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Working Paper · January 2018

DOI: 10.13140/RG.2.2.21388.21128

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Article-26

Poll Res. 37 (1) : 197-199 (2018)

ISSN 0257–8050

REMOVAL OF TOXIC HEAVY METAL IONS USING MODIFIED ADSORBENT

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(Received 10 July, 2017; accepted 16 August, 2017)

ABSTRACT

The efficiency of iron hexamine gel for the removal of certain heavy metal ions has been increased by distributing the gel on used tealeaves. This modified tealeaves (MTL) exhibits good adsorption potential for mercury (II), lead (II), and chromium (VI); significant uptake for nickel (II), cadmium (II), and copper (II); but is a poor scavenger for zinc (II) and manganese (II). The adsorbent columns have been used to remove chromium (VI), mercury (II) and lead (II) from aqueous solutions.

KEY WORDS: Used Tealeaves, Iron Hexamine gel, Heavy Metal Ions

INTRODUCTION

The analytical importance of chelating ion-exchangers in the field of separation and preconcentration of metal ions has received attention owing to their simplicity, elegance and range of variations. In recent years, removal of heavy metal ions from aqueous solutions has been a major concern (Deshkar *et al.*, 1990; Huang, 1977; Shi *et al.*, 2011; Ghoul *et al.*, 2003; Srivastava *et al.*, 1989 and Zhang *et al.*, 1987) Water, being an excellent solvent is more severely threatened by pollution due to industrial waste and excessive inputs of population. Complexones have been used for the preparation of the new chelating resins. One outstanding feature of chelating ion – exchangers is that, a very high selectivily can be attained. In comparison to ion – exchangers and other adsorbents, chelating ion –exchangers have received great attention recently in the field of separation and preconcentration of metal ions (Singh *et al.*, 1987, Gurgel *et al.*, 2009 and Brajter *et al.*, 1988). Iron hexamine gel (IHA) as a chelating material has already been studied for the separation and recovery of certain metal ions (Singh *et al.*, 1989). The objective of the present study is to increase the efficiency of removal of certain heavy metals by distributing iron hexamine gel on used tealeaves.

MATERIALS AND METHODS

Systronic digital pH meter and Perkin Elmer model 552 spectrophotometer were used. Iron (III) nitrate (BDH, India) and hexamine (Lobe, India) were used. All other reagents were of analytical grade.

Used tealeaves sieved for desired mesh size 60 – 100 was washed with demineralised water, filtered and dried at 60^0 C, 250 ml of 0.1 mol/dm^3 iron (III) nitrate solution was added to the weighed amount of used tealeaves, stirred for 3h. Then, 150 ml of 0.4 mol/dm^3 hexamine solution was added and stirring was continued for further 12h. After aging for 24h, the material was filtered, washed with demineralised water and dried at 60^0 C. For adsorption studies, equal amounts of adsorbent (0.2 g) were shaken with 25 mL of 8 x 10 $^{-3}$ mol/dm^3 metal ion solutions at desired pH (adjusted using 0.25 mol / dm^3 hydrochloric acid – 0.25 mol/dm^3 sodium acetate), until equilibrium was attained . Solutions were separated by filtration and the uptake of metal ions was calculated by the

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difference in their initial and final concentrations. Cr (VI) was determined spectrophotometrically using diphenylcarbazide while the concentrations of Pd (II), Mn (II), Ni (II), Hg (II), Cd (II), Cu(II) and Zn (II) were obtained titrimetrically using EDTA. Breakthrough studies were performed in a glass column (30 x 0.39 cm ^{2}) packed with 2g of MTL $_1$ on a glass wool support. The metal ion solution (0.1 mg ml $^{-1}$ each, pH~ 6) were percolated downwards, under gravity at flow rate of 1.5 mL m^{-1}. The operation of column was stopped when metal ion appeared in the effluent . A glass column (30 x 0.79 cm ^{2}) packed with 5 g MTL$_1$ was used for the removal of metal ions. Water samples were passed through the column, at the flow rate of nearly 1.5 mL m^{-1}.

RESULTS AND DISCUSSIONS

The distribution of iron hexamine gel on used tealeaves was found very stable that the product could be utilized for the removal of certain toxic metals. The results of adsorption studies of hexavalent chromium {Cr(VI)} on MTL are presented in Table 1. The sorption capacity data reveal that the uptake of Cr (VI) per weight of dry adsorbent decreases with the increased amount of used tealeaves. However, the capacity g -1 of IHA (calculated on the basis of yield of adsorbent), increases with increased amount of used tealeaves . Probably, the increase in the surface area of the gel is responsible for this increased capacity. The sample (MTL$_1$) is chosen for detailed studies. The uptake of metal ions as a function of pH is shown in Fig 1. The uptake of metal ions decreases with the increasing acidity of the solution except in case of Hg (II) and Cr (VI). The breakthrough curves (C / C 0 vs. eluant volume) were of the traditional S shape. The breakthrough studies showed that 38 bed volumes of Cr (38 mg Cr) could be passed through the column without any trace of Cr being detected in the effluent while in case of untreated used tealeaves column, breakthrough occurred in the first bed volume. For Pb(II) and Hg (II) breakthrough was observed after 45 and 49 bed volumes, corresponding to 45 and 49 mg of Pb and Hg respectively. The breakthrough capacity of metal ions is higher than the batch capacity (Fig. 1). Flow rate greater than 3 mL m^{-1} and increased cross - sectional area of the column resulted decrease in removal efficiency, due to decreased contact time. The effect of foreign metal ions: Mn (II), Zn (II), Ni (II) and Cu (II) in the removal efficiency of Cr (VI) and Hg (II) was studied. It has been observed that the removal efficiency remains almost same in acidic solutions (pH ~ 2) due to elution of diverse ions. The experimental results of the removal of Cr (VI), Hg (II) and Pb (II) from water samples are given in Table 2.

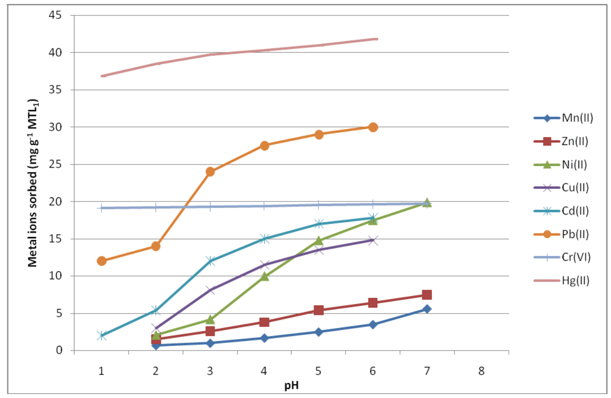

Fig. 1. Sorption of metal ions as function of pH

CONCLUSION

Used tealeaves is waste material. The efficiency of removal of toxic metal ions can be improved by distributing iron hexamine gel on used tealeaves. Regeneration of the adsorbent has been tried by eluting the adsorbed metal ions using appropriate eluants in order to restore the column for further use.

Table 1. Preparation and properties of iron hexamine modified tea leaves (MTL)[c]

Adsorbent	Used Tealeaves added (g)	Yield[a]	Sorption capacity for Cr (VI) (mg g^{-1} MTL)	Sorption capacity[d] for Cr (VI) (mg g^{-1} IHA)
IHA	0.00	4.620	-	26.550
MTL$_1$	5.0	10.125	20.112	41.354
MTL$_2$	10.0	15.243	14.981	46.084
MTL$_3$	5.0	10.312	20.483	42.046

[a] 250 mL of 0.1 mol/dm^3 iron (III) nitrate + used tea leaves + 150 mL of 0.4 mol / dm^3 hexamine :

Table 2. Removal of metal ions from water samples.

Sl. No.	Sample	Metal ions	Volume of effluent (mL)	Concentration of metal (ppm)	Approximate pH of water sample	Removal* %
1.	Distilled Water	Cr (VI)	7000	10	6	99.0 ± 0.9
			8000	10	6	94.0 ± 0.7
			9000	10	6	85.3 ± 0.6
			14000	5	6	99.5 ± 0.6
			16000	5	6	95.3 ± 0.9
2.	Tap Water	Cr (VI)	4000	10	6	100 ± 0.7
			5000	10	6	91.9 ± 0.9
			5000	10	2	99.2 ± 1.0
			6000	10	2	92.4 ± 1.1
3.	Tap Water	Hg (II)	5000	10	3	100 ± 0.5
			6000	10	3	95.8 ± 1.1
4.	Tap Water	Pb (II)	3000	10	6	100 ±1.3
			4000	10	6	88.8 ±1.4

[b] Mesh size of used tealeaves was 100 –140 : [c] Appearance of adsorbent was brownish black : [d] Calculated on the basis of yield.
*Mean and Standard deviation for five measurements

ACKNOWLEDGEMENT

All necessary research assistance from B.S.N.V P.G. College, Lucknow University, and from CDRI, Lucknow, Uttar Pradesh, India is gratefully acknowledged.

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