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# Effect of Presence of Other Heavy Metals on Removal of Cadmium by Low Cost Adsorbents

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**Abstract:** Continuous packed column adsorption experimentations are generally carried out to optimize parameters like flow rates, bed height, initial concentration. Also studies on break through curves are integral part of all these investigations. Modeling for break through curve includes model fitting for Adam Bohart, Yoon Nelson and Thomas models. Estimation of efficiency, breakthrough point and exhaustion point is integral part of packed bed experimentation. It is important to study multicomponent adsorption to closely resemble the study to actual conditions. The current investigation focuses on multicomponent (binary) adsorption of cadmium with chromium and nickel. Investigation is aimed at studying the effect of various concentrations of other heavy metal on cadmium removal by using groundnut shell derived activated carbon (GNSA) and rice husk derived activated carbon (RHA). Ionic radius affected selectivity of adsorbate. Studies reveal that cadmium was most preferred adsorbate as it had higher ionic radius than nickel and cadmium.

**Keywords:** Adsorption, adsorbate, removal, concentration, pH**.**

## I. INTRODUCTION

Removal of heavy metal from synthetic effluent is widely discussed and investigated research domain. There is huge scope for research since different waste materials can be used with different activation methods [1-4]. Also use of various contacting pattern is widely studied [5-8]. Investigation on adsorption is generally carried out conventionally in three parts. The batch adsorption study includes batch experimentation for finding isotherm and kinetic parameters [9-12]. The parameters like pH, initial concentration, contact time, particle size are studied in most of these studies. Continuous experimentation is carried generally to optimize parameters like flow rates, bed height, initial concentration. Also studies on break through curves are integral part of all these investigations [13-18]. Modeling for break through curve includes model fitting for Adam Bohart, Yoon Nelson and Thomas models. Estimation of efficiency, breakthrough point and exhaustion point is integral part of packed bed experimentation [19-25]. Industrial effluent contains more than one metal. It is important to study multi component adsorption to closely resemble the study to actual conditions. Author has, in past carried out investigation on synthetic effluent with single component [18,26]. The current investigation focuses on multicomponent (binary) adsorption of cadmium with chromium and nickel. Investigation is aimed at studying the effect of various concentration of other heavy metal on cadmium removal by using groundnut shell derived activated carbon (GNSA) and rice husk derived activated carbon (RHA).

## II. LITERATURE REVIEW

An investigation on competitive sorption of Cd, Cu, Pb and Zn was carried out by Ramsenthil and Meyyappan [29].According to these studies; there exist a competitive adsorption for the binary mixture solution. Langmuir and Freundlich model in the applied concentration ranges were adequate to describe the uptake. Shaken et.al.used Zeolite for competitive adsorption of heavy metals [30]. In their investigation, they determined percentage sorption and distribution coefficients. They found that Freundlich model described the sorption of metals satisfactorily. Adsorption and distribution coefficient followed the trend Pb> Cu > Zn > Cd > Ni.They found that Cu was better adsorbed metal of the two. Al-Malack et.al.investigated competitive adsorption of lead and cadmium [31]. Municipal organic solid waste derived activated carbon was used by them. Factors affecting adsorption such as pH, contact time, metal concentration and adsorbent dosage were also studied by them. Studies revealed that, non-linear Freundlich adsorption isotherm and pseudo-second-order kinetic models described the uptake of both the metals. An investigation on sorption of heavy metals was carried out by Singh and Gupta [32].According to them, most of the investigations included the isotherm and kinetics of metal uptake. An investigation on competitivesorption of Cd, Cu, Pb and Zn was carried out by Zemanova et.al. [33]. Three types of soils were used by them, aGleyicFluvisol, a GleyicCambisol, and a Chernozem. They found that sorption from single-metal solution was more effective than sorption under multi-metal conditions. According to study carried out by Futalanet.al., forcopper, nickel and lead adsorption on chitosan-immobilized on bentonite, the adsorption followed pseudo second order kinetics[34]. Also they found that, nickel removal followed Langmuir model while other two metals followed Freundlich equation. Rashid et.al investigated uptake of Cadmium (Cd) and Lead (Pb) and their subsequent accumulation in edible tissue of plant[35]. According to them, phytoaccumulationan and adsorption of Cd was higher than Pb and copper. An investigation was carried out by Apiratikul et.al. onbiosorption of binary mixtures of heavy metals[36]. Their emphasis was green macro alga, Caulerpalentillifera. Experiments were carried out in order to study sorption potential of metals. Their results indicated that binary adsorption was competitive in nature and the adsorption capacity for any single metal decreased by 10-40% in the presence of the others.

## III. METHODOLOGY

The adsorbents were prepared by thermal activation preceded by some chemical treatment for the raw material as explained in the earlier work [8,15,19] by the author. The standard solutions of cadmium, nickel and chromium were prepared by taking appropriate amount of cadmium sulphate, nickel sulphate and potassium dichromate as in case of single component batch and column experiments [8,15,19,27]. The appropriate samples were prepared from stock solutions. 100 ml of the samples were contacted with 3 grams of adsorbents at 6 pH and the samples were analyzed after 15-30 minutes intervals. Standard spectrophotometric methods were used for analysis.

## IV. RESULT AND DISCUSSION

### 4.1 Effect of nickel on cadmium removal for GNSA

To study the effect of presence of nickel on cadmium removal, to 100 mg per liter cadmium effluent, nickel was added. Four samples were prepared by using cadmium sulphate and nickel sulphate. The four samples had 10, 20, 30 and 40 mg/l of nickel and 100 mg/l of cadmium each. The batch experiments were performed in the same way as explained in the batch experimental methodology. Optimum values of the pH, adsorbent dose were used. It was observed that with addition of nickel, the cadmium removal dropped marginally. The maximum removal decreased from 68 to 65 percent for addition of 10 mg/l of Ni. For contact time of 15 minutes the loss of percentage removal was 1.2 percent, which increased to 3 percent of 180 minutes. The drop in the cadmium removal was very small. Studies reveal that cadmium had higher ionic radius and hence it is preferred over nickel by the adsorbent.Fig.1 depicts the effect of nickel on cadmium removal. The final removal at equilibrium, was 68 percent without Ni, 65 for 10 mg/l of Ni, 64 for 20 mg/l Ni,63.1 for 30 mg/l Ni and 62.3 for 40 mg/l of Ni.[

Table 1: Cd removal at various Ni concentrations for GNSA

| Time/Ni | % Cd Removal | | | | |
|---|---|---|---|---|---|
| mg/l | 0 | 10 | 20 | 30 | 40 |
| Minutes | | | | | |
| 15 | 26 | 24.8 | 23 | 22 | 21.3 |
| 30 | 36 | 28.5 | 27 | 26 | 25 |
| 60 | 46 | 40 | 38.5 | 37.5 | 36.5 |
| 90 | 51 | 49.8 | 48.3 | 47.3 | 46.3 |
| 120 | 54 | 52 | 50.5 | 49.5 | 48.5 |
| 150 | 56.5 | 55.6 | 54.1 | 53.1 | 52.1 |
| 180 | 68 | 65 | 64 | 63.1 | 62.3 |

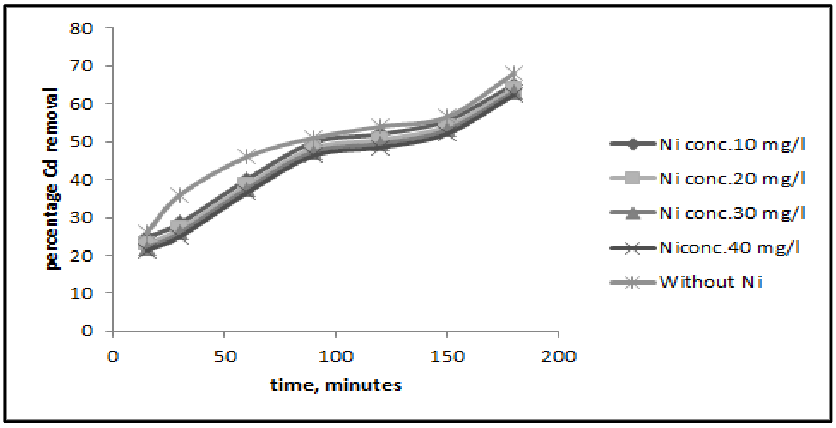


Fig.1 Effect of nickel on cadmium removal for GNSA

### 4.2 Effect of chromium on cadmium removal for GNSA

Effect of presence of chromium on cadmium removal is shown in Fig. 2 for GNSA adsorbent. For 10 mg/l concentration of chromium, initial 2.2 percent reduction decreases to 1 percentafter 180 minutes. The percentage removal at equilibrium was 68 percent without Cr, which reduced to 67, 65.5, 66 and 67 percent respectively for addition of 10, 20, 30 and 40 mg/l of Cr. This indicates that cadmium is most preferred heavy metal for the adsorbent out of these three heavy metals

Table 2 : Cd removal at various Cr concentrations for GNSA

| Time/Cr Concentration | % Cd Removal | | | | |
|---|---|---|---|---|---|
| mg/l<br>minutes | 0 | 10 | 20 | 30 | 40 |
| 15 | 16 | 13.8 | 12.3 | 11.05 | 10.05 |
| 30 | 36 | 26 | 24.5 | 23.5 | 22.5 |
| 60 | 46 | 39.5 | 38.5 | 37.5 | 37.3 |
| 90 | 51 | 47.1 | 45.6 | 44.6 | 43.6 |
| 120 | 54 | 47.5 | 46 | 45 | 44 |
| 150 | 56.5 | 53.8 | 53.3 | 53 | 52 |
| 180 | 68 | 67 | 65.5 | 66 | 67 |

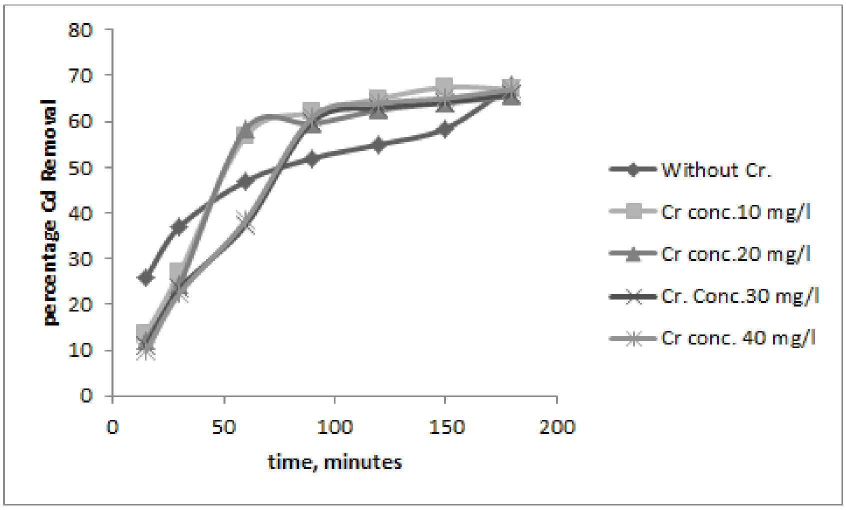


Fig 2: Effect of chromium on cadmium removal for GNSA

### 4.3 Effect of presence of nickel on cadmium removal for RHA

Effect of presence of nickel on cadmium removal is shown in Fig. 3 for RHA adsorbent. The experimental dada reveal that the presence of nickel has slightly more effect than chromium. For 10 mg/l concentration of nickel initial 2.4 percent reduction at 30 minutes increases to 5.6 percent for 180 minutes. The percentage removal at equilibrium was 79 percent without nickel, which reduced to 73.4, 73.2, 71 and 69.1 percent respectively for addition of 10, 20, 30 and 40 mg/l of Ni. This indicates that Cadmium is most preferred heavy metal for the adsorbent out of these three heavy metals.

Table:3: Cd removal at various Ni concentrations for RHA

| Time/Ni | % Cd Removal | | | | |
|---|---|---|---|---|---|
| mg/l<br>minutes | 0 | 10 | 20 | 30 | 40 |
| 30 | 30.6 | 27 | 26 | 25.5 | 25.6 |
| 60 | 43.6 | 40 | 38 | 48.3 | 45.9 |
| 90 | 58.1 | 55 | 52 | 57 | 57.1 |

| | | | | | |
|---|---|---|---|---|---|
| 120 | 74.2 | 70 | 67 | 65 | 64.6 |
| 180 | 79 | 73.4 | 73.2 | 71 | 69.1 |

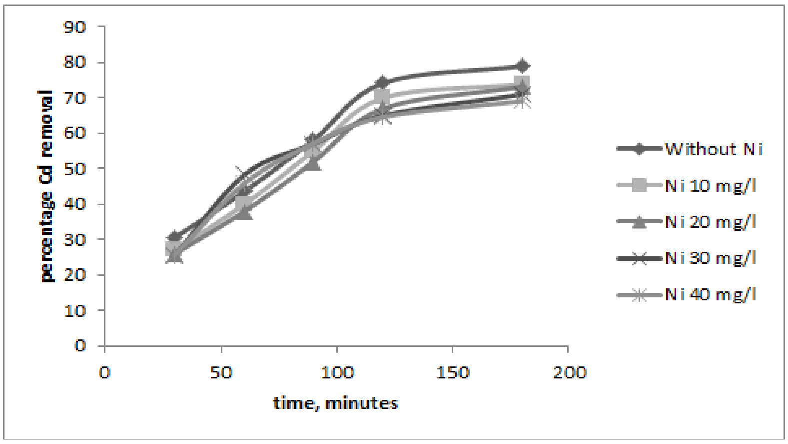


Fig.3: Effect of nickel on cadmium removal for RHA

## 4.4 Effect of chromium on cadmium removal for RHA

To study the effect of presence of chromium on cadmium removal, to, 100 mg per liter cadmium effluent chromium was added. Four samples were prepared by using cadmium sulphate and potassium dichromate. The four samples had 10, 20, 30 and 40 mg/l of chromium and 100 mg/l of cadmium each. The batch experiments were performed in the same way as explained in the batch experimental methodology explained. Optimum values of the pH, adsorbent dose were used. It was observed that with addition of chromium, the cadmium removal dropped marginally. The maximum removal decreased from 79 to78 percent for addition of 10 mg/l of Cr. For contact time of 30 minutes the loss of percentage removal was 0.6 percent, which increased to 1 percent of 180 minutes. The drop in the cadmium removal was very small. Studies reveal that cadmium had higher ionic radius and hence it is preferred over chromiumby the adsorbent.Fig.4 depicts the effect of chromium on cadmium removal. The final removal at equilibrium, was 79 percent without Cr, 78 for 10 mg/l of Cr, 76 for 20 mg/l Cr, 70 for 30 mg/l Cr and 68.1 for 40 mg/l of Cr.

Table:4: Cd removal at various Cr concentrations for RHA

| Time/Cr Concentration | % Cd Removal | | | | |
|---|---|---|---|---|---|
| mg/l<br>minutes | 0 | 10 | 20 | 30 | 40 |
| 30 | 30.6 | 30 | 30 | 29 | 28.5 |
| 60 | 43.6 | 42.2 | 41 | 40 | 38.9 |
| 90 | 58.1 | 57 | 55 | 55 | 52 |
| 120 | 74.2 | 74 | 71 | 69 | 68 |
| 180 | 79 | 78 | 76 | 70 | 68.1 |

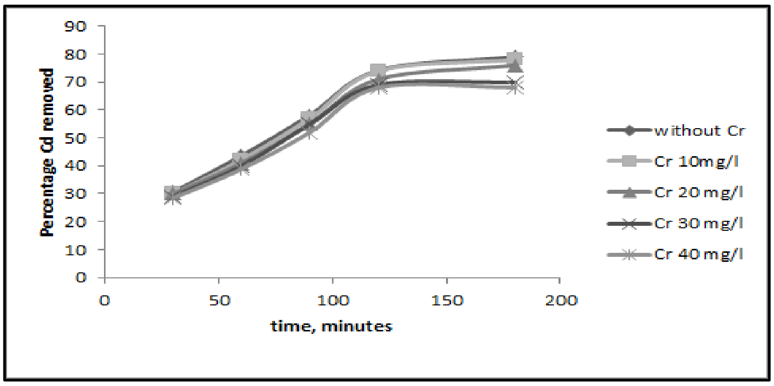


Fig.4: Effect of chromium on cadmium removal for RHA

## V. CONCLUSION

For GNSA with Ni, the maximum removal decreased from 68 to 65 percent for addition of 10 mg/l of Cr. For contact time of 15 minutes the loss of percentage removal was 2.2 percent, which increased to 3 percent of 180 minutes. The drop in the cadmium removal was very small. Ionic radius affected selectivity of adsorbate. Studies reveal that cadmium had higher ionic radius. The experimental data reveal that the presence of Cr has negligible effect. For 10 mg/l concentration of Cr, initial 2.2 percent reduction drops to 1 percent after 180 minutes. For RHA, with chromium, the final removal at equilibrium, was 79 percent without Cr, 78 for 10 mg/l of Cr, 76 for 20 mg/l Cr, 70 for 30 mg/l Cr and 68.1 for 40 mg/l of Cr. For RHA, the experimental dada reveal that the presence of nickel has slightly more effect than cadmium. For 10 mg/l concentration of nickel initial 2.4 percent reduction at 30 minutes increases to 5.6 percent for 180 minutes. The percentage removal at equilibrium was 79 percent without nickel, which reduced to 73.4, 73.2, 71 and 69.1 percent respectively for addition of 10, 20, 30 and 40 mg/l of Ni.

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