

Detection and Removal of Copper from the Industrial Effluents

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Summary: A bench scale hydrometallurgical method is proposed for the detection and removal of copper from the effluents discharged by various industries into Kabul River. The conditions, such as, effect of acid concentration, temperature and acid leaching time were optimized. The effluents were ashed at 500-600°C and the residue was leached with 7.5 M HCl for six hours at 80°C. Almost 99% removal of copper is achieved from the acid leached solution by extraction into 5% solution of trioctylamine in benzene, and subsequently stripping with 0.1 M HCl solutions. The technology developed is economically feasible because the solvents used are regenerated and recycled just after washing with distilled water.

Introduction

Liquid-liquid extraction/hydrometallurgy have been reported for the separation of metal ions in aqueous solution for many years [1]. Until 1960 alkylamine was used as liquid extractant for various anionic species of metal ions [2,3]. However, interest in their application in industrial processes for the recovery of metals is relatively recent [1]

A number of research papers have been published regarding development of various processes for the removal of copper from industrial waste water [4-22]. But these methods are cumbersome and time consuming. The present work describes an easier hydrometallurgical method for the determination, extraction, as well as removal of copper from industrial effluents with dilute solutions of trioctylamine and hydrochloric acid. The method developed is comparatively economical because, about 99% removal of copper is achieved even by repeated reuse of the waste/exhausted solvents (Table-2)

Results and Discussions

Effect of acid concentration:

The effect of hydrochloric acid concentrations, varying from 0.5 to 10 M was studied on percentage leaching of the industrial effluents/waste water and it was noted that 99% extraction and removal of copper is achieved at 7.5M HCl concentration. The results are illustrated in Fig. 1.

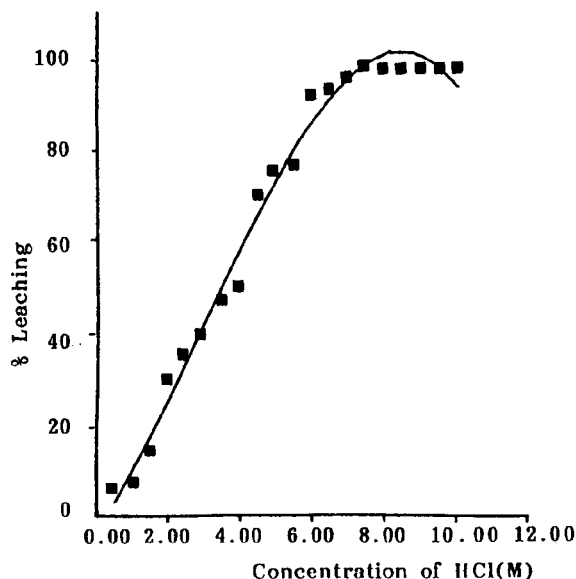


Fig. 1: Effect of acid concentration on acid leaching of effluents

Effect of temperature:

The Effect of temperature ranging from 50 to 200°C on percentage leaching of the industrial effluents/waste water was also studied and the optimum temperature for the maximum leaching was observed at 80°C. These observations are shown in Fig. 2.

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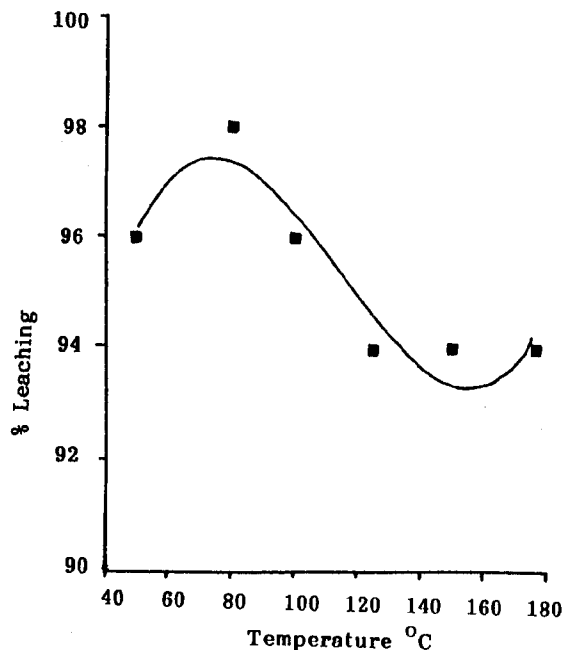


Fig. 2: Effect of temperature on acid leaching of effluents

Effect of acid leaching time:

The effect of acid digestion time from 0.50 to 8.0 hours at a constant temperature of 80°C was also investigated and it was observed that complete digestion of the industrial effluents/waste takes place within 6 hours. The data obtained is presented in Fig.3.

Application of the used and regenerated solvent for the removal of copper from industrial effluents/waste:

The exhausted and regenerated organic solvent was applied as such and also after washing twice with distilled water, for the recovery of copper from industrial effluents/waste. Evidently, washing the used solvent twice with distilled water gives 98% extraction and removal of copper from industrial effluents/waste water. The minor differences in percent removal of copper during the successive application of the regenerated solvent may be due to its partial exhaustion and/or its loss during repeated applications. The data are given in Table-2.

Table-1 Comparative results of the copper determination ($\mu\text{g/ml}$) in industrial effluents.

S.No	Location point.	Methods of determination	
		Present method	Other methods*
1.	500 meters down stream Nowshera cantt. sewerage drain.	0.51	0.49
2.	500 meters upper stream Nowshera cantt. sewerage drain.	0.12	0.10
3.	10 Km down stream-bridge on G.T Road 36 km from Peshawar	3.30	3.00
4.	500 Km upstream of confluence point of Naguman River and Shah Alam River.	0.22	0.20

* "Ammonium Pyrolidine Dithiocarbamate (APDC) Method "-Standard Methods For the Examination of Water and Waste water,16th Edn. American Public Health Association Washington, DC 20005, 1985,pp.160.

Table 2. Methodologies used for removal of copper from industrial wastes with regenerated solvent(sample collected near the bridge on G.T Road 36 km from Peshawar-N.W.F.P.)

S. No.	Methods for regeneration of used solvent	Number of uses of waste/used solvent	Concentration of copper ($\mu\text{g/ml}$)	
			Present	Removed
1.	Direct application of the used solvent without being washed.	I	3.30	2.90
		II	3.30	2.85
2.	Application of used solvent after washing once with distilled water.	I	3.30	3.00
		II	3.30	3.00
3.	Application of the used solvent after washing twice with distilled water.	III	3.30	2.98
		I	3.30	3.25
		II	3.30	3.20
		III	3.30	3.18
		IV	3.30	3.15
		V	3.30	3.15

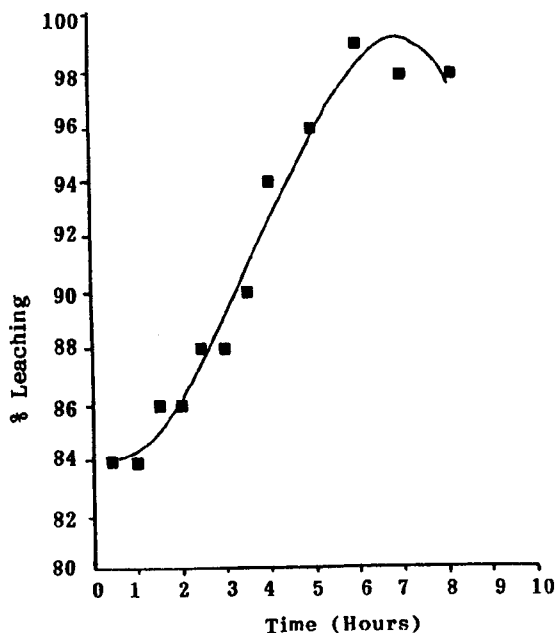
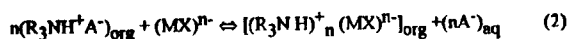


Fig. 3: Effect of time on acid leaching of effluents.

The overall reaction between copper (M) and tertiary amines (R_3N) may be represented by the following equations.



where R_3N = Tertiary amine

H^+A^- = An inorganic acid

$(MX)^{n-}$ = Anionic complex,

M = A metal ion and

X = A ligand.

Experimental

All the chemicals used in these investigations were of analytical grade. A solution of 5% trioctylamine in thiophene free benzene was freshly prepared for each experiment. All the aqueous solutions were prepared in distilled water unless otherwise stated. The acid strengths of these solutions were adjusted with hydrochloric acid that were further diluted for keeping the requisite acid concentration.

Acid leaching of the effluents

100ml of the effluent was transferred to a 250ml China dish, and added to it 25 ml of 10 M hydrochloric acid. The contents were leached over a steam bath at 80°C for 6 hours. The dish was kept covered with a watch glass during acid leaching. The leachate was cooled to room temperature and filtered through a Schwarzband Ø 5.5 cm filter paper into a 100 ml volumetric flask. To the acid leached solution were added as much 10M HCl so that the final acid concentration was 7.5M HCl. This solution was then analysed for copper contents by atomic absorption spectrophotometry.

Determination of copper

Hitachi Polarized atomic absorption spectrophotometer Model Z-8000 in the Zeeman flame mode was used for determination of copper. Instrumental conditions for copper are lamp current 7.5 mA, wavelength 324.8 nm, spectral slit 1.3 nm, oxidant (air) pressure 1.60 kg/cm², fuel (acetylene) pressure 0.30 kg/cm² and burner height 7.5 mm. The copper contents in the industrial wastes was also determined by the application of other standard method and the comparative data is presented in Table-1.

Extraction and removal of copper

10 ml of the leachate was transferred to a 100 ml separating funnel, and added to it 5 ml of 5% trioctylamine in benzene. The two phases were shaken on a vibroshaker for 2-3 minutes and allowed to separate after attaining equilibrium. The organic amine phase was drained into a dried small beaker. Fresh 5 ml of 5% trioctylamine in benzene solution was added to the aqueous phase left in the separating funnel and the extraction was repeated in the manner described above. The two organic phases were mixed and stripped/back-washed to aqueous phase with an equal volume of 0.10 M HCl solution. The resulting stripped solution and the aqueous phase after the extraction of copper were analysed following the foregoing atomic absorption spectrophotometric method for determining the percentage extraction and removal of copper.

Conclusion

It is evident from these investigations that, 99% extraction of copper can be achieved with 5%

trioctylamine solution in benzene if the extraction studies are carried out by parts/in portions. Moreover, 99% removal of copper can be achieved by stripping/back washing of the loaded organic phase with 0.1M solution of hydrochloric acid. In addition, the hydrometallurgical method developed is economically feasible because the used solvents can be regenerated and recycled just by washing with distilled water. The method developed may also be capable of development into a useful and economical industrial tool.

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