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Research Article

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Effects of some adsorption parameters in the removal of cadmium (ii) ion from aqueous solution using garlic skin

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Abstract Cadmium is known to be toxic for living organism even at low concentration. The objective of this study is to investigate the adsorption behavior of Cadmium(ii) from aqueous solution onto Garlic skin. The batch adsorption experiments at 30^0C were conducted to investigate the effects of some operating parameters such as concentration, particle size, adsorbent dosage, pH and agitation time on the removal of cadmium ion from aqueous solution using garlic skin. The investigation showed that amount of Cadmium (ii) ions adsorbed increases with the decrease in particle size of the adsorbent. The percentage of cadmium (ii) ions increase with decrease in initial concentration and increase with increase in agitation time, pH and dose of adsorbent.

Keywords Garlic skin, cadmium ion and adsorbent

Introduction

Since the turn of the century, the rate of cadmium (Cd) into our natural water bodies has increased at a very high proportion. Aquatic systems are specifically sensitive to cadmium pollution. Cadmium metal is therefore regarded as a number one contaminant, and guidelines have been established for the control of cadmium levels in public water supplies and other various uses . Cadmium is a non-essential trace element which has no biological functions. Cadmium metal is an element that is very toxic to both fresh water and aquatic lives [1]. The major routes for the uptake of cadmium by fish are through ingestion (Food and water or both).

Several studies have indicated that cadmium accumulates in specific places in the body rather than been evenly distributed, accumulated cadmium metal has predominantly been deposited in the organs such as kidney, liver, and gills of exposed specimens [2]. Anthropogenically, cadmium metals are widely found in the rural waters as a results of industrial discharge. Cadmium are introduced into the atmospheric environment from processes like mining activities, industrial processes, burning coal and household wastes (such as paints). Cadmium particles in the atmosphere travels long distance before settling on the soil or in water. It enters water and soil from waste disposal spills and sites or leaks at toxic waste sites. Cadmium element is not soluble in water though many of its inorganic and organic salts are very soluble.

Cadmium occurs primarily in freshwaters as divalent element such as free cadmium (II) ion, cadmium chloride and cadmium carbonate e.t.c [1], and cadmium metal does not break down in the environment, but can only change its form. Also, it can remain in the body for a very long period of time and can also bio-accumulated for many years after being exposed to a low level [3].

Adsorption process provides an attractive treatment of wastewater containing cadmium (ii) over other conventional wastewater techniques due to economic and easy to operate as well as greater efficiency [4].

In this study, the effectiveness of garlic skin for removal of Cd(ii) from aqueous solutions was studied. The skin of the garlic is the dried up outer parchment of bulbs and are kitchen and agricultural waste products. Garlic offers a number of skin benefits. Garlic has large amount of allicin present in it and allicin has antifungal, anti-aging and skin smoothing benefits. It is also known to increase antioxidant levels of the skin and body. Sulphur present in garlic prevents infections and helps in reducing inflammation. The skin is also great for boosting

immunity and lowering cholesterol. Literature survey has shown that there has been no previous study for removal of cadmium ion using garlic skins.

This study demonstrates the usage of Garlic skin as an adsorbent for the removal of Cadmium (ii) from aqueous solution.

Materials and Methods

Preparation of Sample

Garlic bulbs bought from a market in Port Harcourt, Nigeriawere cut into small pieces, dried, crushed, and washed thoroughly twice with distilled water to remove the adhering dirt. The skin was finally dried in an air oven at 200 ^{o}C for 24 hours.

Preparation of metal ion standard solution

1000mg/l cadmium was prepared by dissolving 1g of cadmium nitrate in 1litre of distilled water. The pH of the solution was adjusted by using 0.1N of HCl and NaOH.

Adsorption Experiment

Five different sets of batch experiments were carried out to investigate separation of Cd(II) ion using garlic skin. The experiments were repeated at pH from 2-10, concentration of metal from 10ppm to 50ppm, time intervals of 20mins-100mins, dose of adsorbent ranging from 0.1g – 0.5g, temperature range of 50^{o}C to 90^{o}C to investigate the best parameter for the removal of Cd(II) from aqueous solution.

The batch experiments were done using a 250ml volumetric flask. For pH adjustments, concentrated hydrochloric acid or sodium hydroxide solutions were added to adjust the pH of the solution. At equilibrium, the mixtures were filtered using Whatman No 42 and analyzed for free metal concentrations using Atomic Adsorption Spectrophotometry.

The percentage of the metals adsorbed at equilibrium, %M is given in the equation below.

$$\%M = \frac{C_0 - C_e}{C_0} \times \frac{100}{1} \quad (1)$$

The adsorption capacity of the adsorbents. q_t is given as:

$$q_t = \frac{C_0 - C_e}{C_0} \times V \quad (2)$$

Where C_o is the initial concentration of the metal ions (mol), C_e is the concentration of the metal ions at equilibrium (mol), v is the volume of the metal ions in contact with the adsorbent and m is the mass of the adsorbent in (g).

Results

Effects of Adsorbent Dosage on the Removal of Cadmium (ii)ion From Aqueous solution.

Mass of Adsorbent (g)	Amount of Cd(ii) ion Adsorbedq_t (mg/g)
0.2	3.380
0.4	2.096
0.6	1.504
0.8	1.108
1.0	0.880

Effects of pH on the Removal of Cadmium (ii) ion From Aqueous solution

pH	Amount of Cd(ii) ion Adsorbedq_t (mg/g)
2	1.721
4	1.417
6	1.858
8	1.923
10	2.095

Effects of Concentration on the Removal of Cadmium (ii) ion From Aqueous solution

Concentration (ppm)	% Removal of Cd (II) ion
10	85.77
20	75.22
30	77.25
40	69.40
50	61.53

Effects of Agitation Time on the Removal of Cadmium (ii) ion From Aqueous solution

Contact Time (mins)	Amount of Cd(ii) ion Adsorbedq_t (mg/g)
20	2.414
40	1.860
60	1.840
80	1.861
100	2.484

Effects of Particle Sizes on the Removal of Cadmium (ii) ion From Aqueous solution

Particle Size (µm)	Amount of Cd(ii) ion Adsorbedq_t (mg/g)
0.25	0.84
0.45	0.75
0.71	0.73
1.50	0.71

Discussion

Effect of Adsorbent Dosage

The effect of adsorbent dosage on the amount of cadmium adsorbed was carried out at fixed time, concentration, temperature and pH. The adsorbent adsorbed maximum cadmium at dosage level of 0.2g but decrease as the dosage is increase from 0.4g to 0.6g. This is as a result of more competition for available Cd(II) ion. However, the amount adsorbed increased slightly as dosage of the adsorbent was increased from 0.8g to 1.0g. Hence, smaller mass of adsorbent can effectively remove Cd(II) ion from aqueous solution.

Determination of effect of pH

The adsorbent adsorbed higher amount of the metal ion when the pH of the solution is greater than seven (7). This is as a result of increased in the number of negative ions on the surface of the adsorbent which tends to attract the positive cadmium ions to it[4]. However, at pH lower than seven (7), there is increased number of positive ions on the surface of the adsorbent which tends to repel cadmium ions from it [4].

Effect of Agitation Time

The amount of adsorbate adsorbed by an adsorbent at a particular time is one of the important factors governing the efficiency of adsorption. From table 3.4, it can be shown that the uptake of cadmium ion by the adsorbent is in two stages; the rapid stage occurring at a contact time of 20 minutes due to the availability of more than required number of active sites on the surface of the carbons and the slower stage as time proceeds until the equilibrium time is reached at100 minutes. This is due to the decreased or lesser number of active sites [7].

Effect of initial concentration of Cd (ii)

The uptake of cadmium ions was rapid at initial concentration of 10mg/g. however, as the concentration of the metal ion increases, the rate of adsorption decreases as a result saturation of the available active sites [5], resulting in the decrease in the number of active sites for adsorption [5]. It can also be deduced from the experiment, that there is overall increase in the amount of cadmium ions at higher concentration as a result of increase in the driving forces required to break down the mass transfer resistance at the solid-liquid interface.

Effect of Particle size on the Adsorption of Cd (ii)

Since adsorption is a surface phenomenon, it is evident that the greater the surface area per unit mass of the adsorbent, the greater is its capacity for adsorption**.** The rate of adsorption of cadmium ion onto garlic skin was fastest at a very low particle size of 0.25µm. this is as a result of increase of competition for the metal ions as the size of the adsorbent increases. In general, the intra- particle mass transfer effect will increase with the increasing particle size. However, the surface area per unit mass of adsorbent as well as diffusional transport, might be larger in case of smaller particles.

Conclusion

The results obtained from this study showed that garlic skin is an effective adsorbent for the removal of Cd (II) from aqueous solution and the adsorption of Cd (II) onto garlic skin depends on pH, initial metal concentration, adsorbent dosage and agitation time of adsorption.

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