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Studies on Selective Batch Adsorption of Cu(II) and Cr(VI) from aqueous solution

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Abstract:
Copper and Chromium are hazardous heavy metals which are present in most industrial effluent streams which, if not removed, are potential threats to both environment and health of living organisms. So the removal of these metals has become rather imperative. So various techniques have come up over the last few decades but most of them are energy and cost intensive. Adsorption is a technique which has quite less energy requirements and found to be economic. In the current study, selective adsorption of these metals from the aqueous solution using activated charcoal adsorbent has been analyzed. Selective batch adsorption of the metals is studied with two variables (adsorbent dosage, adsorbate dosage), keeping one constant at a time. The results showed that selective adsorption of Cu(II) from the solution is possible using the adsorbent considered.

Keywords: *Activated charcoal, Aqueous solution, Batch adsorption, Cr(VI), Cu(II), Selective.*

Introduction

Copper in small amounts plays a vital role as a cofactor in a variety of essential enzymes required for homeostasis, growth and development in humans [1-3]. The natural concentration of Cu is about 50 ppm in soil, 4-10 μg/L in water (usually bound to organic materials) and 18-45 μg/g in the human liver (dry weight), but excessively high doses of Cu, introduced by the ingestion of food or water with excessive Cu content, may result in a variety of symptoms and illnesses. While these primarily affect the liver, in the form of cirrhosis, they may also result in general weakness, lethargy and anorexia. Copper enters the environment primarily through chemical-related industries such as metal plating and cleaning [4-6]. The current work focuses on removal of hazardous heavy metals from industrial effluent stream to reduce water pollution. This study exclusively focuses on selective removal of Cu(II) and Cr(VI) from wastewater using activated charcoal adsorbent.

Materials and methods

Parameters studied

- Amount of Cu(II) and Cr(VI) each (adsorbate): 1g, 2g, 3g, 4g and 5g.
- Amount of activated charcoal (adsorbant): 3g, 5g and 10g.
- Time of contact: 15 min, 30 min, 45 min and 60 min.

System

The system consists of distilled water, Cu(II) (as $CuSO_4.5H_2O$), Cr(VI) (as $K_2Cr_2O_7$) and activated charcoal.

Apparatus used

250 ml erlenmeyer flasks, shaker and refractometer.

Experimentation

Calibration Procedure

For the preparation of the calibration chart, in 6 different 250 ml erlenmeyer flasks, 100 ml distilled water and 1g of Cr is added to each flask and varying amount of Cu (0g, 1g, 2g, 3g, 4g and 5g) is added. The solution is mixed thoroughly to avoid

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formation of lumps. Once a uniform solution is obtained, the refractive index of the solution is measured using a refractometer. A calibration chart is prepared using the data obtained and a calibration graph is plotted between Refractive Index and weight of Cu present in solution [7-8].

Weight of Cu (g)	Refractive Index
0	1.391
1	1.393
2	1.3971
3	1.4023
4	1.4032
5	1.4053

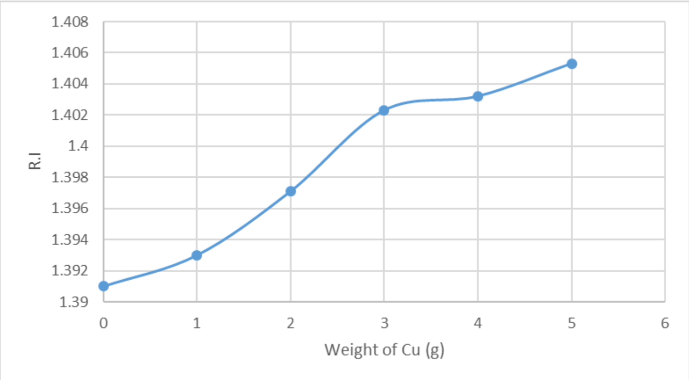

Fig 1: Calibration plot

Experimental Procedure

The adsorption process is carried out in Erlenmeyer flasks. Initially the dosage of Cu (adsorbate) is varied in a 100 ml distilled water system containing 1g Cr for a dosage of activated charcoal adsorbent (1g, 2g, 3g, 5g and 10g). These samples are put in a mechanical shaker for uniform contact. The contact period is 45 minutes, at which equilibrium is expected to attain. The filtrate is separated using a filter paper and separating funnel arrangement. The refractive index of the filtrate is measured using a refractometer and using the calibration plot, the weight of adsorbate in the filtrate is estimated [9-10]. Similar procedure is repeated varying the dosage of activated charcoal adsorbent for a dosage of adsorbate (1g, 2g, 3g, 4g and 5g) in 100 ml distilled water and 1g Cr.

Results and Discussions

Effect of Adsorbent dosage on selective adsorption of Cu(II)

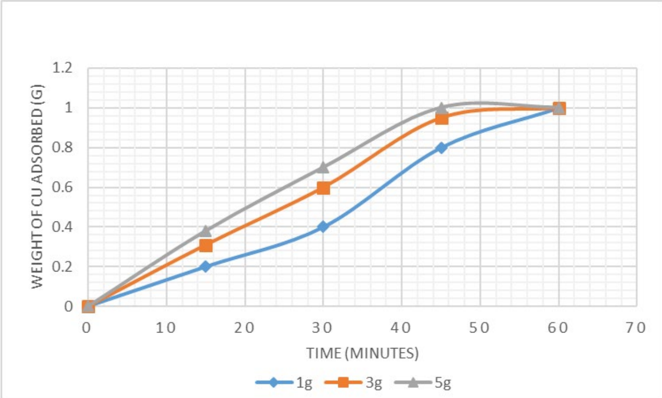

Fig 2. Weight of Cu adsorbed (g) vs Time of contact (minutes)

Fig 2. shows the relation between weight of copper adsorbed and time of contact for different weights of activated charcoal for a dosage of adsorbate (Cu-3g , Cr-1g).

It is observed that as the time of contact of contact increased, the recovery of Copper is better. Also as the weight of adsorbant increased, the rate of adsorption is increasing. Similar trends are observed for other adsorbate dosages (1g, 2g, 4g and 5g).

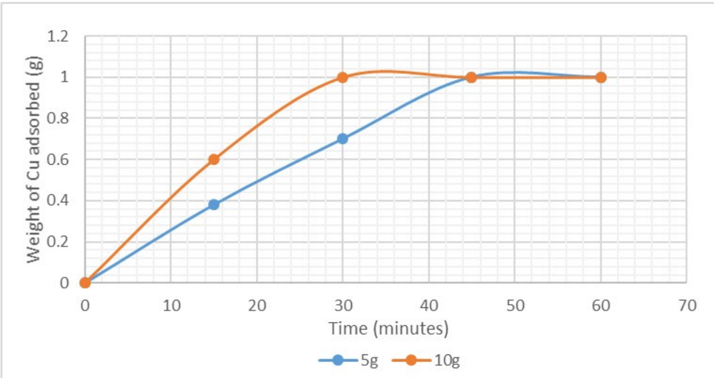

Fig 3. Weight of Cu recovered (g) vs Time of contact (minutes)

Fig 3. shows the comparison between the recovery with time for 5g adsorbent and 10 g adsorbent. It is observed from the plot that over certain time of contact, the recovery is constant for both dosages. The weight of Copper recovered is remaining

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constant after certain time of contact. For 10 g of adsorbent, beyond 30 minutes, the recovery is remaining constant and for 5g of adsorbent, beyond 45 minutes, the recovery is remaining constant.

Effect of time of contact on selective adsorption of Cu(II)

Table 1. Weight of Cu recovered vs Time of contact

Weight of Cu recovered (g)	Time of contact (minutes)
0	0
0.6	15
1	30
1	45
1	60

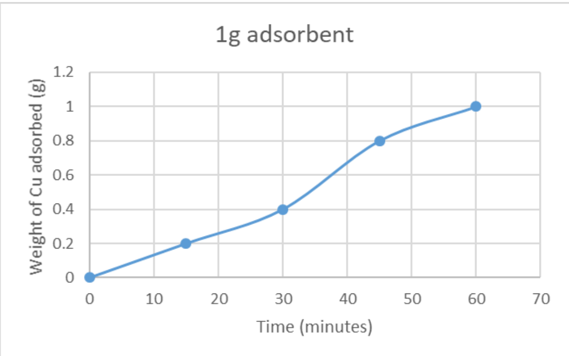

Fig 4. Weight of Cu recovered (g) vs Time of contact (minutes)

Table 1 and Fig. 4 show the variation of recovery with time of contact for an adsorbent dosage of 10g. It is observed from the plots that with the increase in time of contact, the recovery increased initially till 30 minutes and beyond that the recovery remained constant.

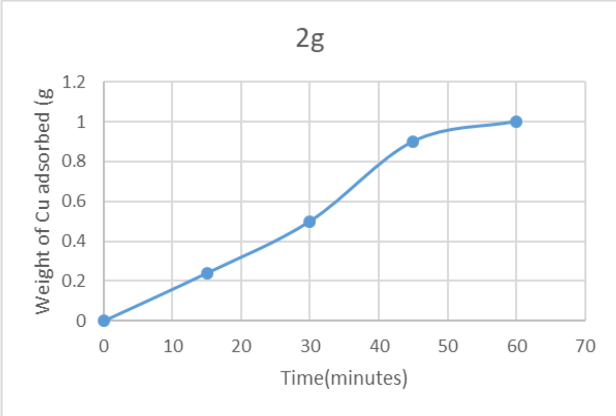

Fig 5. Weight of Cu recovered (g) vs Time of contact (minutes)

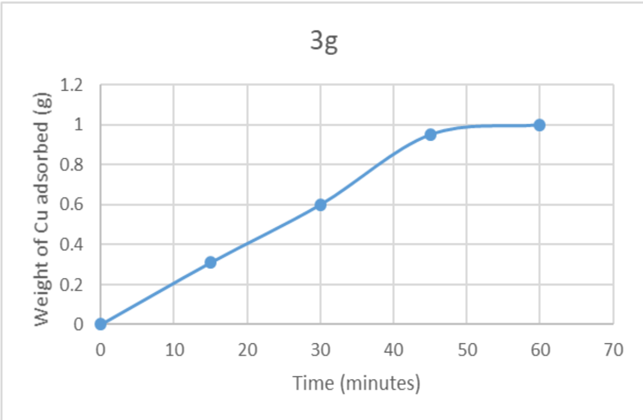

Fig 6. Weight of Cu recovered (g) vs Time of contact (minutes)

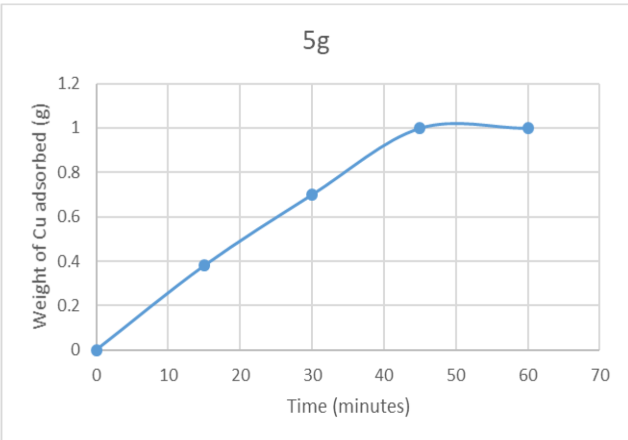

Fig 7. Weight of Cu recovered (g) vs Time of contact (minutes)

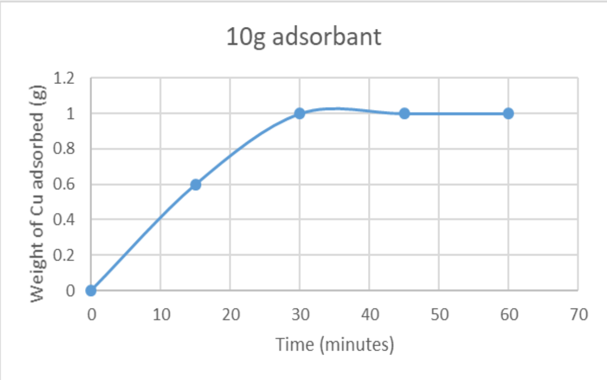

Fig 8. Weight of Cu recovered (g) vs Time of contact (minutes)

Similar trends are observed as shown in Fig. 5-8 for different weights of adsorbents and for different combinations of Cu and Cr but the time required to reach saturation point (constant recovery with increase in time) is different for different dosages of adsorbent and dosages of adsorbate.

Conclusions

Selective adsorption of Cu(II) is possible using activated charcoal from a Cu-Cr aqueous solution. The selective adsorption of Cu(II) using activated charcoal is affected by the parameters such as the dosage of adsorbent, dosage of adsorbate and time of contact. The current study is carried out in a batch process and using this a continuous process can be designed on the basis of the data obtained.

The maximum recovery of Cu(II) is 1g for any dosage of adsorbate starting from 1g of adsorbate and ranging upto 5g for a time of contact of 30 minutes for 3g dosage of adsorbate. Even for higher dosages of adsorbent the recovery is same though the time of contact required is less for higher dosages.

From the study, it is concluded that activated charcoal can be used to achieve almost 100% recovery of Cu(II) in dilute to moderate concentrations with minimum amount of adsorbent (1g or less).

REFERENCES

1. Ajmal MA, Hussain Khan S, Ahmad and Ahmad A., (1998). “Role of sawdust in the adsorption of Cu (II) from industrial wastes”. Wat. Res, Vol. 32, pp. 3085-3091.
2. Ajmal MA, Mohammad R., Yousuf and Ahmad A., (1998). “Adsorption behavior of Cadmium, Zink, Nickel, and Lead from aqueous solution by Mangifera India Seed Shell”. India J. Environment Health, Vol. 40, pp. 15-26.
3. Malkoc E., and Nuhoglu Y., (2005). “Investigations of Nickel (II) Adsorption from Aqueous Solutions Using Tea Factory Waste”. J. Hazardous Materials, B127, 12.
4. Malkoc E., and Nuhoglu Y., (2006). “Fixed bed studies for the sorption of chromium (IV) onto tea factory waste”. Chem. Eng. Sci., Vol. 61, pp. 4363-4370.
5. Malkoc E., and Nuhoglu Y., (2006). “Adsorption of Ni (II) ions from aqueous solutions using waste of tea factory: adsorption on a fixed-bed column”. J. Hazardous Materials, B135 pp. 328-236.
6. Malkoc E., and Nuhoglu Y., (2007). “Potential of tea factory waste for chromium (VI) adsorption from aqueous solutions: thermodynamic and kinetic studies”. Sep. Purif. Technol., Vol. 54, pp. 291-298.
7. ASTM E478 - 08. “Standard Test Methods for Chemical Analysis of Copper Alloys”.
8. S.V.A.R.Sastry & B.Sarva Rao, (2016). “Studies on adsorption of Cu (II) using spent tea extract (STE) from industrial wastewater”. i-manager’s Journal on Future Engineering & Technology, Vol. 11 (3), pp. 31-35.
9. K. Anoop Krishnan, K.G. Sreejalekshmi, V. Vimexen, Vinu V. Dev, (2016). “Evaluation of adsorption properties of sulphurised activated carbon for the effective and economically viable removal of Zn(II) from aqueous solutions”. Ecotoxicology and Environmental Safety, Vol. 124, pp. 418-425.
10. S.V.A.R.Sastry & B.Sarva Rao, (2017). “Determination of adsorption kinetics for removal of copper from wastewater using Spent Tea Extract (STE)”. i-manager’s Journal on Future Engineering & Technology, Vol. 12 (4), pp. 27-32.