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EFFECTIVE ADSORPTION OF CADMIUM (II) ION ON ORANGE PEELS (CITRUS SINENSIS)

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Abstract - Cadmium can cause adverse effects on human health and environment. Cadmium can cause cancer from a life time exposure. Orange peel, a residue of the fruits processing industry, has been used for the adsorption of Cd (II) from aqueous solution.

Batch adsorption study determines that Orange peel has a significant capacity for adsorption of Cr (VI) and Zn (II). The parameters used in the study include contact time, pH, concentration and adsorbent dosage. Adsorption of these metals was found to be pH dependent and maximum removal of Cd (II) by orange peel is 95.14 % at optimum condition.

Key Words:
Orange peel, adsorption, adsorbent, adsorbent dosage and batch studies etc.

1. INTRODUCTION

Cadmium is the toxic metal, released in the environment from a number of industries such as, metallurgy, electroplating process, pigments, fertilizers, plastic and batteries production (1). Heavy metal clean-up technologies cover precipitation, ion exchange, chemical oxidation/reduction, electrodialysis, ultra filtration, reverse osmosis and solvent extraction but these technologies has some disadvantages such as high cost, disposal of the residual metal sludge and are not suitable for small-scale industries (2-3). Adsorption process has received attention and become an alternative of other conventional techniques.

Now a days bio degradable material is in trend for the removal of heavy metals from waste water because these are nonhazardous, abundant in nature and available at low cost.

In the present orange peels is used for the removal of cadmium (II) from aqueous.

Orange peel is found in soft drink industries and normally treated as waste. It contains many functional groups, such as hydroxyl and carboxyl, these functional groups makes it a potential adsorbent for removing heavy metal ions (3-5).

2. MATERIAL AND METHOD

2.1 Adsorbent Preparation

Oranges were purchased from a local market and peeled. The peels was washed with distilled water to remove the dirt and dried at 80°C for 24 h, finally crushed and sieved used as such (3-5).

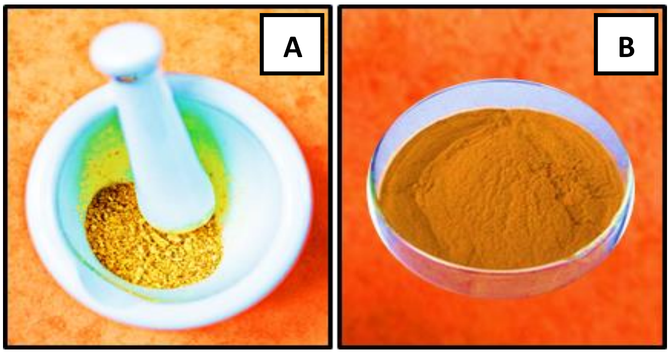

Figure-1: Grinding of orange peel (A)
Orange peel powder in petri dish (B)

2.2 Adsorbate solution

The Cd (II) ion solution was prepared from an AR grade $CdCl_2 .2H_2 O$. Distilled water was used for the preparation of all solutions and adsorption experiments. 1000mgL^{-1} stock solution of cadmium (II) was prepared. The initial concentration (100 mg L^{-1}) of metal was prepared from the stock solutions by dilution.

2.3 Batch adsorption experiments

The adsorption of heavy metals on adsorbent was studied by batch adsorption method.

A known weight of adsorbent (e.g. 0.5 g adsorbent) was equilibrated with 100 ml of the cadmium solution of known concentration (20, 40, 60, 80 and 100 ppm) in conical flask in orbital shaker for a period (20–120 Min.). After equilibration, 10 ml sample collected from each flask, in time interval of 20, 40, 60, 80, 100 and 120 minutes and centrifuged for 15 minutes, the suspension of the adsorbent was separated from solution by filtration using Whatman filter paper No.42.

The concentration of heavy metal ions remaining in solution was measured by atomic absorption spectrophotometer. The effect of several parameters, such as pH, contact time, concentrations and adsorbent dose on the adsorption were studied (1,6). The pH of each solution was adjusted by drop-wise addition of 0.1 M NaOH and 0.1 M HCl.

The results of these studies were used to obtain the optimum conditions for maximum heavy metals removal from aqueous solution.

Adsorption capacity and % removal efficiency were calculated using the following equations respectively.

$$qe = \frac{(Co-Ce)\times V}{m} \qquad (1)$$

$$\textbf{Removal efficiency (\%)} = \frac{(C0-Ce)\times 100}{C0} \qquad (2)$$

Where:

qe (mg g−1) is the amount of Cd (II) ions adsorbed, Ci (mg L−1) is the initial concentration of Cd (II) ions, Ce (mg L−1) is the concentration of Cd (II) ions in solution at equilibrium, V (L) is the volume of of Cd (II) ions and m (g) is the mass of the adsorbent.

3. RESULT AND DISCUSSIONS

3.1. Effect of pH variation

The pH variation is one of the most important parameters for controlling uptake of Cd (II) ions from aqueous solutions. In this experiment, studies were conducted at an initial metal ions concentration of 100 ppm in 100ml solution, 0.5 g of the adsorbent was added and agitated at 250 rpm for 60 minutes at varying pH (1-7) in each solution.

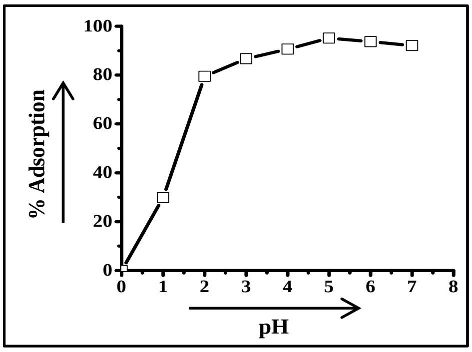

Figure-2: Effect of pH on % removal of Cd (II) ions by orange peel (initial concentration= 100 ppm, pH=4, equilibrium time =60 minutes)

The effect of pH on the adsorption of Cd (II) ion is shown in Figure 1. It shows that adsorption of Cd (II) ion by orange peel is found to increase from pH 1-5. Maximum sorption occurred at pH 5 for Cd (II) metal ion.
The observations can be explained by the fact that at lower pH values, there was competition between H^+ with Cd (II) for the adsorption sites of orange peel it leads to decrease the removal percent of Cd (II). Decreasing in adsorption at high pH may be due to the formation of soluble hydroxyl complexes (1-3).

3.2 Effect of contact time

Figure 3 shows the effect of contact time on the % removal of Cd (II), orange peel is used as an adsorbent. The effect of contact time on the removal of Cd (II) ions was carried out for a period of 2 h at a time interval of 10 minutes (1-5). The flasks were covered and shaken for 1 hour, the suspensions were filtered through Whatman filter paper No. 42, centrifuged for 15 minutes and analyzed by atomic absorption spectrometer.

Equilibrium was attained after 60 min with adsorption capacities of 95.03. It was observed that percent removal efficiency increased with time and after equilibrium it decreases slowly.

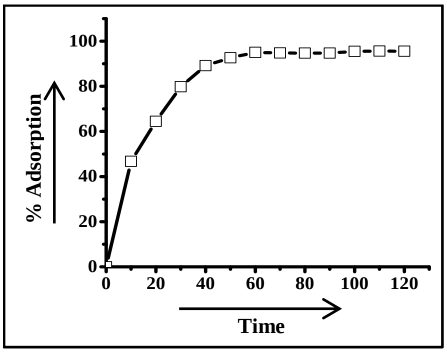

Figure-3: Effect of contact time on the % removal of Cd (II) ions from aqueous solution.
(Initial concentration= 100 mgL^{-1}, pH=5, equilibrium time =60 minutes)

3.3 Effect of metal ions concentrations

In order to determine the effect of Cd (II) ions concentrations, 100 ppm of 100 mL solution, was kept in conical flask for the Cd (II) ions. The amount of adsorbent was 0.5 g added in the flask, pH 5, agitated for 1 h, filtered and centrifuged for 15 minutes and analyzed by atomic absorption spectrometer. The initial pH of each solution was adjusted by drop-wise addition of 0.1 M NaOH and 0.1 M HCl. It can be seen from the figure 4 that the percentage removal decreases with the increasing the concentration of Cd (II). At low concentrations, metal ions are easily adsorbed on vacant sites, therefore the metal ion concentration increases, the percent removal decreases. As the metal ion concentration decreases, the percent removal increases. This may be due to the vacant sites are filled up and no further adsorption occurs due to saturation of vacant sites of adsorbent (1-3).

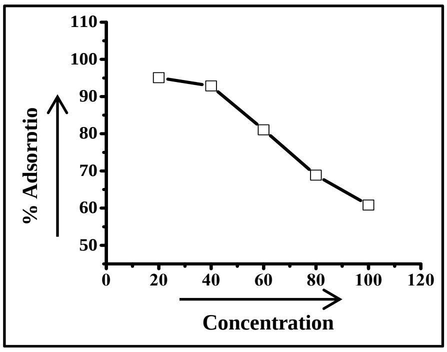

Figure- 4: Effect of concentration on percentage removal of Cd (II) ions by orange peel at continuous parameter- adsorbent dose =0.5g, pH =5, contact time= 60 minutes.

3.4 Amount of adsorbent:

The result for adsorptive removal of Cd (II) with respect to adsorbent dose is shown in Figure 5, over the range 0.2 to 1g/100ml, at pH= 5 and contact time= 90 minutes. The percentage removal of Cd (II) increases with adsorbent dose. There is a sharp increase in percentage removal with adsorbent dose for Cd (II) ions. The maximum removal of Cd (II) was 95.18% at 0.6 gram of orange peel adsorbent(3, 7) .

The percent removal of heavy metals increases rapidly with increase in the dose of the adsorbents due to the greater availability of the exchangeable sites or surface area. Moreover, the percentage of metal ion adsorption on adsorbent is determined by the adsorption capacity of the adsorbent (3,8).

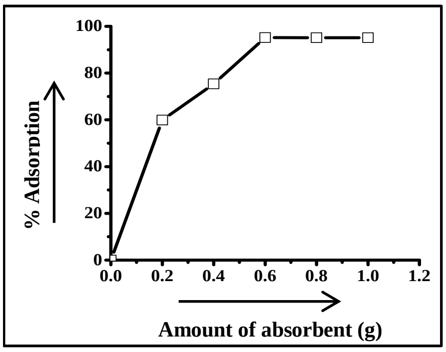

Figure -5: Effect of adsorbent dose on % removal of Cd (II) ion by orange peel at continuous parameter- pH =5, contact time =90 min.

4. CONCLUSIONS

Conclusions are drawn from the above results and discussion:
1. Orange peel is a cheap and effective adsorbent for the removal of Cd (II) ions from aqueous solution.
2. The maximum adsorption of Cd (II) was observed at pH 5
3. Removal of Cd (II) increases with increase of adsorbent dosage.

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