International Journal of Science and Healthcare Research
Website: www.gkpublication.in/ijshr

Original Research Article

Batch Adsorption for Iron and Chromium Removal by Low Cost Adsorbents: Studies on Affecting Parameters

Sunil J. Kulkarni, Lalit Bhole, Mandar Rampure

Datta Meghe College of Engineering, Airoli, Navi Mumbai, Maharashtra, India.

Corresponding Author: Sunil J. Kulkarni

Received: 30/01/2016 | Revised: 02/02/2016 | Accepted: 08/02/2016

ABSTRACT

Heavy metal removal from wastewater can be carried out by various chemical, physical and biological methods. The presence of heavy metal can affect man and environment adversely. The heavy metal treatment by using adsorption can be carried out by using low cost adsorbents. In the present research, the bagasse and groundnut shells are used as low cost starting materials for adsorbent preparation. Batch studies are carried out for studying removal of iron and chromium from synthetic wastewater for bagasse adsorbent (BA) and groundnut shell adsorbent (GSA). It was observed that optimum adsorbent dosage of 2.5 g/100 ml and 1.5 g/100 ml were sufficient for adsorption of almost 90% of the initial metal concentration for iron and chromium respectively. The amount of the metal removed at optimum pH increased with increase in adsorbent dosage. The optimum pH for the removal of chromium (VI) and iron (III) was in the range of 2 to 4 for both, BA and GSA.

Key words: Heavy metals, adsorbate, adsorbent, contact time, concentration.

INTRODUCTION

Removal of heavy metal from wastewater can be carried out by methods such as electrodialysis, ion exchange, membrane separation, biological treatments and chemical treatments. The presence of iron in natural water may be attributed to the dissolution of rocks and minerals, acid mine drainage, landfill leachate sewage or engineering industries. The presence of iron concentration above 0.1 mg/l can damage the gills of fish. Ferrous sulphate is unstable and precipitates as insoluble ferric hydroxide, which settles out as rust coloured silt. Such water often tastes unpalatable even at low concentration (0.3 mg/l) and stains laundry and plumbing fixtures.

Breathing, eating or drinking and through skin contact with chromium of chromium compounds are routs through which chromium enters our body. It can cause allergic reactions, such as skin rash. [1,2] Inhaling Chromium (VI) can cause nose irritations and nosebleeds. The main route of chromium uptake is food chain, as chromium (III) occurs naturally in many vegetables, fruits, meats, yeasts and grains. In the current research low cost adsorbent materials are used for adsorbent preparation. Removal of heavy metals by adsorption is widely investigated research. Removal of heavy metals by adsorption was carried out by various investigators by using various biological, physical and chemical treatment methods. [3-5]

Membrane separation is also tried for metal ion removal from water. Adsorption is one of the widely investigated methods for heavy metal removal. [6-12] Iron and Chromium removal has been investigated by various investigators. Banerjee et.al. investigated removal of Cr(VI) and Hg(II) from aqueous solutions using fly ash and impregnated fly ash. [13] Biosorption of heavy metals by sphaerotilus natans was carried out by Esposito et.al. [14]

Biosorption of Chromium (VI) from aqueous solutions by green algae spirogyra species was studied by Gupta et.al. [15] Removal of toxic metal ions from metal finishing wastewater by solvent extraction was investigated by McDonald et.al. [16]

In present investigation, the batch experiments are carried out to study effect of parameters such as pH, contact time, and adsorbent dose on heavy metal removal.

METHODOLOGY

Preparation of Adsorbents: Agricultural waste was solar dried & crushed in hammer mill. The crushed powder was screened and undersize having average particle size of 0.3mm to 1.2mm was taken for further treatment. Impregnation of sugarcane Bagasse and ground nut shells powder with strong acid was carried out. This impregnated powder was then carbonized in the furnace at various temperatures from 300^o to 500^oC. The washed product was then filtered out and dried at 120^o C. The carbonized powder was then washed with hot water at a rate of 20ml/gm of powder to remove the traces of strong acid. Fig 1 shows physical appearance and nature of raw materials.

Fig 1: Bagasse and groundnut shells

Preparation of Stock Solution: An aqueous stock solution of Iron(Fe) (III) ions (1000ml/l) is prepared by dissolving 7.022gm of ferrous ammonium salt in 500ml of water and 50 ml of 1:1 sulfuric acid was added. The solution was warmed and oxidized with approximately 0.1% $KMnO_4$ until the solution remains faint pink. The pH of the solution was adjusted using 0.1N HCl or NaOH. Fresh dilutions were used for each study. In this solution 1ml=200 µg Fe.

Chromium (Cr) stock solution was prepared by dissolving 141.4 mg of $K_2Cr_2O_7$ in 100 ml of water. Therefore in 1ml of solution concentration is 0.141mg of $K_2Cr_2O_7$ and 70.5 µg of Cr. Dilute 1ml of Chromium stock solution to 100ml of water. Therefore concentration of chromium in standard solution was 70 µg/ml. 0.04 gm of 1, 5 diphenylcarbazide was dissolved in 20 ml Iso-propyl alcohol. 8 ml of conc. H_2SO_4 diluted by addition of 72 ml distilled water was added. Above solutions were mixed. In this solution 1ml = 500µg Cr. Fig.2 and 3 shows stock solution samples.

Batch Experimentation:

The standard stock solutions of iron and chromium were prepared and adsorbents were segregated on the basis of weight such as 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4 g/100ml. And pH of chromium solution was adjusted to 3-4.

Batch experiment were performed to study the adsorption parameters like effect of adsorbent dosage, effect of agitation time, and effect of pH on metal uptake efficiency. The effect of adsorbent dosage for different dosage ranging as 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4 g/100ml bagasse and ground nut shells. The agitation time and p^H were kept constant. For determination of rate of sorption by bagasse and groundnut shells, the supernatant was analysed for residual metal at different time intervals. The p^H and the adsorbent doses were kept constant and the agitation time was changed. To determine the effect of pH on the adsorption of metal solution of different concentration, pH was adjusted to values and effluent was mixed with known weight of adsorbent and agitated. Dilute HCl or NaOH were used to adjust the p^H of the solution.

Fig.2: Iron stock solution

Fig 3: Chromium stock solution

RESULTS

Bagasse Adsorbent: For Iron and chromium removal by bagasse adsorbent, effect of adsorbent dosage was studied by keeping agitation time constant as 45 minutes and also initial concentration(C) was kept constant for chromium (Table1,2).

The effect of agitation was studied with keeping adsorbent dose constant as 2.5 g/100ml for bagasse also initial concentration was kept constant (Table3,4). Effect of pH was studied by keeping agitation time constant as 70 minutes for iron and 60 minutes for chromium and also adsorbent dose was kept constant as 2.5 g/100ml for bagasse (Table 5,6).

Table 1: Iron Removal by Bagasse Adsorbent: Effect Of Adsorbent Dose

Adsorbent Dose (g)	% Adsorbed	C (ppm)
0.5	19.10	161.8
1	27.79	144.42
1.5	43.27	113.46
2	56.82	86.36
2.5	89.72	20.56
3	78.21	43.58
3.5	69.74	60.52
4	74.93	50.14

Table 2: Chromium Removal By Bagasse Adsorbent: Effect Of Adsorbent Dose

Adsorbent Dose (g)	% Adsorbed	C(ppm) (ppm)
0.5	13.19	434.05
1	47.32	263.4
1.5	91.47	42.65
2	86.72	66.40
2.5	68.11	159.45
3	74.21	128.95
3.5	67.37	163.15
4	55.81	220.95

Table 3: Iron Removal By Bagasse Adsorbent:Effect Of Agitation Time

Agitation Time (min)	% Adsorbed	C(ppm)
10	17.12	165.76
20	25.43	149.14
30	47.83	104.14
40	56.40	87.2
50	69.81	60.38
60	81.31	37.80
70	88.42	23.16
80	88.24	23.52
90	88.67	22.56

Table 4: Chromium Removal By Bagasse Adsorbent: Effect Of Agitation Time

Agitation Time (min)	% Adsorbed	C(ppm) (ppm)
10	13.42	432.9
20	22.87	385.65
30	46.12	269.4
40	66.17	169.15
50	84.32	78.4
60	84.57	77.15
70	84.82	75.90
80	84.94	75.30
90	84.99	75.50

Table 5: Iron removal by bagasse adsorbent: effect of pH

pH	% Adsorbed	C (ppm)
1	79.43	41.14
2	91.47	17.06
3	68.21	63.38
4	56.83	86.34
5	81.11	37.78
6	84.29	31.42

Table 6: Chromium removal by bagasse adsorbent: effect of pH

pH	% Adsorbed	C(ppm) (ppm)
1	66.27	168.65
2	71.43	142.85
3	87.21	63.95
4	79.83	100.85
5	56.21	218.95
6	62.11	189.45

Table 7: Removal of Iron by groundnut shell adsorbent: Effect of adsorbent dosage

Adsorbent Dose (g)	% Adsorbed	C(ppm)
0.5	9.21	181.58
1	21.43	157.14
1.5	43.47	113.06
2	55.08	89.84
2.5	88.67	22.66
3	91.27	17.46
3.5	83.61	32.78
4	71.81	56.38

Table 8 Removal of Chromium by Groundnut Shell Adsorbent: Effect of Adsorbent Dosage

Adsorbent Dose (g)	% Adsorbed	C(ppm)
0.5	19.72	401.41
1	29.48	252.60
1.5	57.83	210.85
2	72.43	137.82
2.5	87.21	63.95
3	76.87	115.63
3.5	63.21	183.95
4	80.82	95.90

Table 9: Removal of Iron by Groundnut shell adsorbent: Effect of agitation time

Agitation Time (min)	% Adsorbed	C(ppm) (ppm)
10	11.34	177.32
20	27.41	145.18
30	39.66	120.68
40	57.83	84.34
50	81.77	36.46
60	85.32	29.36
70	84.92	30.16
80	85.11	29.78
90	85.81	28.38

Table 10: Removal of Chromium by Groundnut shell adsorbent: Effect of agitation time

Agitation Time (min)	% Adsorbed	C (ppm)
10	10.11	449.45
20	22.73	386.35
30	35.53	322.35
40	43.21	283.95
50	56.81	215.75
60	65.43	172.85
70	86.83	65.85
80	86.91	65.45
90	86.98	65.10

Groundnut Shell Adsorbent: Effect of adsorbent dosage was studied by keeping agitation time constant as 45 minutes and constant initial concentration iron and chromium (Table 7,8). The effect of agitation was studied with keeping adsorbent dose constant as 1.5 g/100ml for groundnut shell also initial concentration is kept constant as 200ppm/1ml for iron and 500ppm/1ml for chromium (Table 9,10). Also effect of pH was studied on metal uptake as indicated in table 11 and 12.

Table 11: Removal Of Iron By Groundnut Shell Adsorbent: pH Effect

pH	% Adsorbed	C(ppm)
1	61.83	76.34
2	73.06	53.88
3	79.12	41.76
4	88.72	22.56
5	64.82	70.36
6	57.77	84.46

Table 12: Removal of Chromium by groundnut shell: pH effect

pH	% Adsorbed	C(ppm)
1	67.42	162.9
2	81.23	93.85
3	92.44	37.8
4	87.63	61.85
5	70.12	149.4
6	59.87	200.65

DISCUSSION

Effect of adsorbent dosage was studied. From the results it was observed that adsorption efficiency or metal uptake varies with the adsorbent dosages. The optimum metal uptake was noted for particular adsorbent dosage such as for bagasse adsorbent maximum removal of iron and chromium was obtained for 2.5 g/100ml and 1.5 g/100ml respectively.

The effect of agitation time was studied with keeping adsorbent dose constant as 2.5 g/100ml for bagasse also 1.5 g/100ml for groundnut shell and initial concentration was kept constant It· was observed that adsorption goes on increasing till equilibrium time is achieved, and then onwards no significant rise in adsorption is observed. Also effect of pH was studied by keeping other parameters constant. Acidic conditions favoured adsorption. The availability of adsorbent sites, availability of adsorbate, interference of H^+ and OH^- ions and difficulty in reaching the active sites may be reasons for the effect of these parameters on adsorption.

Effect of pH was studied by keeping agitation time constant as 70 minutes for iron and 60 minutes for chromium and also keeping adsorbent dose constant as 2.5 g/100ml for bagasse and 1.5 g/100ml for groundnut shell. The analysis has been carried out and it was observed that, for iron maximum metal recovery was obtained at p^H value 2 and for chromium the maximum recovery was obtained at p^H value 2.5-3.

CONCLUSION

The present investigation shows that the agricultural by-products like sugarcane bagasse and groundnut shells can be used as effective raw materials for adsorbent preparation for the treatment of wastewaters containing metals like chromium (VI) and iron (III). Effect of parameters such as agitation time, adsorbent dosage and pH on the removal of metals was examined.

The uptake of metals increased with increase in the agitation time till the equilibrium was reached. The percentage of metal removed increased with increase in adsorbent dosage due to increased adsorption surface area. For all the adsorbents studied adsorbent dosage of 1.5g-2.5 g/100 ml were sufficient for adsorption of almost 90% of the initial metal concentration. The optimum pH for the removal of chromium (VI) and iron (III) was in the range of 2 to 4 for both, BA and GSA.

REFERENCES

1. Sumit Chibbar, Nandini Sharma, A Review on Impact of Heavy Metal Toxicity on Environment ,Int. Journal of Innovative Reseach and Studies, 2014, 3(5), 530-541, 2014.
2. Sunil J. Kulkarni, Sonali R. Dhokpande, Dr.Jayant P. Kaware, A Review on Studies on Effect of Heavy Metals on Man and Environment, International Journal for Research in Applied Science and Engineering Technology, 2014, 2(10), 227-229.
3. Sunil J. Kulkarni, Dr. Jayant P. Kaware, A Review on Research for Cadmium Removal from Effluent‖, International Journal of Engineering Science and Innovative Technology, 2013, 2(4), 465-469.
4. Sunil J. Kulkarni, Dr. Jayant p. Kaware, Fixed Bed Removal of Heavy Metal- a Review, International Journal of Research (IJR), 2014, 1(6), 861-870.
5. M.H. Salmani, M.H. Ehrampoush, S Sheikhalishahi, M. Dehvari, Removing Copper from Contaminated Water Using Activated Carbon Sorbent by Continuous Flow, Journal of Health Researches, 2012, 1(1), 11-18.
6. Sunil J. Kulkarni, Jayant P. Kaware, Cadmium Removal By Adsorbent Prepared From Local Agricultural Waste Of Rice Processing, International Journal of Scientific Research in Chemical Engineering, 2015, 2(1), 14-22.
7. Kulkarni S.J, Goswami A.K, Applications And Advancements In Treatment Of Waste Water By Membrane Technology- A Review, International Journal Of Engineering Sciences and Research Technology, 2014, 3(9),446-450.
8. Kulkarni S.J, Kaware J.P, Adsorption For Cadmium Removal From Effluent- A Review, International Journal of Science, Engineering and Technology Research 2013, 2(10), 1840-1844.
9. Yuh-Shan Hoa, Augustine E. Ofomaja, Kinetic Studies Of Copper Ion Adsorption On Palm Kernel Fibre, Journal of Hazardous Materials, 2006, B137, 1796–1802.
10. Kulkarni S.J, Dhokpande S.R, Kaware J.P, A Review On Isotherms And Kinetics Of Heavy Metal Removal, International Journal of Ethics in Engineering & Management Education, 2014, 1(2), 1-4.
11. Sunil J Kulkarni, Dr Jayant P Kaware. Removal of Cadmium from Wastewater by Groundnut Shell Adsorbent-Batch and Column Studies, International Journal of Chemical Engineering Research, 2014, 6(1), 27-37.
12. Sunil J Kulkarni, Dr Jayant p Kaware. Fixed Bed Removal of Heavy Metal- a Review. International Journal of Research, 2014, 1(6), 861-870.
13. Banerjee S S, Joshi M V and Jayaram R V., Removal Of Cr(VI) And Hg(II) From Aqueous Solutions Using Fly Ash And Impregnated Fly Ash, Sep. Sci. Technol., 2004, 39, 1611–1629
14. Esposito, F. Pagnanelli, A. Lodi, C. Solicio and F. Veglio, Biosorption of Heavy metals by Sphaerotilusnatans:

an Equlibrium Study At Different pH And Biomass Concentrations, Hydrometallurgy, 2001, 60, 129–141
15. Gupta V. K., Shrivastava A. K. and Neeraj Jain, Biosorption of Chromium(VI) From Aqueous solutions by Green Algae Spirogyra Species‖., Water Research, 2001, 35 (17), 4079-4080.
16. McDonald, C.N. and Bajwa, R.S., Removal Of Toxic Metal Ions From Metal Finishing Wastewater By Solvent Extraction, Sep. Sci., 1977, 12, 435-445.

How to cite this article: Kulkarni SJ, Bhole L, Rampure M. Batch adsorption for iron and chromium removal by low cost adsorbents: studies on affecting parameters. International Journal of Science & Healthcare Research. 2016; 1(1):22-27.

******