Effect of Adsorption Dose and Contact Time on the Removal of Toxic Elements from Water Using an Agricultural Waste: An alternative to the use of Activated Carbon

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Abstract
This study focuses on the use of walnut shell as a low cost adsorbent for removal of toxic elements namely Pd(II), Cd (II) and As(III) ion from water. Batch adsorption method was used to evaluate the effect of adsorbent dose and contact time on adsorption. The result showed an increase in the adsorption of all metal ions with increase in adsorbent dose. On the other hand, a decrease in adsorption for the metal was obtained with increase in initial metal ion concentration. An equilibrium contact time of 20, 40, and 50 min was achieved for AS (III), Cd (II), and Pb (II) ion respectively. The adsorption of metal ions followed the order AS (III) > Cd (II) > Pb (II). The result of this study shows that walnut shell can be used as a cheap adsorbent for removal of Pb (II), Cd (II) and As (III) ions from water.
Keywords: Walnut shell,adsorption,toxic elements, water

INTRODUCTION

Commonly encountered heavy metals are chromium, cobalt, nickel, copper, zinc, arsenic, selenium, silver, cadmium, anhmony, mercury, thallium and lead. The excessive release of heavy metals into the environment due to industrialization and urbanization has posed a great problem worldwide. It has been observed that the harmful effect of heavy metals discharged annually into the environment far exceeds the combined total toxicity of all radioactive and organic waste (Kobya *et al*, 2005). This account for the reason why the discharge of heavy metals into the environment became a problem of great concern over last few decades. Heavy metals are known to be toxic at certain concentration (Dawode *et al.,* 2012) copper, selenium, zinc are essential to maintain the metabolism of the human body, however, at higher concentration they can lead to poisoning. Due to the massive problem resulting from these metals pollution, researches on the removal of these metals from effluents has become a major topic for environmental scientists. Treatment process for heavy metal removal from industrial waste water include precipitation, membrane filtration, ion exchange, chemical oxidation, electrochemical treatment, evaporation and solvent extraction. These techniques have the disadvantages of high cost, low selectivity, incomplete metal recovery, high energy requirement, difficult to apply and generation of toxic slurries which are difficult to dispose (Dawodu and Akpome, 2014).

Studies on the treatment of effluent bearing heavy metal have revealed adsorption to be a highly effective technique for the removal of heavy metal from industrial waste water due to it's high efficiency, low cost of maintenance and ease of application. Activated carbon has high adsorption capacity and it also remain an expensive material. In recent years, the need for safe and economical method for the elimination of heavy metal from contaminated water has necessitated research interest towards production of low cost alternatives to commercially available activated carbon. The low cost agricultural waste by- products such as sugarcane biogases, rice husk, saw dust, clay, biomass, red mud lateritic material (DAS and Monoal, 2011). In Nigeria, we have Walnut deposits in quantity. The walnut shell usually constitute nuisance to the environment or serve as a source of energy for burning. In the process. This study therefore investigates the potential of walnut shell as a low cost adsorbent for heavy metals elimination.

Statement of the Problem

Heavy metals such as cadmium, lead and arsenic are released continually from industrial effluent into receiving water bodies. These metals are toxic and have dangerous health effects on plants, human, and aquatic life and can lead to death at high concentration. Activated carbon which is used as an adsorbent for the removal of these toxic elements is expensive making many industries release these metals to the environment without treatment. Low cost adsorbent have become the focus of many scientists. This study, therefore investigates walnut shell as a low cost adsorbent for heavy metals removal.

Aims of the Study

The aim of this research work is to bring an idea of a local available Nigeria walnut shell to adsorb lead, cadmium and arsenic from water as an alternative low cost adsorbent to the expensive activated carbon that has been used.

Materials and Methods

The walnut was washed with de-ionized water to get rid of unwanted materials and sundried for 7 days and was grinded to powdery form. The sample were then passed through a 100um mush sieve to obtain the prepared walnut shell adsorbent for the adsorption process.

Batch adsorption was used to determine the effect of adsorption dose and contact time.

Determination of the effect of adsorbent dose

The walnut shell was weighed differently 0.1, 0.2, 0.3, 0.4, and 0.5 after which It was placed in five 100ml plastic bottles and 20ml of the metal ion solution with concentration of 2000mg/l, then covered and shacked for 5 seconds and allowed to stand for 180 min at temperature of 300k, the solution was then filtered with a filter paper and the filtrate taken to. Atomic absorption spectrophotometer (AAS) to determine the concentration of metal ions remaining after adsorption process (Akpomie *et al.*, 2014).

DETERMINATION OF THE EFFECT OF CONTACT TIME

0.lg of walnut shell was weighed differently and placed in eight 100ml of plastic bottles. 20ml of metal ions solution of concentration 200mg/l of pH 6.0 was added to the plastic bottles and corked very well, it was shaked for 5 seconds and allowed to stand at different contact time of l0min, 20min, 30mm, 40min, 50min, 60min, 90min, and 120min. When it was time for each experiment, the solution was filtered and the filterate was taken to AAS to determine the concentration of the metal ions that remains (Akpomie *et al*, 2014).

EFFECT OF ADSORBENT DOSE

The effect of adsorbent dose is a very important factor that can affect the adsorption amount of metal ions from solution. It was observed that as the weight of walnut shell was increased from 0.1 to 0.5g a corresponding increase in the percentage removal was obtained for the three metal ions. This is mainly due to an increase in the surface area and the availability of more active binding site on the surface of the adsorbent with increase in adsorbent dose (Barka *et al*, 2013). However, the maximum adsorption capacity of an adsorbent can be determined from column experiment by the use of excess amount of the adsorbent (Zafar *et al*, 2006).

EFFECT OF CONTACT TIME

The effect of contact time on the percentage adsorption of Pb(II), Cd(II) and As(III) from aqueous solution unto walnut shell is shown in fig. 4.4, and it is observed that the rate of removal of the metal ions from solution was initial rapid and then diminished gradually until an equilibrium time beyond which there was no significant increase in the removal rate. The fast adsorption at the initial stages is due to the presence of vacant and abundant active site on the walnut shell which become used up with time and become saturated thereby attaining equilibrium.

(Gupta et al, 2003), equilibrium was established around 20mins for As (III), 40mins for Cd(II) and 50mins for Pb(II) ions. The faster rate of adsorption of As(III) is due to the smaller ionic radii which makes its to diffuse faster to the surface of walnut shell when compared to the other metals. The same also applies for the faster rate of Cd(II) adsorption than Pb(II) ions as stated earlier. A contact time of 180mins was chosen in this study to ensure equilibrium sorption was attained for the three metal ions.

Conclusion

The experimental factors such as the effect of adsorbent dose and contact time affected the adsorption of Pb (I), Cd (II), and AS (III) ions onto walnut shell. The use of commercially available activated carbon can be replaced by the utilization of inexpensive, effective and readily availably agricultural by product such as walnut shell used in this study since it can be utilized as low cost adsorbent for the removal of Pb (II), Cd (II), and As (III) from aqueous solution and industrial waste water. More studies should be carried out to better understand the process of low cost adsorption and to demonstrate the technology effectively.

Table 1: Adsorbent dose parameters on the adsorption of Pb (II) ion unto walnut shell

Adsorbent dose (g)	Ce (mg/L)	qe (mg/g)	% Removal
0.1	70.8	25.84	64.6
0.2	54.1	14.59	72.95
0.3	32.8	11.14667	83.6
0.4	26.9	8.655	86.55
0.5	20.2	7.192	89.9

Table 2: Adsorbent dose parameters on the adsorption of Cd (II) ion unto walnut shell

Adsorbent dose (g)	Ce (mg/L)	qe (mg/g)	% Removal
0.1	53.8	29.24	73.1
0.2	38.6	16.14	80.7
0.3	23.1	11.79333	88.45
0.4	18.2	9.09	90.9
0.5	11.3	7.548	94.35

Table 3: Adsorbent dose parameters on the adsorption of As (III) ion unto walnut shell

Adsorbent dose (g)	Ce (mg/L)	qe (mg/g)	% Removal
0.1	32.4	33.52	83.8
0.2	20.3	17.97	89.85
0.3	11.6	12.56	94.2
0.4	5.8	9.79	97.1
0.5	2.4	7.904	98.8

Table 4: Kinetic parameters for the sorption of Pb (II) ions unto walnut shell

T(min)	Ce(mg/L)	Qt(mg/g)	% Removal
10	175.6	4.88	12.2
20	134.9	13.02	32.55
30	106.8	18.64	46.6
40	83.7	23.26	58.15
50	71.4	25.72	64.3
60	69.9	26.02	65.05
90	70.3	25.94	64.85
120	71.2	25.76	64.4

Table 5 : Kinetic parameters for the sorption of pb (II) ions unto walnut shell

T(min)	Ce(mg/L)	Qt(mg/g)	% Removal
10	151.4	9.72	24.3
20	103.6	19.28	48.2
30	75.8	24.84	62.1
40	53.6	29.28	73.2
50	53.8	29.24	73.1
60	53.1	29.38	73.46
90	54.2	29.16	72.9
120	52.9	29.42	73.55

Table : Kinetic parameters for the sorption of As (III) ions unto walnut shell

T(min)	Ce(mg/L)	Qt(mg/g)	% Removal
10	95.3	20.94	52.35
20	35.8	32.84	82.1
30	32.4	33.52	83.8
40	32.8	33.44	83.6
50	32.7	33.46	83.65
60	33	33.4	83.5
90	33.4	33.32	83.3
120	32.6	33.48	83.7

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