Purification of Industrial Effluents by Adsorbing copper (Cu^{+2}) Ions on *Chlorella pyrenoidosa (marine algae)*

C.Sri Harsha[1] , J.Bharadwaj[1] , Siddhant V[2],Dr. Pramod Kumar[1]

1-CCST, IST, JNTU HYDERABAD
2-Surface Coating and polymer Department, ICT, Matunga, Mumbai

Abstract:

During the last two decades, extensive attention has been paid on the management of environmental pollution caused by hazardous materials such as heavy metals. Decontamination of heavy metals in the soil and water around industrial plants had been a challenge for a long time. In this project, selective biosorption of copper by marine algae called as *Chlorella pyredoinosa* from industrial effluents was done. The effect of various parameters like agitation time, biosorbent dosage, initial concentration of copper ions and pH were investigated and optimised. The equilibrium time was found to be 30 mins; optimum dosage, pH were 1.5 grams and 5.127 respectively. The maximum adsorption was observed at initial concentration of 100 ppm and at above conditions the maximum percentage removal of copper is found to be 85.37%. These results indicate that *Chlorella pyredoinosa* is best suited for biosorption of copper from industrial waste waters.

Keywords: Biosorbent, effluent, biosorbent.

Introduction:

Water is a primary resource important for drinking, irrigation, industrial purposes, cleaning etc. Life on earth could not have evolved without it. Although it is crucial for us, it is frequently contaminated by metal ions released by effluents from industries like metallurgy, electroplating, electronic, metal finishing industries. Living organisms require varying amounts of heavy metals like Iron, cobalt, copper, manganese, molybdenum, and zinc [2]. All metals are toxic at higher concentrations[1] and they disrupt metabolic functions either by accumulating and disrupting function in vital organs such as the heart, brain, kidneys, bone, liver, etc. or by displacing the vital nutritional minerals from their original place, thereby, hindering their biological function. In this project, an attempt has been made to adsorb (Cu^{+2}) ions from industrial water efficiently using *Chlorella pyrenoidosa* algae.

Methodology:

Initially, algae was collected from rocky sea shore, washed, sun dried, ground and screened through BSS meshes ensuring particle size was from 100 to 125 micrometres. Copper stock solution (1000 ppm) was prepared by dissolving 3.84 gms of 99% pure $Cu\ (NO_3.)_2 3H_2O$ salt in 1 litre of distilled water. From this different dilutions (20 ppm, 40 ppm, 60ppm, 80ppm 100ppm) were made.

Various parameters such as adsorbent dosage, agitation time, adsorbate concentration and pH were optimised batch wise- 10 mL of copper solution (100 ppm) was taken in a 250 mL conical flask and 0.5 gm of adsorbent was added and incubated on an orbital shaker at 220 rpm at room temperature (30^0C) for 5min. Later, the adsorbate was separated from the adsorbent using filter paper (Whattman No-1) and analyzed in Atomic Absorption Spectrophotometer against blank. Same procedure was carried out by changing agitation times (15, 30, 45, 60,90mins etc). A graph was plotted using concentration (mg/l) on y-axis and agitation time (min) on x axis.

Dosage of biosorbent was optimised in the same manner explained above but by taking different weights (0.3,0.4,0.5,0.6.....2g) of *Chlorella pyrenoidosa* and incubating for equilibrium time of 30min. Metal uptake and percent removal was calculated using the formulae,

$$\text{Metal uptake}=\frac{(\text{Blank solution concentration} - \text{equilibrium concentration})}{Weight\ of\ the\ adsorbent}.\ volume\ of\ copper\ stock\ solution$$

$$\text{Percent removal}=\frac{Blank\ \ solution\ \ concentration\ \ -equilibrium\ \ \ concentration}{Blank\ \ solution\ \ concentration}\times 100$$

A graph was plotted between metal uptake (mg/g) and percent removal on y axis *vs* dosage (gm) on x axis.

The optimum concentration of copper in the aqueous solution was also analysed using different concentrations-20, 40, 60, 80 and 100ppm of copper solution and a graph was plotted against metal uptake and percent removal.

Likewise pH was optimised by dissolving 1.5 g of adsorbent in 10 ml of 100 ppm copper stock solution; followed by addition of different volumes (0.1, 0.5, 1.5, 10 ml) of 0.1N nitric acid. pH was measured by pH meter and incubated for equilibrium time of 30 mins. Samples were then analysed and a graph was plotted between metal uptake (mg/g) and percent removal on y axis *vs* pH on x axis.

Results and discussions:

After performing the experiment in batch mode by incubating adsorbate and adsorbent at different time intervals, it has been observed that the adsorption of copper ions on adsorbent decreased from 29.169mg/l at 5min to 28.147mg/l at 30 mins(table 1) and later it was constant. Hence the equilibrium time was confirmed as 30 mins. The concerned graph (concentration vs time) is shown below in figure 1.

Table 1: Effect of Equilibrium Time

S.No.	Time (mins)	Conc.(mg/l)
		0.5 gm.
1	5	29.169
2	10	29.127
3	20	28.707
4	30	28.413
5	50	28.413
6	70	28.413
7	90	28.413
8	BLANK	54.54

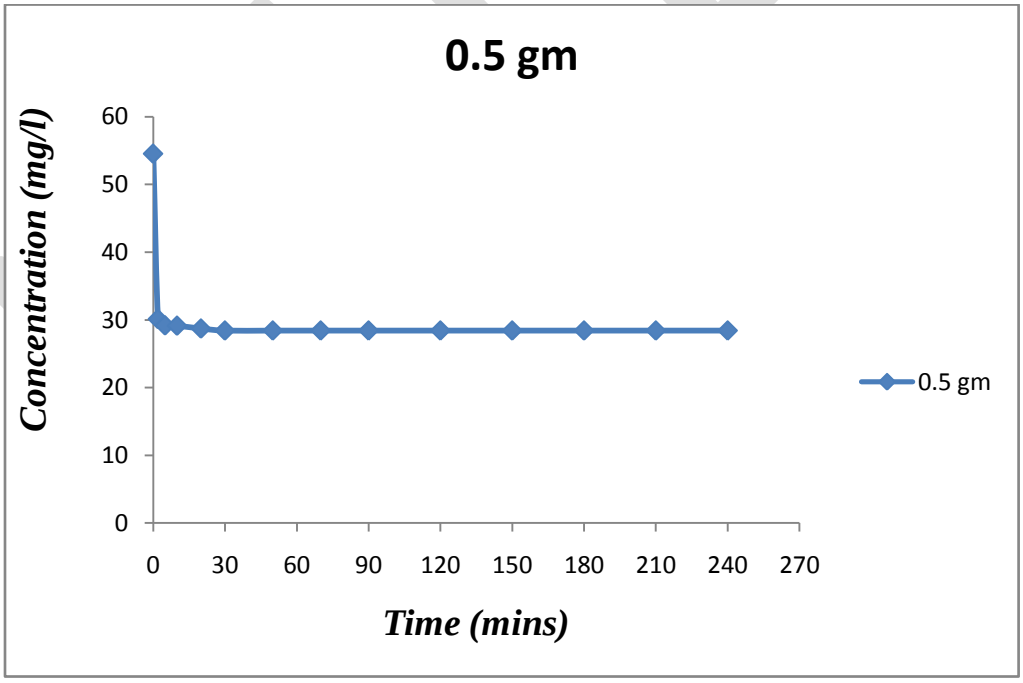


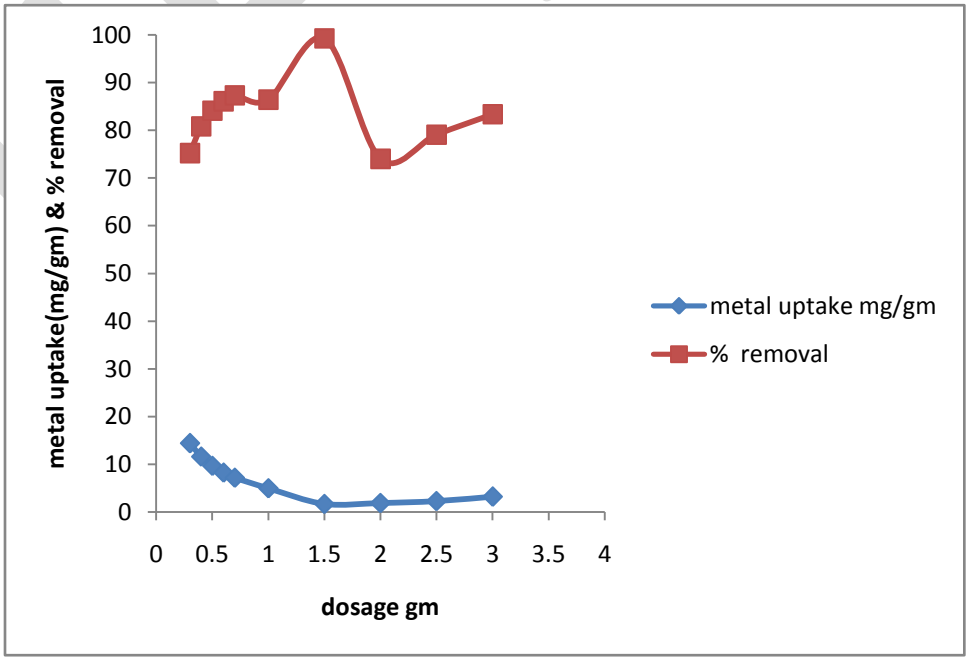
Figure1: A graph showing effect of time on concentration (mg/l)

After performing similar experiment by changing dosage of biosorbent at equilibrium time of 30min, it has been observed that with increase in dosage, percent removal of copper ions

increases slowly and maximum percent removal of 99.26% is achieved at 1.5gm of dosage. Hence 1.5gm of biosorbent is taken as optimum dosage.

Table 2: Effect of Biosorbent Dosage

S.No.	Dosage(gm)	Metal Uptake(mg/g)	Percentage Removal
1	0.3	14.392	75.20
2	0.4	11.597	80.79
3	0.5	09.655	84.08
4	0.6	08.235	86.06
5	0.7	07.161	87.30
6	1.0	04.960	86.39
7	1.5	01.699	99.26
8	2.0	01.899	73.99



+ **Figure2: A graph showing metal uptake (mg/gm) &% removal vs dosage**

After doing the same experiment for various initial concentrations of copper (20, 40, 60, 80, 100ppm) at equilibrium time of 30 mins and by adding optimum dosage of 1.5 gms it has been observed that at 100 ppm (table 3), maximum percentage (74.64) removal of copper is achieved. The respective graph between %removal and metal uptake vs concentration of solute is shown in figure 3.

Table3: Effect of concentration of solute

PPM	**C_T**	**C_e**	**q_e**	**% removal**
20	**10.382**	**05.213**	**0.171**	**49.780**
40	**19.337**	**06.888**	**0.830**	**64.380**
60	**30.950**	**07.644**	**1.030**	**75.300**
80	**36.554**	**05.802**	**1.388**	**84.120**
100	**39.651**	**0.317**	**1.751**	**99.254**

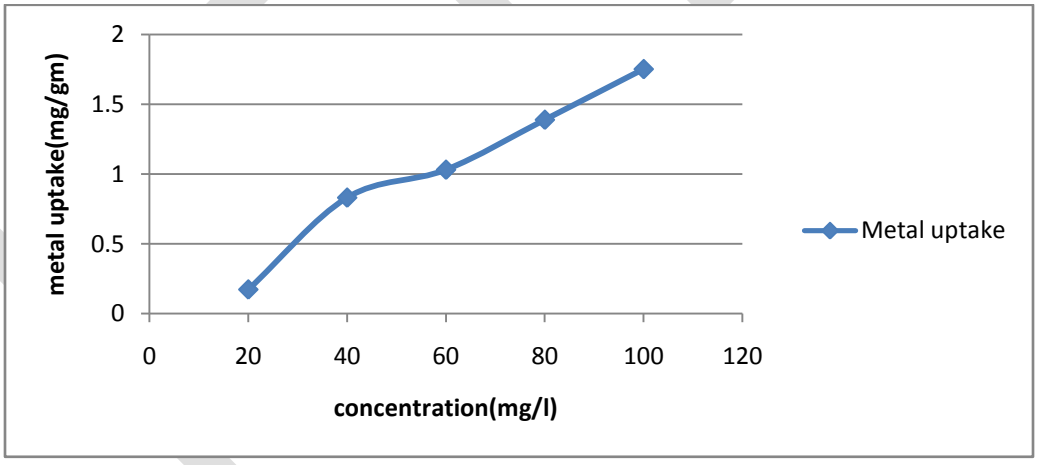


Figure 3:Effect of metal uptake vs conc of sol(mg/l)

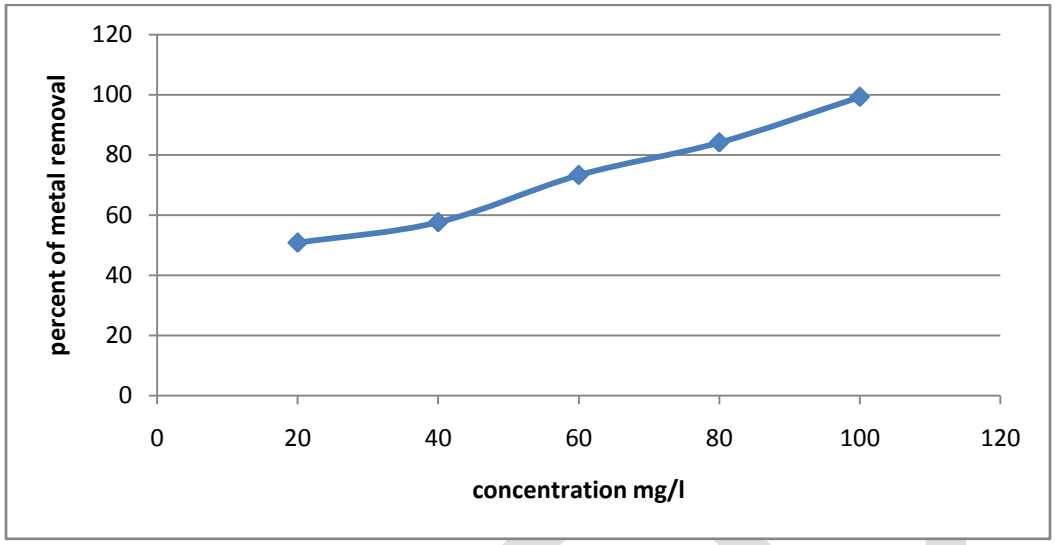


Figure 4:Effect of % removal vs conc(mg/l)

Likewise, effect of pH on the solution is verified by adding different volumes of nitric acid and incubating at equilibrium time. The percentage removal of copper was highest(85.37) when 10ml (table) of nitric acid was added.

Table 4: Stock solution concentration: 100 ppm

Volume of HNO_3 acid(ml)	pH	C_T	C_e	q_e	% removal
0	2.590	35.196	08.925	1.751	74.64
0.1	3.236	35.385	09.870	1.701	71.90
0.5	4.298	35.490	08.736	1.78	72.10
1.0	4.467	35.784	05.229	1.828	75.38
5.0	4.867	33.999	06.804	1.813	79.98
10.0	5.127	35.049	09.954	1.973	85.37

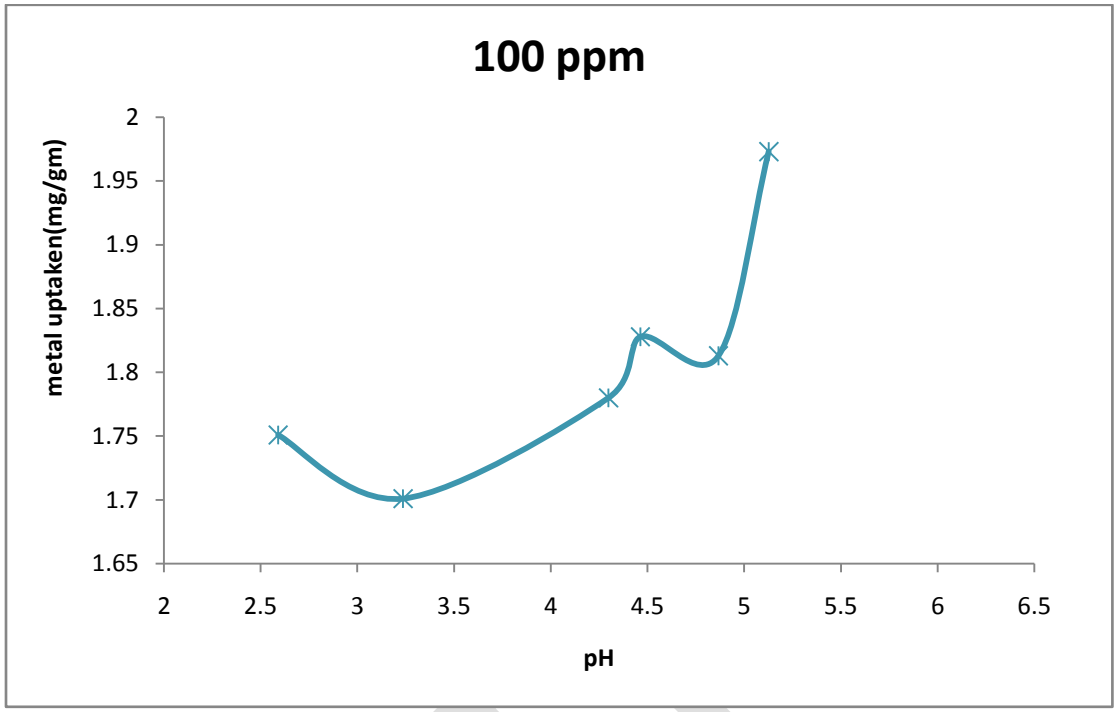


Figure 5: Effect of metal uptake (mg/gm) on pH

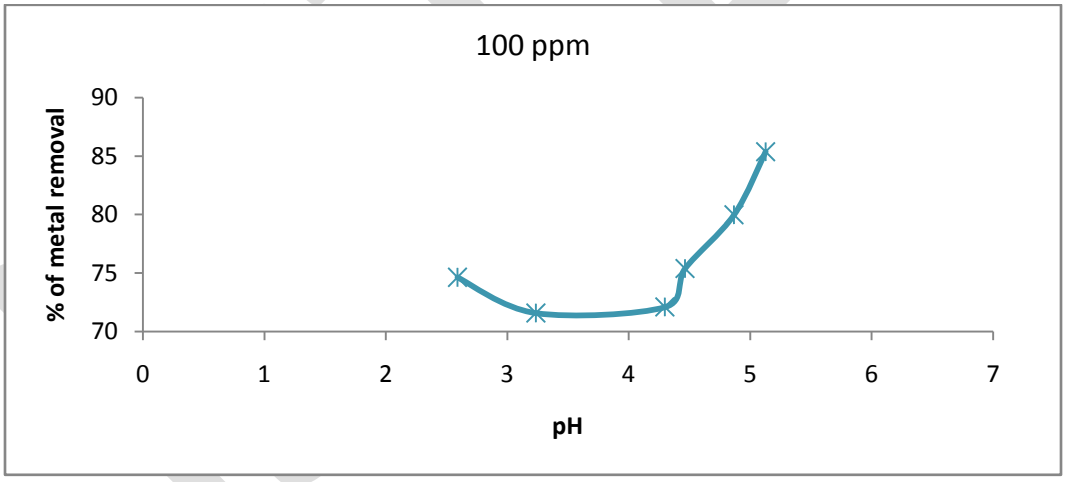


Figure 6: Effect of % removal on pH

Conclusion:

The *Chlorella pyrenoidosa* is capable of removing Copper from industrial effluents up to 85.37%. Use of conventional biosorbents such as activated carbon is sometimes restricted because of its high cost. To replace the expensive activated carbon, a wide range of inexpensive biosorbents such as *Chlorella Pyrenoidosa* were investigated. However, it is of utmost importance to dispose the spent adsorbents.

References:

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