH on the reduction of Cr (VI). pH was kept as variable. The pH of solution (1) and (2) were varied at 2, 3, 4, 5, and 6 with H₂SO₄. The reduction of chromium was investigated by the adding of reducing agent at each pH. Fig. 2. shows that the reduction of Cr (VI) increased with decreasing pH and then remained nearly stable at pH 7. It was observed that at pH 2.0 the reduction was fast and completed. However at pH values above 3.0, the reaction rate was markedly slow.

FeSO₄ was used as reducing agent, available from pickling waste Fe (II) reacts with chromates by reducing the chromium to trivalent state and Fe (II) ions are oxidized to Fe (III). The concentration of FeSO₄ was gradually increased to investigate its effect on the reduction of Cr (VI). After each addition of ferrous sulphate the presence of Cr⁺⁶ was determined with diphenylcabazide [11]. 1 mg of Cr requires 16 mg FeSO₄ based on stoichiometry. 1475.96 mg/ L was added for complete reduction, now chromium was present in

+3 state. More addition of FeSO₄ made no change. The reaction remained stable when it reached the equilibrium.

Chromium in + 6 state is highly toxic even in very low concentration. The reduction in valence also reduces the associated toxicity by a factor of 1000 [12]. After reduction the metal was removed by pH adjustment and precipitation and subsequently removal of insoluble hydroxides. In this treatment procedure, the metal was removed with 20 % liquid sodium hydroxide. The reduced trivalent Cr is precipitated individually or in combination with other metals. In actual there is strong tendency of metal ions to co precipitates as hydroxides. The effect of pH on removal of metal by precipitation with sodium hydroxide was also studied as shown in Fig. 3. pH range from 9.0 to 10.5 does not effect the removal efficiencies of chromium, so pH was only raised up to 9.0 and the clear upper layer after settling was ready to discharge and no pH adjustment was required.

The pH of solutions (1) and (2) were raised to 9.0 with liquid caustic. Then solution (1) and (2) were mixed at 20 rpm for 30 minutes. Both solutions (1) and (2) were allowed to settle overnight. The supernatant from the two solutions were then analyzed for the concentration of Chromium indicated in Table-2. In treated effluent it was noted that removal efficiency was 95 % for this chemical treatment.

Experimental

A sample in bulk quantity was collected five times from the electroplating industry situated at Kot Lakhpat Lahore in a 30 liter container. The pH was measured at site using Crison Micro pH meter. Before treatment, the effluent was analyzed by using Standard methods [11]. In all experiments, the Chromium concentration was measured by calorimetric technique. The chromium was

Table-2: Chromium concentration in collected and synthetic wastewater before and after treatment.

Parameter	Waste Water		Synthetic Waste Water	
	Before Treatment	After Treatment	Before Treatment	After Treatment
pH	6.50	9.09	2.0*	9.05
Chromium (mg/ L)	22.0 ± 0.05	< 0.1	22.0 ± 0.01	< 0.1

*Remark: pH of synthetic chromium (VI) solution before treatment adjusted with H₂SO₄.

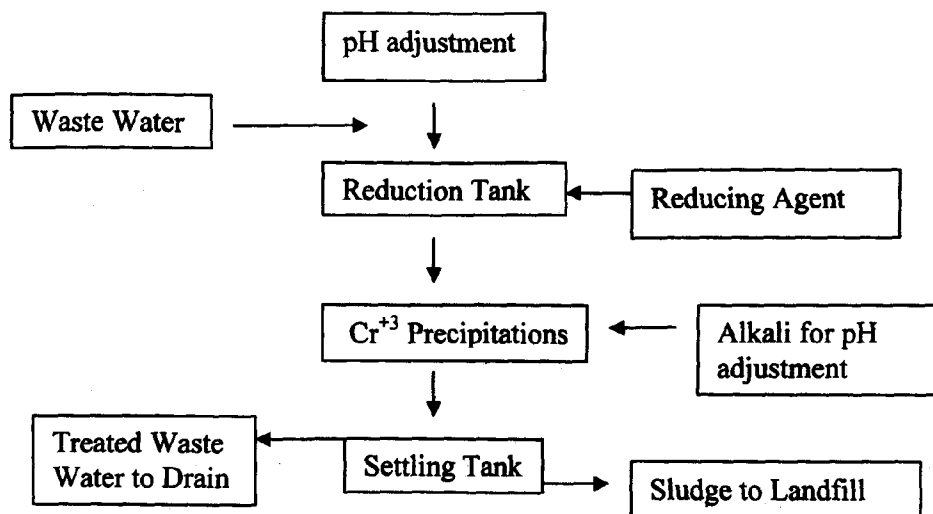


Fig. 1. Schematic treatment system of chromium containing wastewater.

complexed with a solution of 1, 5, diphenylcarbazide (DIPC) in acetone, acidified and then read spectrophotometrically at 540 nm. A synthetic solution with concentration 22 mg/L was prepared with sodium dichromate (Fluka Co., Ltd.). All chemical reagents were analytical reagent grade.

The electroplating effluent and prepared synthetic solution were subjected to different treatment steps. A flow schematic of proposed treatment system is shown in Fig. 1.

Batch experiments were carried out in the laboratory to evaluate the removal efficiency of Cr (VI) by chemical precipitation.

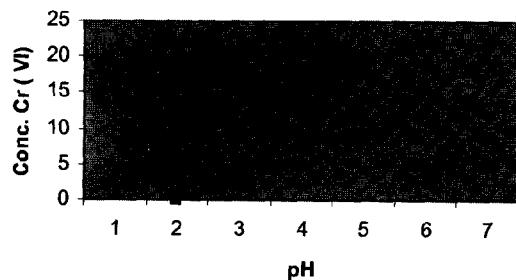


Fig. 2 The effect of pH on hexavalent chromium concentration.

The pH of the sample and synthetic solution was adjusted at pH 2 with 96 % H₂SO₄. At this pH the reducing agent (ferrous sulphate) was added gradually into sample as well as in synthetic solution and stirred with magnetic stirrer for rapid mixing at 90 rpm for 30 seconds. The concentration of chromate remaining was determined using diphenylcarbazide method [11]. If chromates present the addition of reducing agent followed by stirring the solutions will be done again. A 1475.96 mg/L Concentration of FeSO₄ was added to sample and synthetic solution. When the chromium was totally reduced, the reduced trivalent chromium was precipitated along with other metals by the addition of 20 % sodium hydroxide. So the pH of both sample and synthetic solution was

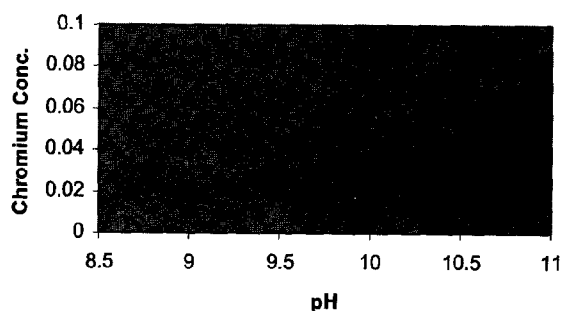


Fig.3. The effect of pH on removal of chromium metal.

raised. Both sample and synthetic solutions were stirred again. After stirring, the contents were allowed to settle overnight. The clear upper layer and settled precipitates were observed for metal concentration. The supernatant was separated and analyzed for Chromium. Results indicated in Table-2, which are comparable to National effluent guild lines.

Conclusion

Electroplating effluent was characterized for metal concentration to be discharged into water bodies. The results have indicated that metal concentrations loading are very high. On the basis of laboratory scale studies, the extent of pollution due to electroplating effluent was decreased and an economical and feasible method of treatment has been developed. This method is based on pH adjustment, reduction, precipitation, settling and removal of targeted metal at sequence. Following this sequence color, pH, Cr concentration was reduced below the permissible limit of NEQS.

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