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RESEARCH ARTICLE

Removal of iron from waste waters by precipitation using lime in conjunction with alum

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SUMMARY : In recent years, increasing awareness of the environmental impact of heavy metals has prompted a demand for the purification of industrial waste waters prior to discharge into natural waters. The purpose of this study was to evaluate the possibility of using lime in conjunction with alum to precipitate iron from synthetic solution under varied experimental conditions, *viz.*, pH (8 to 12), alum dosage (400 to 1100 mg/l) and initial concentration of metal (Co 2 to 6 mg/l). Increase in removal efficiency with increase in pH, alum dosage upto certain limit was observed. Maximum removal efficiency of 98% was recorded at alum dosage of 700 mg/l, pH of 10, Co being 4 mg/l. However, all the dosages of alum, at all the pH values and Co, have successfully reduced the iron content in synthetic solution to permissible limits.

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Key Words :
Synthetic solution, JAR test, Iron precipitation, Alum

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Industries that use iron salts and that involve ferrous alloys like plating shops, steel mills, foundries, tanneries and smelters were found to discharge waste water containing iron beyond the disposal standards. Discharge of heavy metals in general and iron in specific into the environment due to these industrial activities is of serious concern as these metals are toxic to all forms of life. The increase in stringent environmental regulation and enforcement of discharge limit necessitates effective decontamination and purification method (Chaturvedi and Dave, 2012). Some of the commonly adopted physico-chemical waste water treatment processes for heavy metal removal are chemical oxidation/ reduction, precipitation, adsorption, solidification, electrolytic recovery and ion exchange.

Low cost adsorbents including duck weeds for removal have been tried by many researchers (Ahalya *et al.*, 2007 and Ratna *et al.*, 2010). Other methods tried by researchers to remove iron include water hyacinth, chelating resin purolite, ultrafiltration and desalination. However, technical and economical constraints restrict the wide application of many of these processes (APHA, 2006).

Authors are of the opinion that precipitation techniques for removal of iron from waste waters is relatively economical and suitable compared to other methods. In the present study, removal of iron from synthetic waste water using lime in conjunction with alum has been tried.

EXPERIMENTAL METHODOLOGY

Synthetic waste water :

The solution of Fe (+2) metal ion was prepared using analytical grade ferrous sulphate. Stock solution was prepared with deionized water and this stock solution was further diluted with deionized water to obtain standard solutions (2,3,4 and 5 mg/1).

Stock solutions:

Stock solutions of lime and alum were prepared by dissolving calculated quantities of analytical grade hydrated lime and alum powder in

deionized water. Further, these stock solutions were diluted to arrive at pre-determined dosages and used for experimentation.

Experimentation :

The effectiveness and required doses of coagulant under varied condition of experimentation were evaluated by using jar test apparatus. The apparatus is operated to simulate a mixing, flocculation and settling. Each set of experimentations was carried out by varying initial concentration of iron and keeping pH and alum dosage constant. Further experiments were repeated to evaluate the effect of pH and alum dosages. The mixing of contents of jars were carried out at high speed for a short period of time (around 2 – 3 minutes). This rapid mixing phase was followed by about 20 minutes of gentle mixing to promote formation of flocs. The suspension was allowed to settle for 1.5 hours and then supernatant was tested for its flouride concentration.

For analysis of iron spectrophotometer DR:5000 was used and procedure as given in instrument supplier manual was used for analysis.

EXPERIMENTAL FINDINGS AND DISCUSSION

The results of experimentation are presented in Table 1. The effect of alum dosage on iron removal efficiency at different pH values and initial concentration of iron studied are also presented graphically in Fig. 1. The observations made are based on the results of experimentation documented below :

Increase in the removal efficiency of iron from synthetic waste water with increase in pH value from 8-10 was observed. Further increase in pH of the solution beyond 10 was found to have a detrimental effect on iron removal. Similarly increase in iron removal efficiency with increase in alum dosage from 500-700 mg/l and further decrease in efficiency at alum dosage of 900 and 1100 mg/l was noticed. Also the results revealed that maximum removal of iron with initial concentration of 4 mg/l for given set of experimental condition compared to other initial concentration tried in the present study.

For all the pH and initial concentrations of iron studied, but at alum dosage of 500, 700, 900 and 1100 mg/l the removal efficiency varied from 32.2 to 80 %, 51.2 to 98.0 %, 47.6 to 88.0 % and 42.7 to 81.0 %, respectively. Thus, it was inferred that removal will be better at alum dosage and 700 mg/l and can be considered as optimum dosage. Further at this alum dosage of 700 mg/l for all initial concentration of iron studied removal efficiency varied from 51.2 to 65.0 %, 63.2 to 75.4 %, 80.5 to 98.0 %, 71.3 to 88.4 %, and 61.3 to 78.2 %, respectively, at solution pH of 8, 9, 10, 11 and 12. From these values, solution pH 10 was found to be optimum. Again at optimum pH 10, removal percentage recorded for initial iron concentration of 2, 3, 4, and 5 mg/l were, respectively, 80.5, 88.0, 98.0 and 85.0 %. Thus, it can be stated that removal efficiency will be better at initial concentration of 4 mg/l compared to 2, 3 and 5 mg/l.

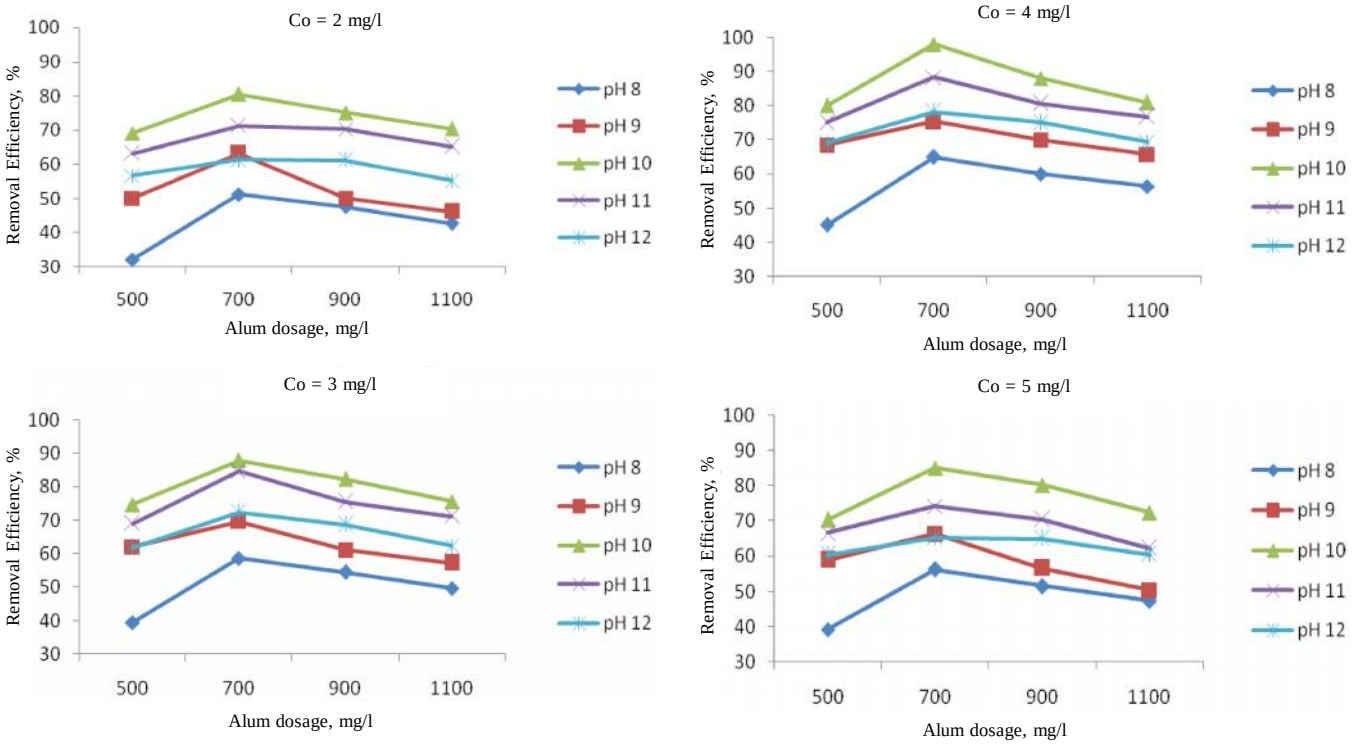

Fig. 1 : Effect of Alum dosage on removal efficiency

Table 1 : Results of experimentation on iron removal : Coagulation

Alum dosage mg/l →	500				700				900				1100			
Co, mg/l→ / pH↓	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5
8	32.2	39.5	45.0	39.2	51.2	58.7	65.0	56.2	47.6	54.5	60.0	51.5	42.7	49.7	56.4	47.4
9	50.1	62.1	68.5	59.0	63.2	69.6	75.4	66.3	50.1	61.2	70.7	56.5	46.2	57.3	65.7	50.3
10	69.1	74.8	80.0	70.4	80.5	88.0	98.0	85.0	75.1	82.3	88.0	80.2	70.4	75.7	81.0	72.6
11	63.2	69.1	75.0	66.6	71.3	84.6	88.4	74.2	70.2	75.6	80.6	70.4	65.2	71.2	76.7	62.3
12	56.7	61.9	69.0	60.5	61.3	72.4	78.2	65.3	61.2	68.7	75.0	65.0	55.3	62.4	69.3	60.5

Finally it was inferred that iron can be better removed at alum dosage of 700 mg/l, pH of 10 and Co of 4 mg/l.

However, it is opined that the disposal standard of 3 mg/l fixed for iron in wastewater can be achieved by alum precipitation, the dosage being 500 mg/l and pH – 8.0.

Conclusion :

The iron precipitation from aqueous solution using alum has been carried out in the laboratory by varying pH, alum dosages, and iron concentrations. The variation in the percentage removed under varied experimental conditions were recorded. Linear relationship between removal efficiency and alum dosage up to certain limit was observed. Increase in pH was found to have a good bearing on removal efficiency upto pH of 10. Optimum removal efficiency was recorded with a alum dosage of 700 mg/l at pH – 10, initial concentration of iron being 4 mg/l.

However, all the alum dosages and pH values studied in the present work were found to result the iron concentration of 3 mg/l after treatment. Thus, it is concluded that alum could be used effectively to remove iron from aqueous solutions.

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