Extraction of Cobalt From Synthetic Waste Water Using Low Cost Adsorbent (Delonix Regia)

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Abstract- *Cobalt is beneficial for humans because it is in Vitamin B-12 but its high concentration may cause health problems like heart problems, thyroid damage etc. The present work focused on the effectiveness of low cost adsorbent (Gulmohar kernel powder) for the removal of cobalt (II) from synthetic Waste water investigated by column process. FTIR results indicated the presence of number of active sites present on the adsorbent as compared to Activated Carbon. UV Visible spectroscopy results shows maximum adsorption capacities of Co(II) 72.22% from synthetic water. It is reused in the synthesis of complex and practical % yield of regenerated cobalt obtained is 56.46%.*

Keywords- Adsorption, Delonix Regia, low cost materials, Activated carbon.

I. INTRODUCTION

One of the most important environmental issues is the presence of heavy metals contaminated in aqueous streams, arising from the discharge of untreated metal containing effluent into water bodies[1]. The removal of recalcitrant contaminants, such as cobalt, from wastewater is essential as they pose a serious health and environmental hazard. Severe effects of acute cobalt poisoning in humans include asthmatic symptoms and damage to the heart, thyroid and liver. At elevated concentrations, cobalt may also cause genetic mutations in living cells, emphasising the need to increase awareness of the problems associated with cobalt poisoning[2]. So, their removal from contaminated waters has become a major topic of research in recent years, due to the toxicological problems caused by the metal ions to the environment and to human health. Various processes of heavy metals elimination are used, such as precipitation, electro precipitation, electro coagulation, cementing and separation by membrane, the solvent extraction and the exchange of ions on resins[3]. Of all these adsorption using activated carbon is most commonly employed for the removal of heavy metals present in aqueous systems. Nowadays emphasis is more on use of low cost natural adsorbents like biomass, rice husk, chitosan, tea leaves, coconut shells, etc[4]. Agricultural waste materials such as spent grain, polymerized onion skin, bark and sawdust, maize and wheat bran, cortex fruit wastes, bagasse, and modified *Agaricus bisporus* zeolite and bentonite has been studied to investigate their effectivities in binding heavy metal ions[5-7]. Low-cost adsorbents have demonstrated outstanding removal capabilities for certain metal ions as compared to activated carbon[8]. *Delonix regia* reported to have anti-diarrhoeal, anti-inflammatory, activity, antioxidant, hepato protective and antimicrobial activity and isolated compounds from seed are Cyanidin -3-O-glucoside, Cyanidin 3-O-rutinoside, Pelargonidin3-O-rutinoside, Lupeol, Epilupeol, β-Sitosterol etc[9]. Due to surface active groups Delonix Regia kernel powder may act as a good adsorbent. In this study kernel powder of Delonix Regia is employed for the removal of Co(II).

II. MATERIAL AND METHOD

1. Preparation of Gulmohar kernel powder (GKP)

Dry Gulmohar fruits were collected and dried in sun for removal of moisture or any fungus etc. if present. Gulmohar kernels from the fruit were taken and dried in an oven at 100^{o}C for moisture removal or any micro-organisms or bacteria if present. Dried kernels were taken and grinded in a mixer. This powder was then screened by passing through a mesh size 10 to get uniform fine particles. Finally, this grinded powder was kept in oven at 200^{o}C for about 3 hours for final removal of moisture traces if any present. After this Gulmohar kernel powder (GKP) was ready to use.

Composition of GKP is as follows:

Moisture:	11.4-22.7%
Protein:	15.0-22.0%
Fat/oil/lipids:	3.9-8.0%
Crude fibre:	2.5-8.2%
Carbohydrates:	65.1-72.2%
Total ash:	2.4-4.2%

2. Preparation of Calibration curve

5.0 gm of Cobalt chloride was taken and dissolved in 1000 ml distilled water for preparation of stock solution. 10 ml of 100 ppm solution was taken. Evaporated almost to dryness and added 1 ml. conc. nitric acid. Dissolved the residue in 10 ml water containing 0.5ml. each of 1:1 HCl and 1:10 nitric acid. Boiled for few minutes to dissolve any solid material. Added 2 ml of 0.2% aqueous solution of nitroso - R-salt and 2 gms of hydrated sodium acetate. pH of the solution maintained at 5.5. Boiled for 1 minute and then added 1 ml con. HCl, boil again for 1 minute and cooled to room temperature and transferred to 25ml. volumetric flask. The optical density was determined at 500mμ. by shaking thoroughly. Similarly, noted down the absorbance of 80 ppm, 60 ppm, 40 ppm and 20ppm. solutions. Then plot of absorbance versus concentration in ppm gave the calibration curve as shown if Fig 4.

Column Studies

4.1 Preparing the column.

An adsorption column of diameter around 2 cm was taken and washed thoroughly. The neck of the column is plugged with cotton wool. GKP was taken and slurry was prepared with distilled water and poured into the column. Water was allowed to run out from the column. After all water had drained out the column was ready for use. 100 ppm initial concentration 50 ml solution is passed through the bed and solution collected at the bottom of the bed.

4.2 Regeneration of the coloumn.

4.5 cm of bed depth of column is prepared. 100 ppm initial concentration 50 ml solution is passed through the bed and solution collected at the bottom of the bed. the column was desorbed by using 0.01N HCl The column is now regenerated. Again pass 100 ppm solution and check absorbance. Compare the concentration before and after regeneration.

Fig.1. Before regeneration in beaker and Solution in Volumetric flask –after regeneration.

1. Test Program

Synthesis of chloropentaamminopcobalt (III) Chloride $[Co(NH_3)_5 Cl]Cl_2$ from regenerated cobalt.

Cobalt(III) forms stable octahedral complex. The complex chloropentaamminocobalt (III) chloride has the molecular formula $[Co(NH_3)_5 Cl]Cl_2$. In this study cobalt (II) chloride is oxidized to cobalt (III) chloride by hydrogen peroxide which acts as an oxidizing agent. In the structural formula one chloride ion is directly attached by a co-ordinate bond to the central metal ion cobalt, while the other two chloride ions are not attached by co-ordinate bonds and remain outside the coordination sphere.

Initially 10 gm. Ammonium chloride is taken & dissolved in 40 ml liquor ammonia. Then regenerated cobalt solution is taken in a 100 ml beaker. Ammonium chloride in ammonium solution is added with constant stirring after that the solution is cooled in a water bath. 25 ml 6% H_2O_2 added then neutralized this solution with conc. HCl. Then 5 to 10 ml conc. HCl was added in excess. Solution was heated gently to boiling then allowed it to cool to room temperature when purple coloured crystals start to separate out. Filter, dried and weighed the product.

III. RESULT AND DISCUSSION

1. Characterisation of Adsorbent (Gulmohar powder)

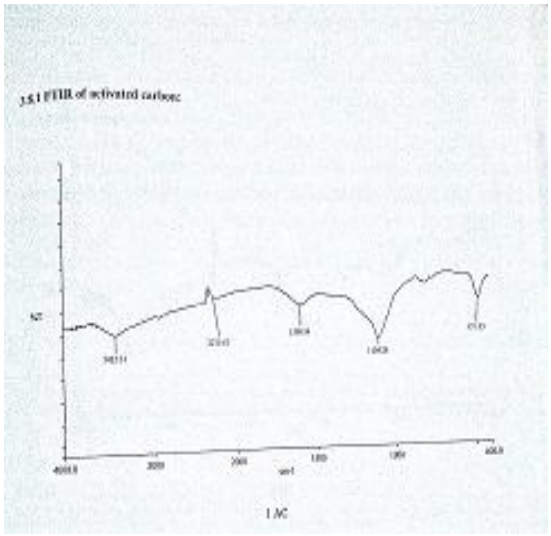

Fig. 2- FTIR spectra for Activated carbon

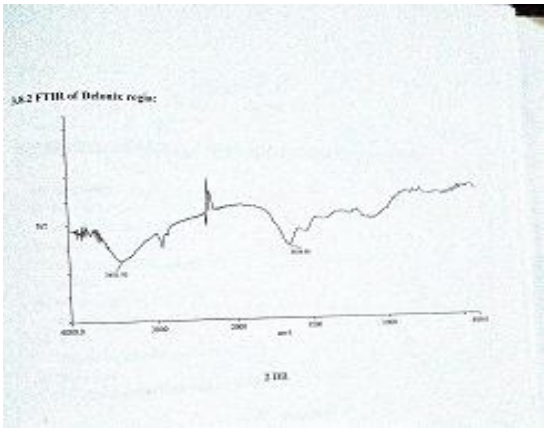

Fig. 3- FTIR spectra for Delonix regia

The FTIR showed the characteristic peaks at 1598.54 cm^{-1} due to C=O stretch of carboxylic group and 3422.31 cm^{-1} due to OH stretch of hydroxyl group which confirmed presence of surface functional groups like carboxyl and hydroxyl groups comparable to activated charcoal.

Calibration plot

This is the standard curve on uv-visible spectrophotometer (SPECROSCAN UV-Visible 2600) which relates absorbance with concentration in ppm. This was in validation with Beer Lamberts Law.

Table 1. Column studies for adsorption of synthesis cobalt waste water

S.No.	Concentration	Absorbance
1.	20 ppm.	0.217 Å
2.	40 ppm.	0.417 Å
3.	60 ppm.	0.591 Å
4.	80 ppm.	0.887 Å
5.	100 ppm.	1.107 Å
6.	**Initial**	**1.002 Å**
7.	**Before regeneration**	**0.109 Å**
8.	**Regenerated**	**0.701 Å**

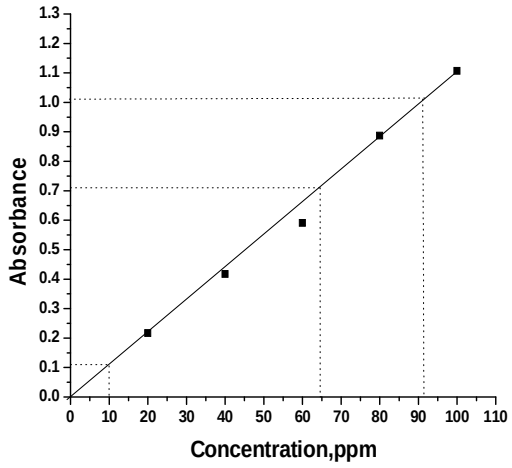

Fig .4- Calibration plot of column studies

Calculations for regenerated cobalt is
% regeneration = 65 x 100/90
= 72.2 %

Calculation for % yield of complex

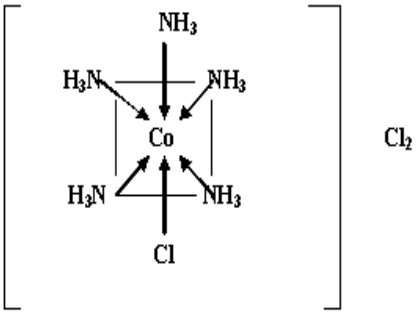

Fig. 5- Structure of chloropenta amminopcobalt (III) Chloride $[Co(NH_3)_5 Cl]Cl_2$

1) Theoretical Yield
Starting compound End product
$CoCl_2.6H_2O$ $[Co(NH_3)_5Cl)Cl_2$
237.93g 250.43g
237.93g $CoCl_2.6H_2O$ =250.43g of the
5.00g $CoCl_2.6H_2O$ =5.26 g of the complex

2) Practical yield of the complex= 2.97gm.

1) Percentage practical yield
5.26g of the complex = 100% yield
W g. of complex = (2.97 x100)/5.26
practical yield = 56.4%

Regenerated cobalt from synthetic waste water is used in synthesis of complex, its practical % yield 56.4 is obtained. This complex is antibacterial and antiviral agent[13].

IV. CONCLUSION

In the present study removal of Cobalt (II) from aqueous media by low cost Delonix Regia seed powder can be considered as an effective method. The experimental column studies revealed that 100 ppm of Cobalt stock solution showed up to 72.22% removal. Thus GKP was an effective adsorbent for removal of Cobalt ions in aqueous medium. For further improving efficiency surface modified natural adsorbent can be used. The study concluded that the regenerated cobalt can be reused in the synthesis of cobalt complexes. .

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REFERENCES

[1] Salah N. Farhan, "Biosorption of Copper and Lead Ions Using Wheat Husk", Diyala Journal of Engineering Sciences, pp. 835-845, December- 2015.

[2] Musapatika ET, Onyango MS, Aoyi O. Cobalt(II) removal from synthetic wastewater by adsorption on South African coal fly ash. S Afr J Sci, V. 106 (9/10), 1-7 pages, 2010.

[3] George Z. Kyzas, "Commercial Coffee Wastes as Materials for Adsorption of Heavy Metals from Aqueous Solutions", Materials, 5, 1826-1840, 2012.

[4] Doss et al., "Adsorption of Ni^{2+} From Waste Water Via Silver- Delonix Regia Nano Composite", Sci. Revs. Chem. Commun.: 2(3), 244-250, 2012.

[5] BULUT Yasemin and TEZ Zeki, "Removal of heavy metals from aqueous solution by sawdust adsorption", Journal of Environmental Sciences 19, 160–166, 2007.

[6] Reyad A. Al Dwairi and Aiman E. Al-Rawajfe, "Removal Of Cobalt And Nickel From Wastewater By Using Jordan Low-Cost Zeolite And Bentonite", Journal of the University of Chemical Technology and Metallurgy, 47, 1, 69-76, 2012.

[7] Swarup Biswas and Umesh Mishra, "Continuous Fixed-Bed Column Study and Adsorption Modeling: Removal of Lead Ion from Aqueous Solution by Charcoal Originated from Chemical Carbonization of Rubber Wood Sawdust", Hindawi Publishing Corporation Journal of Chemistry, Volume 2015.

[8] Rekha Devi al., "Removal of Heavy Metals from Wastewater Using Low Cost Adsorbents: A Review", International Journal of Recent Research Aspects, Vol. 2, Issue 2, pp. 5-7, June 2015.

[9] Sumitra Singh and Sonia Naresh kumar, "A Review: Introduction To Genus Delonix", World Journal of Pharmacy And Pharmaceutical Sciences, Volume 3, Issue 6, 2042-2055, 2014**.**

[10] Doss V.R and Natarajan G.S, "Rate of adsorption of complexing species (ligands) on Granular Activated Carbon", Asian Journal of Chemistry. Vol 18 (3) pp. 2645-2649. 2006.

[11] Doss V.R and Kodolikar S.P, "A comparative study of 8-hydroxyquinoline-5-sulphonic acid and its 7-nitro derivative loaded on F-400 granular activated carbon for removal of copper ions from aqueous solutions" International Journal of Environmental Sciences. Vol 3 (6) pp. 2048- 2067. June 2013.

[12] Doss V.R and Kodolikar S.P, "Heavy metal adsorption by ligand loaded granular activated carbon: thermodynamics and kinetics", International Journal of Environmental Sciences, Vol. 2 (4) pp. 2133-2149. 2012.

[13] Eddie L. Chang,et.al, "Cobalt complexes as Antiviral and Antibacterial Agents",Pharmaceuticals, Vol-3, 1711-1728, 2010.