Lab Scale Study of Iron Removal from Industrial Wastewater by Electro-coagulation Process: A Case Study

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***Abstract*: Heavy metals present in industrial wastewater tend to persist for longer time in environment and pose a risk of environmental pollution. So, in order to remove these heavy metals, techniques such as Electro-coagulation (EC) has re-emerged. In this study waste water sample was collected from Tata Steel industry located in Pithampur, [M.P.] and was treated by the process of electro-coagulation for the removal of heavy metal i.e. iron. For this a lab scale model of electro-coagulation was set up. This model consisted of a 3 L capacity plastic jar, Al-Al electrode pair, DC power supply, rheostat, multi-range ammeter and a voltmeter. Firstly, the characteristics of raw wastewater sample were determined in the laboratory, then the effect of various operational parameters (such as pH of sample, applied current intensity and time of operation) on removal efficiency of iron was investigated. In order to determine optimum operating conditions, the analysis of sample was done at different values of pH (i.e. 3, 5 and 7) and varying intensities of current (i.e. 1 A, 1.5 A and 2 A) for a periodical time interval of 15, 30 and 45 minutes. From the result analysis it was observed that maximum iron removal efficiency achieved was 99.71 % at an optimum pH of 7 and 4.44 mA/cm^2 current density after an operating time of 45 min.**

Keywords: Electro-coagulation Process, Industrial wastewater, Iron Removal

1. INTRODUCTION

Rapid Industrialization is one of the major cause for the release of heavy metals in the environment such as Nickel, Chromium, Iron, Zinc, Lead etc. Removal of these heavy metals by treatment of wastewater has become important due to their persistent nature. If not treated and discharged into municipal sewers then it may cause environmental problems. Concerning about pollution, industries come under great pressure to find innovative ideas with environmental regulations. Electro-coagulation (EC) has re-emerged as a viable technology.

EC is a broad spectrum treatment technology that removes Total Suspended Solids (TSS), heavy metals, emulsified oils, bacteria and other contaminants from water or wastewater by introducing an electric current through parallel plates constructed of various materials. It uses methods that precipitate large quantities of contaminants from waste in a single operation. Electro-coagulation Process (ECP) provides rapid settling of electro-generated flocs and small amount of sludge production. Thus, it has an advantage of removing smaller colloidal particles with respect to traditional method of chemical coagulation. Also, the capital as well as operating cost of this technology is usually less than that of chemical coagulation. The capital cost can be recovered in less than a year.

The plates are generally made of iron, aluminium or stainless steel as these materials are inexpensive and non-toxic. EC consist of several cathode-anode pair that may be connected in polar mode. In this technology, metal cations are released into solution dissolved by metal electrodes. At the same time, beneficial side reaction can remove flocculated material from the solution. However, this can also affect the deposition of salts on the surface of electrode which can lead to deterioration in purification performance after long operation.

1.1 SITE SELECTION

Wastewater sample used in this study was collected from Tata Steel industry located in Sector-3, Pithampur road, Indore (M.P.). This industry produces 6 kL of wastewater per day.

2. MATERIALS & METHOD

Effect of various parmeters such as pH, current density and contact time on removal of iron was studied and analyzed by electrolysis process.

2.1 EXPERIMENTAL SET-UP

The set up of lab scale model of electro-coagulation has been presented in Fig. 1. Plastic container of 3 litres capacity was used to carry out experiments in batch mode. In tis set up two Aluminium electrodes of 120 mm x 10

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mm x 3 mm were placed 1 cm apart in plastic container. Aluminium was selected as electrode material because it requires less oxidation potential and also it does not impart any colour to wastewater. A DC power (6V, 12 V) was supplied. An electric circuit consisted of a rheostat and multi-range ammeter connected in series while a voltmeter connected in parallel with the cell to measure its voltage.

Number of experiments were performed to determine the removal efficiency of iron at different values of pH (i.e. 3, 5, 7) and different values of current densities (i.e. 1.77 mA/cm^2, 3.16 mA/cm^2, 4.44 mA/cm^2) at periodical time interval of 15 min, 30 min and 45 min respectively.

Fig. 1 Lab Scale Electro-coagulation Set-up

2.2 METHODOLOGY

Plastic air tight container was used to collect effluent from Tata Steel industry. Various physico-chemical parameters of this collected wastewater sample were determined in the laboratory and the observed values were presented in Table 1.

Table 1: Characteristics of raw wastewater

S. No.	Characteristics	Unit	Value
1.	pH	-	7
2.	Iron	mg/ l	3.5
3.	Conductivity	µS/cm	20165
4.	TDS	mg/ l	35.30
5.	Colour	-	Reddish

As pH of raw wastewater sample was found to be 7 so to adjust pH to the desired values of 3 and 5, conc. H_2SO_4 was added to the solution. Then the solution was kept still to settle for 2 hrs. Two litres of this pH adjusted settled wastewater sample was then taken in the reactor and electrodes were placed in the reator. Desired amount of current (i.e. 1 A, 1.5 A and 2 A) was passed for stipulated time and the contents were briefly stirred with a glass rod. It was then allowed to settle for 30 minutes. After settling a small amount (approximately 100 ml) of supernatent was withdrawn and was filtered to remove any flocs. Concentration of iron in the filterate was then determined using Atomic Absorption Spectrophotometer.

The experiment was repeated for different pH values (i.e. 5 & 7) and current densities. Electrodes were rinsed with dil. HCl and were weighed after each run.

3. RESULTS & DISCUSSION

Effect of different operational parameters (such as pH of sample, current density and operating time) on removal efficiency of iron (Fe) from wastewater sample obtained from Tata Steel industry was investigated in order to determine the operating optimum conditions.

4.1 Effect of pH

Current intensities and solubility of metal hydroxide affects the removal efficiency of iron at different values of pH. Fig 2 sjows the results of experiments performed to determine the removal efficiency of iron using pH values of 3, 5 and 7 at different current intensities i.e. 1 A, 1.5 A & 2A for periodic time interval of 15 min, 30 min and 45 min respectively.

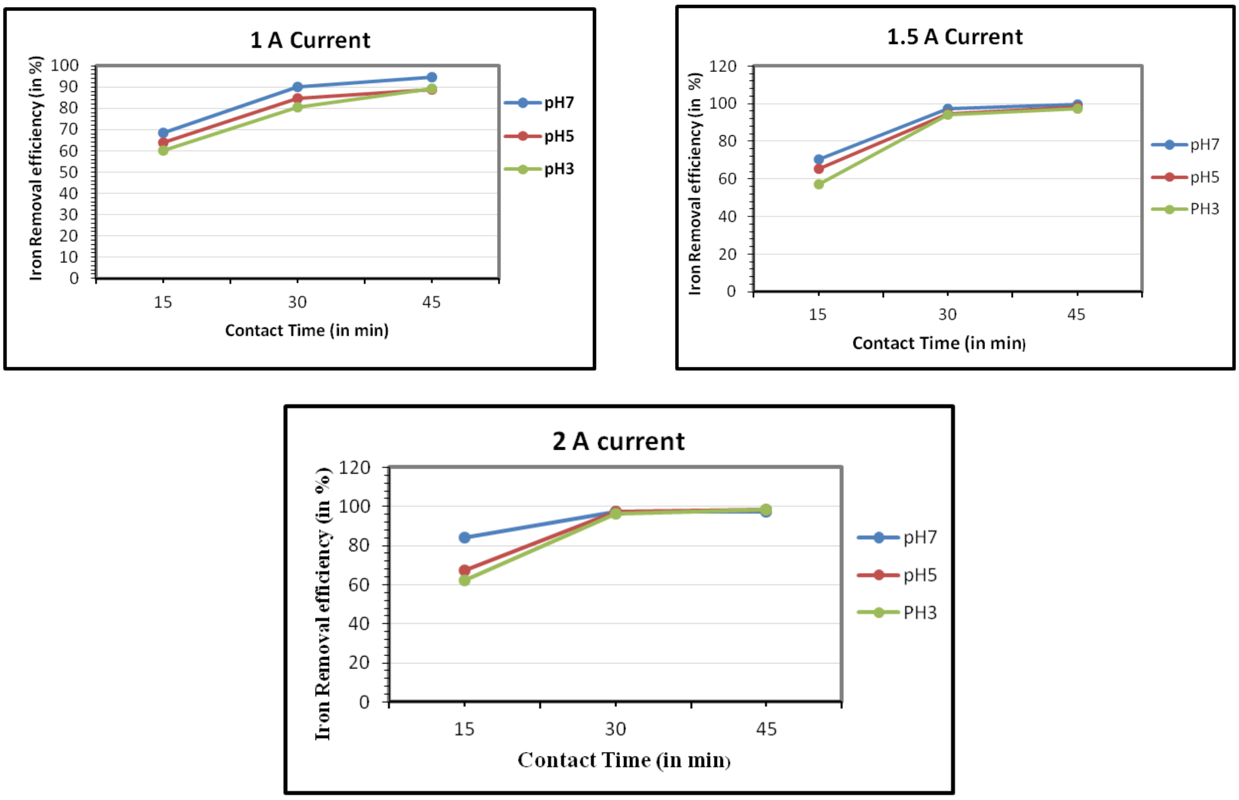

Fig. 2 Iron removal efficiency v/s Time using variable pH values at different current intensities

It could be observed from Fig. 2 that the highest removal efficiency of iron was achieved at pH 7 and the minimum removal efficiency at pH 3 at all the values of current intensities i.e. 1 A, 1.5 A and 2 A. The maximum removal efficiency of iron achieved was 99.71% at pH 7 at the current intensity of 1.5 A during 45 min. contact time and the minimum removal efficiency was 89.24% at pH 3 at current intensity of 1 A during 45 min. contact time. It was also observed that there was a considerable increase in the removal efficiency of iron till 30 min operating time and thereafter the increase was not significant. The possible reason for this could be the accumulation of enormous amount of hydroxyl ions at the cathode in sufficient acidic condition which increased the removal efficiency of iron.

4.2 Effect of Current Densities

In electro-coagulation process, current density is an important parameter that controls the reaction rate as current density is directly proportional to the rate of EC reactions taking place on the electrode surface which influences the electrode potential defining the reactions taking place on electrode surface. Fig. 3 shows the effect of different values of current densities i.e 1.77 mA/cm^2, 3.16 mA/cm^2 and 4.44 mA/cm^2 on iron removal efficiency at an optimum pH of 7 at periodic time interval of 15 min, 30 min and 45 min respectively.

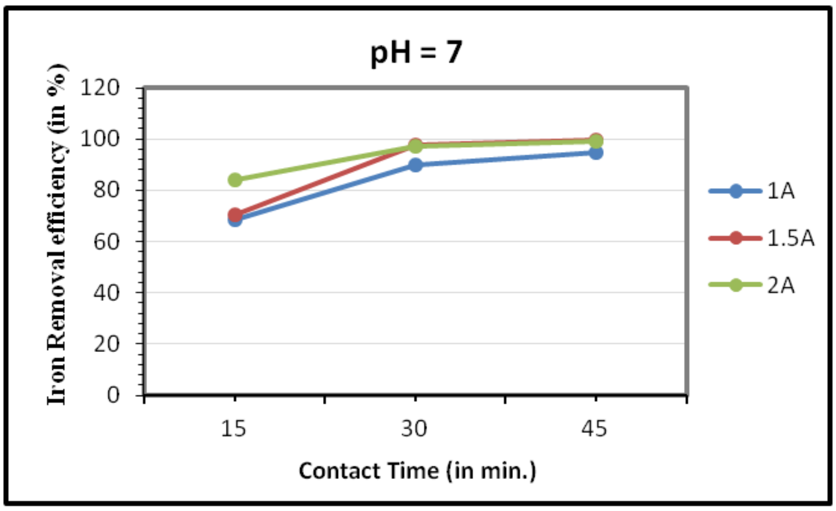

Fig. 3: Effect of current density on Iron removal efficiency at optimum pH of 7

Fig. 3 shows that the iron removal efficiency increased with an increase in the current density ranging from 1.77 mA/cm^2 to 4.44 mA/cm^2 till an operating time of 30 min. Also, it was observed that if the current density was increased further then the increase in removal efficiency was very less, as the increase in current density would also increase the consumption of electrical energy resulting in higher cost of treatment. Hence, the current density of 4.44 mA/cm^2 was observed to be the most appropriate current density giving maximum removal efficiency at optimum pH of 7.

5 CONCLUSION

It could be observed from the results that Electro-coagulation is one of the best techniques for removal of heavy metal such as iron from industrial wastewater. It reduces concentration of iron to a very low level (0.010 mg/l) which is much less than the permissible limit (3 mg/l) specified by Environmental Protection Rules 1986. As the economy of a treatment process plays an important role for project sanctioning, so its applicability in the specified area should be considered. It could be concluded that removal of heavy metal (iron) from Tata Steel industrial wastewater using electro-coagulation with an Al-Al electrode pair achieved 99.71% removal efficiency at 4.44 mA/cm^2 current density and optimum pH of 7 after an electro-coagulation time of 45 min with electrical energy consumption of 9 KWh/m^3.

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