Engineering/Science/Technology Civil/WR/EE/GIS

Optimization of Dosage of Precipitating Agents used for the Removal of Chromium from Tannery Wastewater by Chemical Precipitation

H Tripathi*,P.Hari Prasad Reddy**,K.V.Jayakumar***
M-Tech Scholar*, Assistant Professor**, Professor***
Dept. of CE, NIT Warangal,Warangal, Telangana
tripathi.harsh.39@gmail.com*, hari@nitw.ac.in**
kvj@nitw.ac.in***

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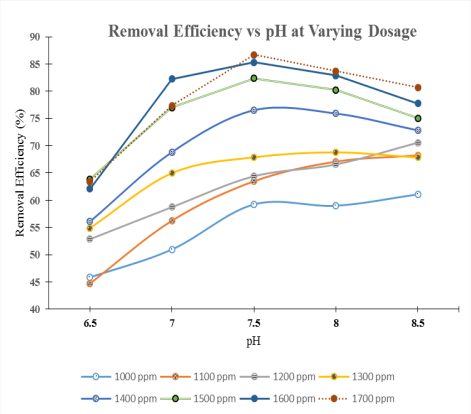
GRAPHICAL ABSTRACT



ABSTRACT

Chromium is a heavy metal and is among the top 10 abundant elements found in the Earth's crust. Chromium is present in the form of chromium oxide and exhibits mainly two oxidation states i.e the trivalent and hexavalent form. Chromium is widely used in tanning industries for the production of leather. Almost 30-40% of chromium comes out with the wastewater produced during the tanning process which cannot be disposed directly as it is harmful to the environment and human beings. The removal of chromium from wastewater is important as chromium is not only harmful but is also a costly element which can be recovered and reused in the tanning process. In this work the removal of chromium from tannery wastewater is carried out by using chemical precipitation. Sodium hydroxide and sodium bicarbonate are used as a precipitating agents and a comparison is done among the two in terms of effectiveness of precipitating chromium. The precipitation of chromium is highly dependent on pH and takes place when the pH greater than 7.5 for both the precipitating agents.

***Keywords*—Chemical Precipitation, Precipitating agents Tanning Industry and Wastewater.**

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Introduction

Chromium is widely used in Tanneries in a process known as chrome tanning in order to improve the quality of leather. Chromium exists in two oxidation states i.e the trivalent and the hexavalent state. Generally, chromium is found in the trivalent form. The hexavalent form is rarely found but chronic exposure to it can lead to carcinogenesis and mutagenesis [1]. The raw hides generally take up 60-70% of the chromium which is applied to them and the remaining 30-40% of chromium comes out with the wastewater which is generated in the tanning operations [1, 2]. The chromium content in the tannery wastewater is very high and hence removal of chromium from the wastewater becomes necessary due to environmental concerns. The recovery and reuse of chromium from the tannery wastewater reduces the release of chromium in the environment. There are various techniques to remove and recover chromium from tannery wastewater which are chemical precipitation, ion exchange, adsorption, membrane separation and biological reduction [3].Chemical precipitation is one method to remove chromium from the wastewater. The precipitation is highly pH dependent [3, 4]. The precipitation of chromium takes place in the form of chromium hydroxide and it can be done by using various precipitating agents like sodium hydroxide, lime, magnesium oxide, sodium bicarbonate, stannous chloride etc. This study does a comparison of two precipitating agents i.e. sodium hydroxide and sodium bicarbonate on the

basis of removal efficiencies and the settling time required for the precipitation of chromium present in the wastewater produced from a tanning industry in Warangal.

I. METHOD AND EXPERIMENTATION

A. Methodology

The methodology adopted for the determination of concentration of chromium is by the use of 1, 5 Di-phenyl Carbazide. This method is suitable for determining hexavalent chromium. DPC combines with Cr (VI) to form Di-Phenyl Carbazone [5]. This method determines the concentration of the hexavalent chromium in the sample. A UV-vis Spectrophotometer was used for the determination of the concentration at a wavelength of 540 nm.

A stock solution of 1000 ppm was prepared by using potassium dichromate and from that stock solution, standard solutions were prepared having a concentration from 1ppm to 50ppm by diluting the stock solution. For these standard solutions, absorbance was measured in the spectrophotometer and a calibration curve was prepared. Fig. 1 shows the calibration curve which was obtained. Then using this curve the concentration of chromium present in the wastewater sample was determined. The wastewater sample was collected from a tanning industry situated in Warangal.

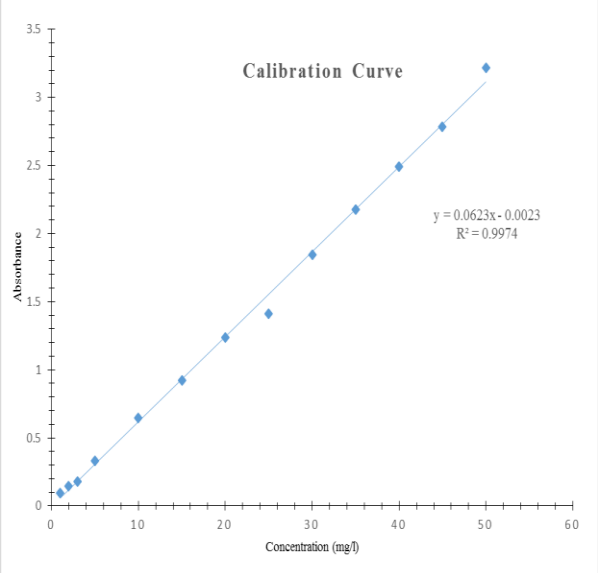

Fig. 1. Calibration Curve

From the calibration curve the initial concentration of chromium was determined as 390mg/l in equivalence of hexavalent chromium.

B. Experimental Procedure

After the determination of initial concentration of chromium in the wastewater sample, the precipitation of chromium was done by first using sodium hydroxide and then by using sodium bicarbonate. Varying dosage of these compounds were added and at different pH conditions the removal of chromium was observed. For sodium hydroxide the dosage varied from 500ppm to 1000ppm and for sodium bicarbonate it varied from 1000ppm to 1700ppm.

25mL of sample was taken and to it dosage of precipitating agents were added. Then mixing was done for 5 minutes and then it was allowed to settle. The settling time provided in case of sodium hydroxide was 30 minutes and for sodium bicarbonate it was 45 minutes. Then the concentration was determined by using Di-phenyl Carbazide.

C. Results

Table I shows the maximum efficiency of removal of chromium at every dosage of sodium hydroxide. The maximum removal in case of sodium hydroxide was observed in a pH range of 8 to 8.5 and at a dosage of 800ppm the removal efficiency was found to be 90.56%.

Table II shows the maximum efficiency of removal of chromium at every dosage of sodium bicarbonate. The maximum removal in the case of sodium bicarbonate was observed in the pH range of 7.5 to 8 at a dosage of 1600ppm and the max removal efficiency was found to be around 85%.

Fig. 2 and Fig. 3 show the variation in the removal efficiency at different dosage and at varying pH conditions for sodium hydroxide and sodium bicarbonate respectively.

TABLE 1. MAXIMUM EFFICIENCY OF REMOVAL FOR SODIUM HYDROXIDE

Dosage (ppm)	**Removal Efficiency (%)**
500	82.86
600	84.92
700	87.64
800	90.56
900	89.04
1000	87.64

TABLE 2. MAXIMUM REMOVAL EFFICIENCY OF SODIUM BICARBONATE

Dosage (ppm)	**Removal Efficiency (%)**
1000	61.09
1100	68.23
1200	70.46
1300	68.79
1400	76.52
1500	82.37
1600	85.33
1700	86.69

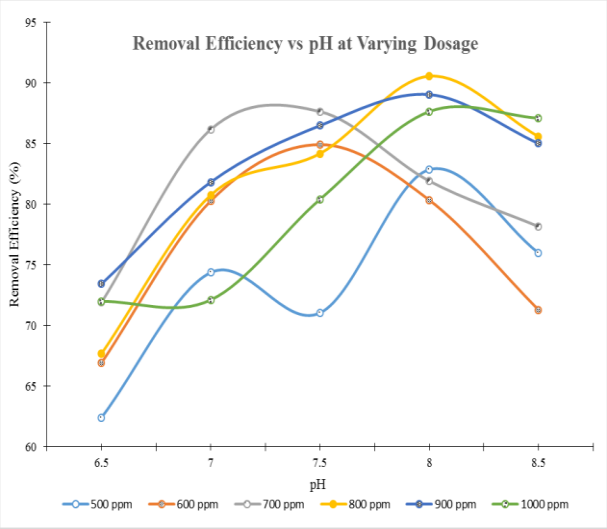

Fig. 2. Removal Efficiency vs pH at Varying Dosage for Sodium Hydroxide

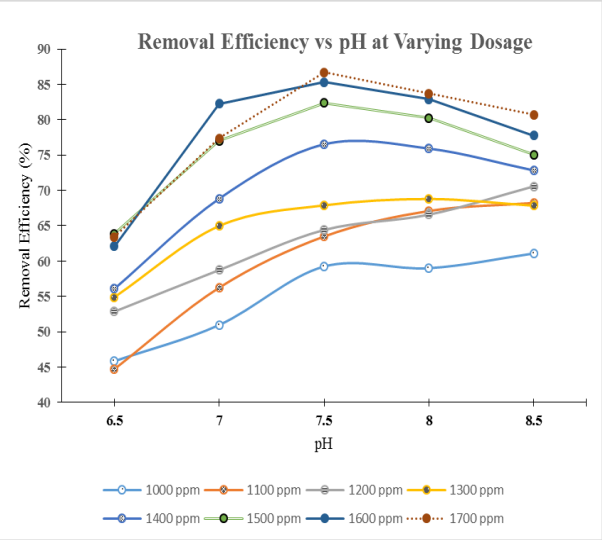

Fig. 3. Removal Efficiency vs pH at Varying Dosage for Sodium Bicarbonate

Fig. 4 and Fig. 5 show the maximum removal efficiency obtained for varying dosage of sodium hydroxide and sodium bicarbonate respectively.

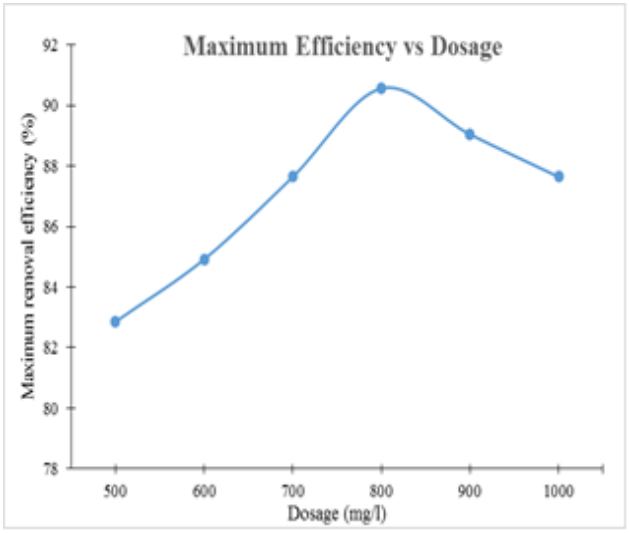

Fig. 4. Maximum Efficiency vs Dosage for Sodium Hydroxide

Fig. 6 shows the comparison of sodium hydroxide and sodium bicarbonate on the basis of maximum removal efficiency obtained at different dosage at varying pH conditions.

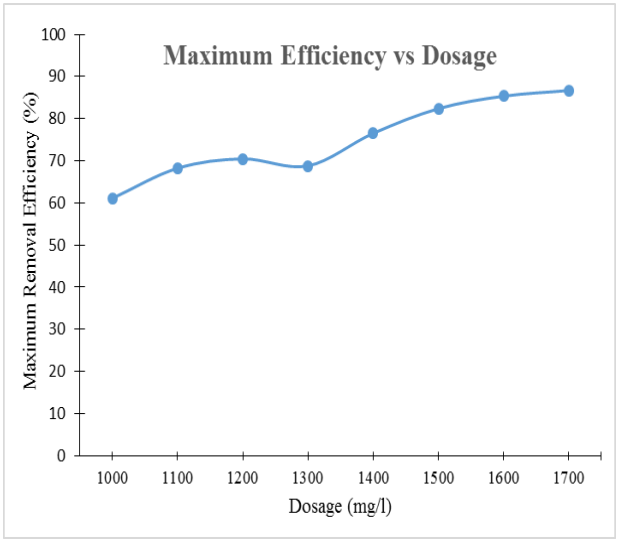

Fig. 5. Maximum Efficiency vs Dosage for Sodium Bicarbonate

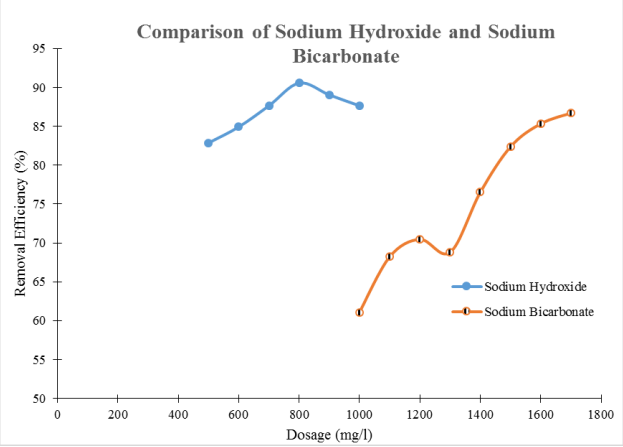

Fig. 6. Comparison of Sodium Hydroxide and Sodium Bicarbonate

D. Units

The concentration is expressed in ppm or mg/l and the efficiency is expressed in percentage.

E. Equations

Equation 1 is derived from the calibration curve which is used for the calculation of the residual concentration of chromium after the precipitation at varying dosage. Equation 2 is used to calculate the percentage removal of chromium. The Equations are given by:

$$Y = 0.0623x - 0.0023 \quad (1)$$

Where, 'Y' is the absorbance of the sample and 'x' is the concentration which is to be calculated.

$$\% \text{ Removal} = [(C_o - C_1)/C_o] \times 100 \quad (2)$$

Where, 'C_o' is the initial concentration in mg/l and 'C_1' is the final concentration in mg/l.

F. Abbreviations and Acronyms

Dept.- Department
CE- Civil Engineering
etc.- Etcetera

II. Conclusion

The removal of chromium is carried out using chemical precipitation by the use of two precipitating agents which are sodium hydroxide and sodium bicarbonate. On performing the experiments it was found that at a dosage of 800ppm of sodium hydroxide, an efficiency of around *90%* was obtained. This removal efficiency was obtained in the pH range of *8 to 8.5*. Similarly, for sodium bicarbonate the maximum efficiency was obtained at a dosage of 1600ppm and was almost constant for the higher dosage which was around *85%* in the pH range of *7.5 to 8*.

It was observed that on increasing the dosage of sodium hydroxide above 800ppm the residual concentration of chromium was increasing which means that there is a re dissolution of sodium hydroxide in the solution. On the other hand, on increasing the dosage of sodium bicarbonate above 1600ppm, the removal efficiency was nearly constant.

The presence of other elements along with chromium in the wastewater can affect the precipitation of chromium. Elements like calcium, magnesium and aluminium are generally present along with chromium in the tannery wastewater. They may react with the precipitating agents ahead of chromium reducing the efficiency of chromium removal. Also the presence of organic matter increases the dosage required for precipitation. Hence if these interfering substances are present then their removal should also be considered.

Hence it is concluded that sodium hydroxide is more effective in precipitating chromium than sodium bicarbonate. The optimum dosage for sodium hydroxide to achieve a maximum removal efficiency was *800ppm* and the optimum dosage for sodium bicarbonate was *1600ppm*.

The settling time in case of sodium hydroxide was *30 minutes* and for sodium bicarbonate it was *45 minutes* as the rate of precipitation was faster in the case of sodium hydroxide. Although, sodium hydroxide is more effective than sodium bicarbonate, the sludge which is formed in the case of sodium hydroxide is much more than that of sodium bicarbonate. It is concluded that the precipitation of chromium takes place when the pH is greater than 7.5 i.e. alkaline conditions favors the precipitation of chromium and both the compounds are capable of precipitating chromium but sodium hydroxide is a much powerful precipitating agent as compared to sodium bicarbonate.

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