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Assessment of alkalinity on the adsorption of cadmium ion using KOH-activated carbon from Sesame stem

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Abstract

The increase alkalinity on the adsorption of cd^{2+} using KOH-activated carbon from Sesame stem was studied. Determination of metal ion in solution shows adsorption capacities of 86.68 % for KOH-AC at saturated state. Effect of metal ion concentration shows that, Removal efficiency of Cd^{2+} by KOH-AC increases with increasing presence of the adsorbate due to the availability of adsorption sites on the activated carbon. Increase acidity general favors the adsorption. The effect of pH shows that the adsorption of cadmium ions increases with increasing acidity between the pH of 7.5 to 6. However, as the Cd^{2+} concentration becomes exceedingly high, the removal efficiency decreases. A general observation was that before equilibrium, there is rise in the removal efficiency of Cd2+ by KOH-AC with increasing contact time which is universally true for good adsorbents. Effect of metal ionic strength shows that activated carbon adsorption decrease with increase in ionic strength in any acidic medium.

Keywords: Sesame; Adsorption; Acidity; Removal; Activated carbon

1 Introduction

Sesame leaves are used for various traditional and medicinal purposes, such as pain relief [1]. In Nigeria and many other tropical areas, the leaves of *Sesamum radiatum* are used for the treatment of catarrh, eye pain, bruises, and erupted skin lesions [2]. The stems of sesame are usually discarded as waste given it a huge potential to be exploited for waste management. Cadmium excretion from the body is slow and occurs via the kidneys, urine, saliva, and milk during lactation. In humans, Cadmium exposure can result in a variety of adverse effects, such as renal and hepatic dysfunction, pulmonary edema, testicular damage, osteomalacia, and damage to the adrenals and hemopoietic system [3][9]. An association between Cadmium exposure markers (blood and urine) and coronary heart disease, stroke, peripheral artery disease, and atherogenic changes in lipid profile was also observed (IARC 1993). In addition to its cytotoxic effects that could lead to apoptotic or necrotic events, cadmium is a proven human carcinogen (group I of International Agency for Research on Cancer classification) [4]. Occupational or environmental cadmium exposure has been related to lung, breast, prostate, pancreas, urinary bladder, and nasopharynx cancers [7][10]. Recently, it has also been demonstrated that cadmium arsenite in yeast cells may interfere with the folding of nascent proteins, which reduces cellular viability and is probably responsible for various pathological conditions, such as neurodegenerative diseases and age-related disorders, and Alzheimer's and Parkinson's diseases [5]. Therefore, a study on the assessment of increase alkalinity on the adsorption of cadmium ion using KOH-activated carbon from Sesame stem.

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2 Material and methods

2.1 Materials

Sesame stem, Beaker, Conical flask, Mortar and Pestle, Spatula, separating funnel, distilled water, Volumetric flask, Cadmium chloride, Potassium hydroxide, hydrochloric acid, Glass rod, measuring cylinder, Filter paper, Petri dish, Weighing balance.

2.2 Preparation of reagents

Cadmium: Dissolve 2.0360 g of cadmium chloride ($CdCl_2$) in 100 ml of deionizer water dilute to 1L in a volumetric flask (1000 ppm AAS standard) and 33 g of KOH dissolved in 500 ml of distilled water.

2.3 Sampling and sample preparation

Sesame stems were collected from Wukari market Taraba State, the samples were room dried and cut into pieces in order to enhance carbonization, purification, chemical activation using the methods [3][7]. Sesame stems is carbonized in a specially constructed chamber, after cooling the charred products were grounded with the use of mortar and pestle to produce a fine powder. Chemical activation was done using aqueous KOH. Sample of the carbon from sesame stem was poured into a beaker containing dilute potassium hydroxide, the content of the beaker was thoroughly mixed until a paste was formed. The paste of the sample was transferred into a Petri dish, dried for 48hr after which it was washed with distilled water, then filtered and dried again.

2.4 Determination of metal ion in solution

A concentration of 200ppm of the aqueous Cadmium solution was prepared with distilled water from the above concentration, 50ml of the solution of metal ion was taken into a beaker, and 2 g activated carbon of sesame stem was added and then shaken vigorously for 1 hour using flask shaker. The mixture was filtered and the residual metal ion concentration is determine using AAS [4][11].

2.5 Effect of ionic strength on adsorption capacity

Selected mass was adjusted with 0.1, 0.5, 1.0 g, and 2.0 g of NaCl in 200 ppm to obtain various desired concentration of Cadmium ion. 2.0 g activated carbon sesame stem was added to the sample to 50 ml of the prepared solution and the equilibrium concentration of the residual metal ion was determined. It was shaken for 1 hour using flask shaker then the mixture was filtered and the residual metal ion concentration is determine using AAS [4]

2.6 Effect of initial metal ion concentration on adsorption capacity

Different sample consisting of 50 ml of the metal ion concentration from 10ppm, 20ppm, 40 ppm, 60 ppm, 100 ppm of cadmium ion, and each containing 2 g activated carbon sesame stem were prepared and shaken for 1 hour until equilibrium was obtain, the mixture was filtered and analyzed for residual metal ion concentration using AAS [4]

2.7 Effect of time on kinetic of adsorption

To determine the kinetic of sorption, five different set of samples consisting of 2 g activated carbon sesame stem and 50ml of metal ion solution was prepared as the sample undergoes agitation with flask shaker. They were removed at a predetermined time interval from 1hrs, 2hrs 3hrs, 6hrs and 24hrs. The solution was filtered and analyzed for residual metal [2][4]

2.8 Effect of pH on sorption capacity

The pH of 50ml of 200ppm of the metal is taken using the pH meter. Another 50ml of 200ppm of the metals is taken and 2drops of HCl is added while the pH is determining, this is repeated by adding 3, 5, 7 and 9 drops of concentrated HCl and taking note of the pH. The solutions are filtered and analyzed for residual metal ion concentration using AAS [4]

3 Results and discussion

3.1 Effect of adsorption Capacity of cadmium ions using KOH-AC

Figure 1 shows the sorption efficiency of Sesame stem in Cadmium ion solution. It can be seen that the higher sorption capacity was recorded for the adsorption of the Cadmium ion 88.4 %. The result from the present studies is comparable with those reported from similar study [7]. The adsorption capacity can be explained base on the formation of covalent bond with a ligand. Base on this fact, Cadmium forms a covalent bonding easily with NH_2 [2].

3.2 Effect of contact time in the sorption of cadmium using KOH-AC

The results of the study are depicted by Fig. 2. From the figure, the equilibrium adsorption was attained after about 60 min for the activated carbon powders with adsorption capacities of 86.68 KOH-AC. A general observation was that before equilibrium, there was rise in the removal efficiency of $Cd2+$ by KOH-AC with increasing contact time which is universally true for good adsorbents [9]. The major shift was observed between 1-2 hours.

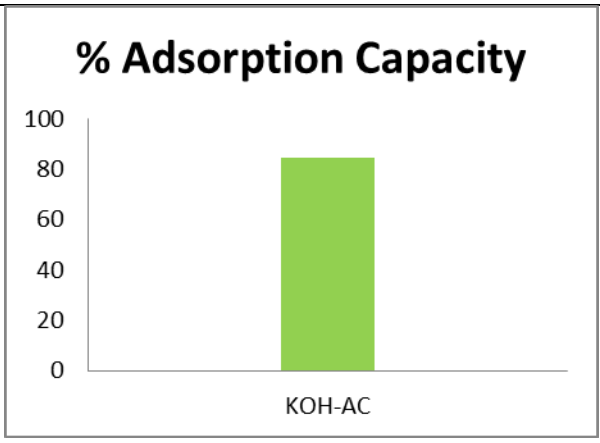

Figure 1 Effect of adsorption Capacity of cadmium using KOH-AC

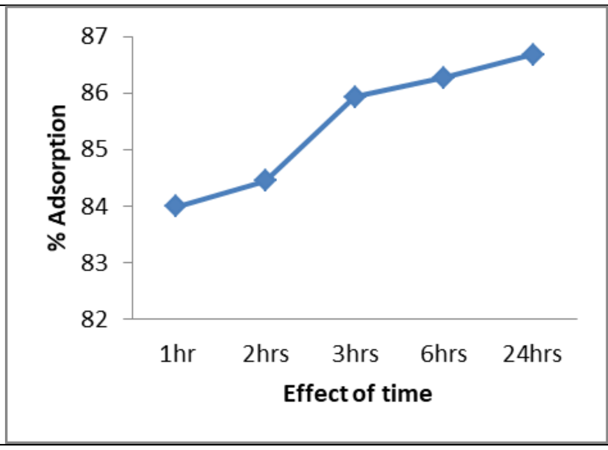

Figure 2 Effect of contact time in the adsorption of cadmium using KOH-AC

3.3 Effect of metal ion concentration in the adsorption of cadmium using KOH-AC

The effect of initial heavy metal concentration was studied within the range of 10ppm–100ppm. The results of the study are shown in Fig. 3. The removal efficiency of Cd^{2+} by KOH-AC increases with increasing presence of the adsorbate [2]. However, as the Cd^{2+} concentration becomes exceedingly high, the removal efficiency also increases. Increase in the amount of acidity increase the adsorption rate but as the acid drops get access the adsorption rate attained equilibrium. It may be noted that the efficiency of adsorption was generally high >70 % with the chemically activated carbons [11]

3.4 Effect of pH in the adsorption of cadmium using KOH-AC

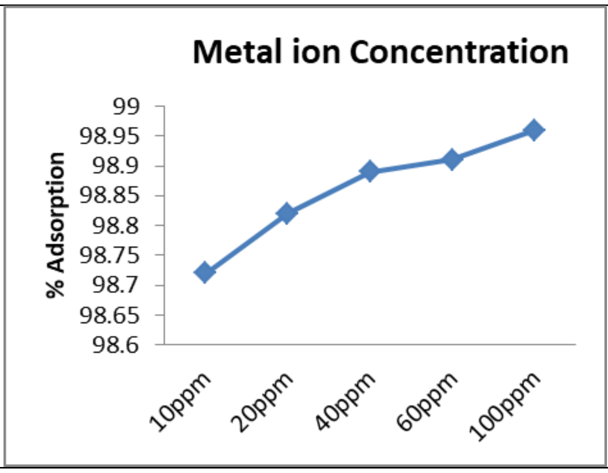

Figure 3 Effect of metal ion concentration in the adsorption of cadmium using KOH-AC

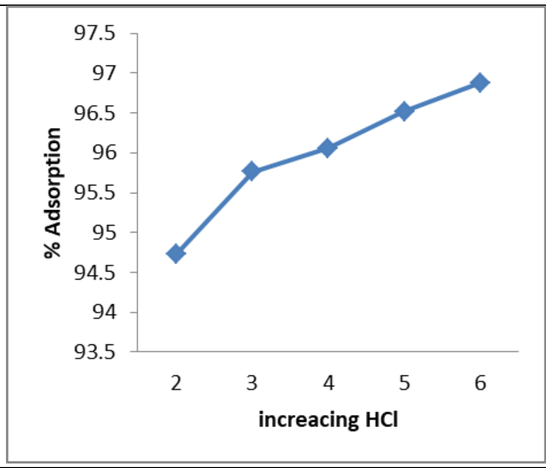

Figure 4 Effect of pH in the adsorption of cadmium using KOH-AC

Effect of pH in the adsorption of cadmium using KOH-AC shows that, the pH of the aqueous suspension of adsorbent is an important parameter that may control the adsorption of metals [10]. It can be seen from Fig. 4 that for the regular KOH-AC, low removal capacity of cadmium ion was observed when the drops of HCl were added in an increase manner in the cadmium ion solutions containing KOH-AC which improved fairly as acidity is increase the adsorption was favored towards the pH of 7.

3.5 Effect of metal ionic strength in the adsorption of cadmium using KOH-AC

It is seen that the adsorption capacity of sesame stem activated carbon decrease with increase in ionic strength. The ionic strength can however be explained as a competition of Na^+ with other metal ion for electrostatic binding to the sesame stem. A sharp decrease was observed between 0.5 g and 1.0g. this shows that the major decrease is obtained within this rang.

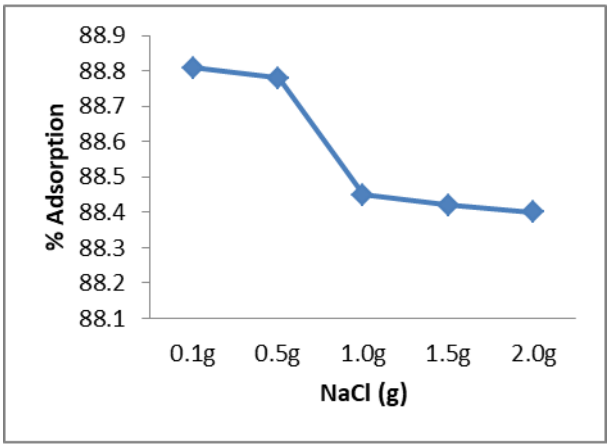

Figure 5 Effect of metal ionic strength in the adsorption of cadmium using KOH-AC

4 Conclusion

Research over the past decade has provided a better understanding of metal biosorption by certain potential bio-sorbents. The group of cheap bio-sorbent materials based on natural and waste biomasses constitutes the basis for a new cost-effective technology that can find its largest application in the removal of metal contaminated industrial effluents. Sesame stem carbon have shown that it is good adsorbent for cadmium ion. Application aspects of biosorption are being aimed at biosorption process optimization [8].

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest.

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