Removal of Cu & Fe from aqueous solution by using eggshell powder as low cost adsorbent

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ABSTRACT

In the present work, the adsorption efficiency of eggshell powder for the removal of Cu and Fe studied. Calcium carbonate, magnesium carbonate & calcium phosphate are the main constituents of eggshell powder, which have good adsorption capacity. The research is a batch scale experiment using different amount of adsorbent in solution with five different concentrations (5, 10, 20, 40, 100 mg/L) of both metals and in mixed combination. About 85% to 95% Fe removal achieved by using 0.5 to 1.5 g adsorbent for solution having concentration of 5 and 10 mg/L of Fe. Two main things comes out by the above study, first, the adsorption efficiency depends on the amount of adsorbent as the adsorption efficiency of Cu was increased from 80% to 95% in the same solution (5mg/L). Second, it a also found that adsorption efficiency was decreased about 7 % and 3% of Fe and Cu to mixed metal solution, which clearly indicates that the presence of more metals in the solution will decrease the adsorption efficiency.

Key words: Eggshell powder, Adsorption, Copper, Lead, batch experiment.
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INTRODUCTION

The continuously mixing of industrial effluents containing heavy metals to the river water causes several adverse effects. Water is essential to all forms of life and makes up 50-96 % of the weight of all plants and animals. It is also a vital resource for agriculture, manufacturing and other human activities. In urban areas, the careless disposal of industrial effluents and other wastes in rivers & lacks causing toxic effect to river water species [1-4]. Asian countries experiencing rapid industrial growth and this is making environmental conservation a difficult task [5]

Heavy metals are dangerous environmental pollutants due to their toxicity and strong tendency to concentrate in environment and in food chains, [6-7].The source of environmental pollution with heavy metals is mainly industry, i.e. metallurgical, electroplating, metal finishing industries, tanneries, chemical manufacturing, mine drainage and battery manufacturing [8]. Several big cities contribute to increase this problem, as they are sources of industrial effluents. In order to reduce the environmental pollution, a number of studies been considered to minimize the problems caused by the commonly employed treatment of metal bearing effluents [9-10]. Removal of heavy metals from wastewater achieved principally by the application of several processes such as adsorption [6], sedimentation [11], electrochemical processes [12],ion exchange[13], cementation [14] coagulation/flocculation[15], filtration and membrane processes[16], Chemical precipitation and solvent extraction[17-18]. Adsorption is the one of the important procedure for the removal of heavy metals from the environment because of strong affinity and high loading capacity.

Moradabad known as Brass City of India situated at a distance of 167 km from the national capital, New Delhi (NH-24), on the bank of river Ramganga and located at 28.830 N 780 E. It has an average elevation of 186 meters (610 feet) above sea level. The city is full of small-scale brass and steel industries. Most of these industries are in unorganized sector and thus have unplanned growth leaving to high degree of air, water and soil pollution [19-21]. The most of the industries are dumping their wastes in Ram Ganga River pass from the heart of the city. As Copper, Zinc & Iron and its compounds used in brass and steel industries, the continued intake of copper and Iron by humans leads to several severe diseases   like mucosal irritation, depression, diarrhea and most dangerous lung cancer. Therefore, it is a need to treat industrial effluents containing such heavy metals prior to discharge to protect public health. In the present study, adsorption efficiency of low cost adsorbent (eggshell powder) towards Cu and Fe has been examined.

MATERIALS AND METHODS

Adsorbent and Analysis
The eggshell used in the experiment collected from different hotels located in Moradabad city, India. The samples were then washed with distilled water several times to remove dirt particles and dried for three hours in an oven at 150^0 C and then allowed to cool, crushed and then finally sieved to prepare fine powder of $80 – 210$ μm particle size. The dried eggshell powder used as adsorbent. The chemical composition of eggshell powder determined by ICP-AES has following composition:

$CaCO_3$: 92%
$MgCO_3$: 4%
Protein : 3%
Organic Matter: 1%

Adsorbate Solution
Analytical grades of $FeSO_4$, HCl and NaOH purchased from Merck, India. Ferrous ions were prepared by dissolving its corresponding Sulphate salt in distilled water. Stock solution of Cu(II) was prepared by using $CuSO_4.5H_2O$. All chemicals used of analytical grade and distilled water was used to prepare solutions.

Adsorption Studies
Individual and mixed solutions of Fe and Cu with different concentrations of 5, 10, 20, 40, 100 mg/L were prepared , the experiment were performed using three different amount of adsorbent   0.5, 1, 1.5, in single solution. 0.5 gm adsorbent was placed in a conical flask in which 100 ml of solution with known concentration of Fe was added and the mixture was shaken in shaker. The mixture was than filtered after 24 hours contact time and final concentration of metal ion was determined in filtrate by atomic adsorption spectrophotometer (GBC 902). All the Experiments carried out in triplet and mean concentration calculated by averaging them. The procedure repeated by varying the adsorbent dose and concentration of Fe and Cu solution both individual and in mixed solution. Based on residual concentrations, the adsorption efficiency of eggshell powder is calculated and summarized in Table 1-3.

RESULTS AND DISCUSSION

The results of analysis indicate that the adsorption efficiency of eggshell powder is high for Cu (Table-1and 2). Table-1 shows the adsorption efficiency for various concentrations of Cu by 0.5 g eggshell powder. It is clear that eggshell powder is a good adsorbent for removal of Cu from wastewater. The adsorption rate is dependent on adsorbent amount and initial concentration of metal in synthetic solution. 95% removal of Cu from 5 mg/L solution was possible by applying 0.5 g eggshell powder where as the similar amount of adsorbent was not enough to treat 100mg/L Cu solution to above 65%. However, by increasing the amount of eggshell powder to 1.5 g it was possible to increase the efficiency of adsorption to about 93% for the same solution (100mg/L Cu). It shows that we would have better treatment by using excess eggshell powder.

Table- 2 shows that adsorption efficiency is dependent on the type of metal too, as for Fe we have 80% removal in same condition (0.5 gm adsorbent in solutions 5mg/L). Table-3 represent the results of adsorption experiments conducted on the mixture of metal solution as mentioned before , the maximum and minimum removal efficiency in the first stage experiments with 0.5 g of adsorbent was 95% and 80% for Cu and Fe . However, for the mixture of these metals a decrease of 3% has observed for Cu whereas Fe adsorption has decreased about 7%. The efficiency of

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Cu and Fe adsorption by various amounts of eggshell powder shown in fig-.1 to 3 for individual solution and for mixed solution of Cu and Fe (fig-4).

Table-1: Eggshell powder Adsorption Efficiency for Copper at various Concentrations
(24 hour contact time)

S. No	Quantity of Eggshell powder(gm)	Initial Concentration of Cu (mg/L)				
		5	10	20	40	100
		Adsorption Efficiency (%)				
1.	0.5	91	90	86	70	65
2.	1	93	92	90	90	80
3.	1.5	99	98	98	97.5	95

Table-2: Eggshell powder Adsorption Efficiency for Iron various Concentrations
(24 hour contact time)

S No.	Quantity of Eggshell powder(gm)	Initial Concentration of Pb (mg/L)				
		5	10	20	40	100
		Adsorption Efficiency (%)				
1.	0.5	82	82	80	73	62
2.	1	86	85	80	76.5	70.5
3.	1.5	93	90	80	80	74

Table-3: Eggshell powder Adsorption Efficiency for Copper and Iron in Mixed Metal solution using 0.5g Eggshell powder
(24 hour contact time)

S No.	Metal Solution	Initial Concentration (mg/L)				
		5	10	20	40	100
		Adsorption Efficiency (%)				
1.	Cu	88.4	87	80	80	73
2.	Fe	76.8	76	70	63	60.3

Fig. 1: % Adsorption of Copper and Iron by 0.5 g Eggshell powder
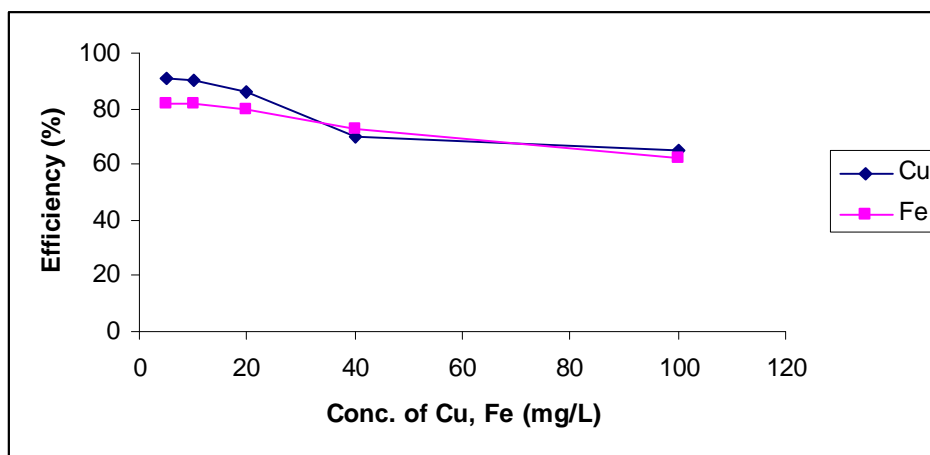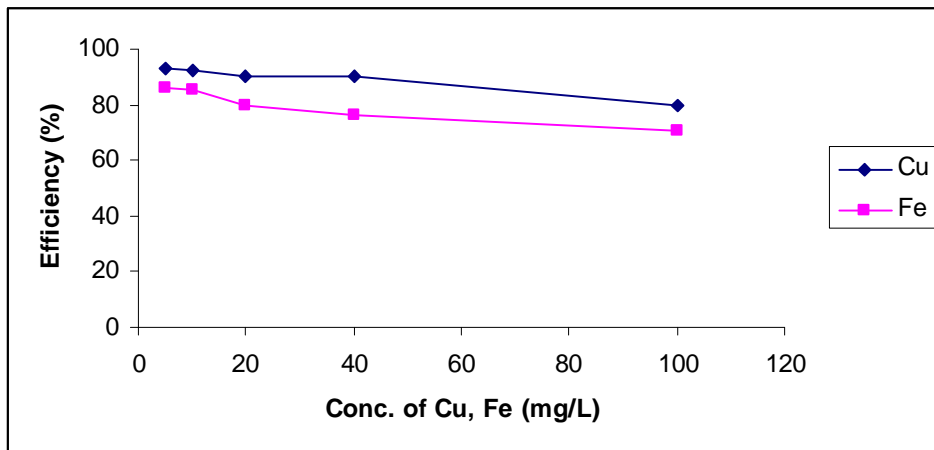
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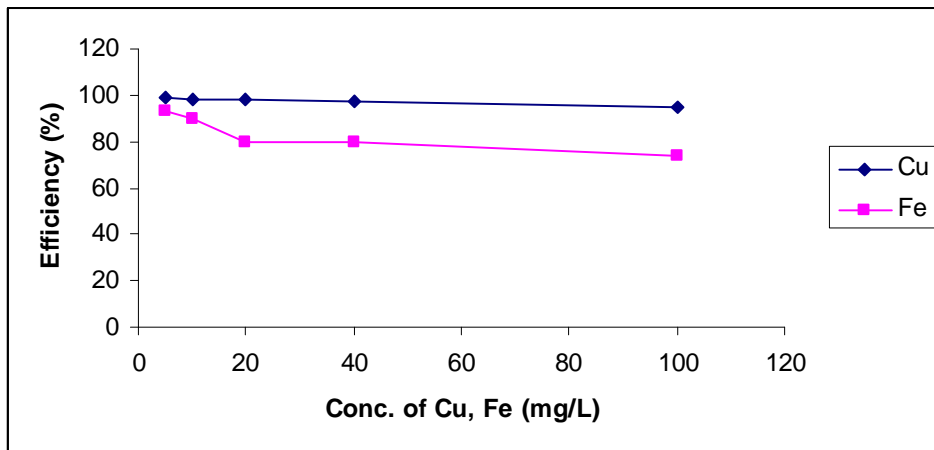**Fig. 2: % Adsorption of Copper and Iron by 1 g Eggshell powder**

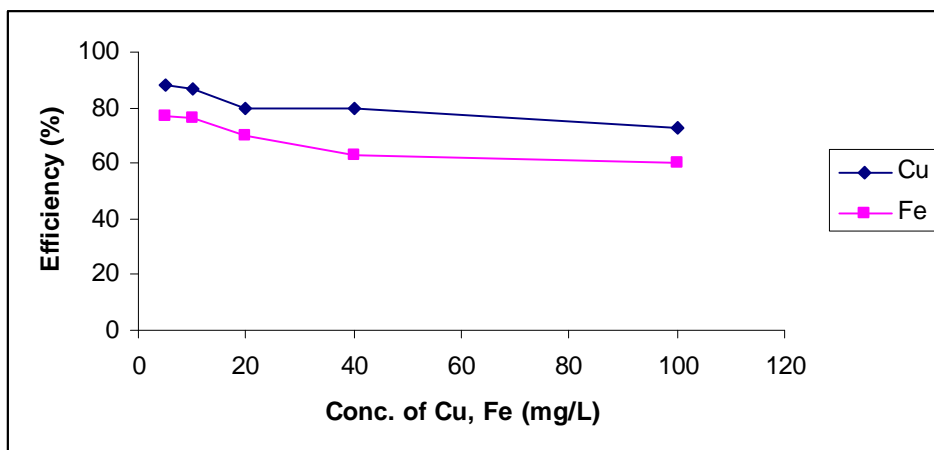**Fig. 3: % Adsorption of Copper and Iron by 1.5 g Eggshell powder**

Fig. 4: % Adsorption of Copper and Iron in Mixed Metal Solution by using 0.5 Eggshell powder

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CONCLUSION

The above analysis shows that eggshell powder like the most other natural adsorbents can be used in the treatment process of heavy metals and the treatment efficiency may be as high as 100% by precise choosing of adsorbent amount. It was also observed that the concentration of heavy metals has an important effect on the result of this treatment. Eggshell powder is a waste material and conveniently used for the treatment of industrial wastewater containing Cu and Fe heavy metals. The most important finding of the study shows that in the mixture of metal ions the percentage adsorption decreased. It clearly indicate that heavy metals need to be removed from the industrial waste before the discharge in to the rivers as study shows that the presence of one more metal will decrease the adsorption efficiency of adsorbent

REFERENCES

[1] Chindah A C, Braide A S and Sibeudu O C, *Ajeam-Ragee*, , (**2004**) 9**,** 1-14.
[2] Emongor V, Kealotswe E, Koorapetse I, Sankwasa S and Keikanetswe S, *J. Appl. Sci*., (**2005**),5**,** 147-150.
[3] Furtado A A L, Albuquerque R.T, Leite S G F and Pecanha R P, *Brazilian Journal of Chemical Engineering*, (**1998)**, 15**,**1-7.
[4] Agarwal A and Saxena M, *Der Chemica Sinica*, (**2011**),2(2),172-176.
[5] Waziri M and Ogugbuaja V O, *Am. J. Sci.Ind. Res*., (**2010**),1, 76-80 .
[6] Sari A, Tuzen M and Soylak M, *J. Hazard. Mater*, (**2007**),144, 41- 46.
[7] Bulut Y and Baysal Z, *J. Environ. Manage*, (**2006**),78**,**107-113.
[8] Matheickal J T and Yu Q, *Miner Eng*., (**1997**),10, 947–957
[9] Carvalho de R P, Freitas J R, de Sousa M G, Moreira R L, Pinheiro M V B, Krambrock K, *Hydrometallurgy*, (**2003)**, 71**,**277-283.
[10] Valdman E, Leite S G F, *Bioprocess Engineering,*, (**2000**), 22, 171-173
[11] Song Z, Williams C J, Edyvean RG J, *Desalination*, , (**2004),** 164, 249-259.
[12] Fahim N F, Barsoum B N and Eid A E, *J. Hazard. Mat.,* (**2006**), 136**,** 303-337.
[13] Tiravanti G, Petruzzelli D and Passino R, *Water Sci. Technol*., (**1997**),36**,**197–207.
[14] Filibeli A, Buyukkamaci N and Senol H, *Resour.Conserv. Recy*., (**2000**), 29**,**251- 261.
[15] Song Z, Williams C J and Edyvean R G J, *Water Res.,* (**2000**), 34,2171-2176.
[16] Fabianil C, Rusciol F, Spadonil M and Pizzichini M, *Desalination,* (**1996**), 108**,**183.
[17] Fabianil C, Rusciol F, Spadonil M and Pizzichini M, *Desalination,* (**1996**), 108**,**183.
[18] Brooks C S, Metal recovery from industrial waste, *Lewis Publisher*, USA, (**1991**)
[19] Agarwal A and Saxena M, *International Journal of Environmental Engineering and Management,* (**2011**), 2(1) ,107-110
[20] Agarwal A and Saxena M, *Asian J. of Water, Environment and Pollution,* (**2011**), 8,97-100.
[21] Schaafsma A,. Pakan I, Hofstede G.J.H., Muskiet F.A.J., Vander Veer E.,
[22] De Vries P.J.F, *Poultry Sci*., (**2000**),79 1833-1838.