International Scholars Journals

International Journal of Food Safety and Public Health Vol. 9 (1), pp. 001-005, January, 2022. Available online at www.internationalscholarsjournals.org

Full Length Research Paper

Adsorption of Cadmium Ions using activated carbon prepared from Coconut shell

Olowoyo, D.N and Garuba, A.O

[1]The department of industrial safety and environmental technology.

[2]Petroleum training institute, Effurun - Warri, Delta state, Nigeria.

Accepted 12 August 2021

The adsorption of cadmium ions on activated carbon prepared from coconut shells obtained from Effurun market via Warri were carbonized and chemically activated using phosphoric acid, potassium hydroxide, calcium carbonate and zinc chloride solutions as activating reagents. The effects of contact time and pH in the presence of activating reagents mentioned above on the adsorption capacity of the adsorbents were investigated. However, the adsorption of Cd (11) ions with respect to time in all the activating agents had similar patterns and the order of decreasing in percentage of Cd (11) ions removed according to activating agents used is H_3PO_4 > $ZnCl_2$ > KOH > $CaCO_3$ while the results of pH indicated that adsorption of cadmium (11) ions increased at a steady rate as the pH increased most especially in $CaCO_3$ and KOH activating agent solutions which is almost tending to 100% out of the four activating agents investigated. In a nutshell, the activated carbons with high adsorption capacities can be produced from coconut shells when they are activated with some reagents like $CaCO_3$, KOH, H_3PO_4 and $ZnCl_2$. This was attested when the influence of equilibration time and pH on the adsorption capacities of the activated coconut shell were investigated.

Keywords: Cadmium ion, activated carbon and Coconut shell

INTRODUCTION

Industrial activities and mining operations have exposed man to the toxic effects of metals (Carrein and Becker, 1984). Heavy metals are present in the soil, natural water and air in various forms and may become contaminates in food and drinking water (Forsther, 1977). Some of them are constituents of herbicides, pesticides, paints and fertilizers applications. Hazards associated with the contamination of water have led to the development of various technologies for water purification namely filtration and ion exchange, precipitation with carbonate or hydroxide (Arowolo, 2004).

Man's exposure to heavy metals comes from mining, smelting, refining and manufacturing processes (Nriagu, 1996). Heavy metals constitute an important part of environmental pollutants which can be detrimental to a variety of living species. Excessive ingestion of these metals by humans can cause accumulative poisoning,

Corresponding author Email: olowoyoniyi@yahoo.com

cancer, nervous system damage and ultimately death (Issabayeva et al., 2007). Examples of these metals are cadmium, chromium, Copper, Lead, Mercury, Nickel, Selenium, Silver, vanadium, cobalt and Zinc.

Heavy metals are non-biodegradable and they tend to accumulate in living organisms, causing various diseases and disorder e.g cadmium causes serious renal damage, anemia and hypertension. Cadmium occurs naturally in the environment and the main anthropogenic pathway through which cadmium enters environment is through waste from industrial processes such as electroplating, smelting, alloy manufacturing, cadmium-nickel batteries, pesticides, mining, fertilizers, textile operations and refining (Cheung et al, 2000; Wu et al, 2010).

The reduction of the Pollutant to an acceptable level is necessary when toxic metals are present in aquatic environment. Adsorption and ion exchange processes are the most useful methods to apply in their removal. These methods explore the availability of different kinds of adsorbents associated with convenient procedures for obtaining high efficiency. A large number of different adsorbent materials containing a variety of attached chemical functional groups have been reported for this purpose. For instance, activated carbon is the most popular materials and can be defined as a porous carbon materials, usually charred, which had been subjected to reactions with gases during and after carbonization in order to increase porosity. Activated carbon was distinguished from elemental carbon by the removal of all non-carbon impurities and the oxidation of the carbon surface (Gueu et al, 2007 ; Bennaissa, 2006).

In recent time, special attention has been focused on the rise of natural adsorbents as an alternative to replace the connectional adsorbent, based on both the environmental and economical points of view. Several researchers have reported on the potential use of agricultural by products as good substrates for the removal of heavy metals. This process attempts to put into use the principle of using waste to treat waste and become even more efficient because these agricultural by products are readily available and often pose waste disposal problems. Hence, they are available at little or no cost, since they are waste products. This makes the process of treating waste waters or effluents with agricultural by product adsorbents more cost effective than the use of conventional adsorbents like activated carbon (Igwe and Abia, 2005). However, activated carbon from coconut shell is a good material for activated carbon/charcoal production and it has numerous advantages over other materials such as wood, corn cob, groundnut shell, banana stem, rice husk etc because of its ability to adsorb colour and aroma It is used as supporting material for food and non-food industries in the processing of cooking oil, sugar and chemical matter purification.

In this research, a local agricultural coconut shell was used to prepare activated carbon and the effects of pH and agitation time were studied.

MATERIALS AND METHODS

Collection of Samples and Materials

Coconut fruits were bought in large quantity in Effurun/Warri Markets of Delta State, Nigeria. The fruits were transported to the laboratory for immediate use. The coconut fruits were sorted out to obtain coconut shells (endocarps) which were thoroughly washed with water to remove dirt/ unwanted parts and dried very well in an oven at 105^{0}C for one hour (Olowoyo and 0rere, 2012).

Carbonization/Activation of Samples

The coconut shells samples were carbonized in the muffle furnace at optimum devolatilization temperature of 300^{0}C for 1hour according to the method reported elsewhere. They were ground into powder; pass through 0.22mm mesh size (Olowoyo and Oghuvwu, 2002). The chemical activated was carried out on the carbonized samples. A weighed quantity of 10g each of the activating agents of $CaCO_3$, KOH, H_3PO_4 and $ZnCl_2$ were dissolved in each of four different 100ml beakers that contained 50ml of distilled water. 50g of the carbonized sample was weighed and mixed thoroughly with each of the prepared solutions of activating agents mentioned above. They were all activated for 15 minutes at the temperature of 350^{0}C. The activated carbon samples were washed with 0.5M acetic acid, rinsed with distilled water until their pH were almost neutral ≈ 7 and dried. The activated carbons thus obtained were finally smoothened, stored in well-fitted airtight corked bottles and properly labeled for further investigation (Olowoyo and 0rere, 2012).

Preparation of Cd (11) ions standard solutions

Six different standard solutions with concentrations (mg/l) of 5, 10, 15, 20, 25 and 30 were prepared from the stock solution of 1000ppm. 5.0g of the activated adsorbent was added to each of the four activating agents of $CaCO_3$, KOH, H_3PO_4 and $ZnCl_2$ solutions in 100ml flasks. These procedures were carried out for all the standard solutions prepared and the activating reagents used.

The effect of equilibration time

About 10mg/l Cd (11) ions standard solution was

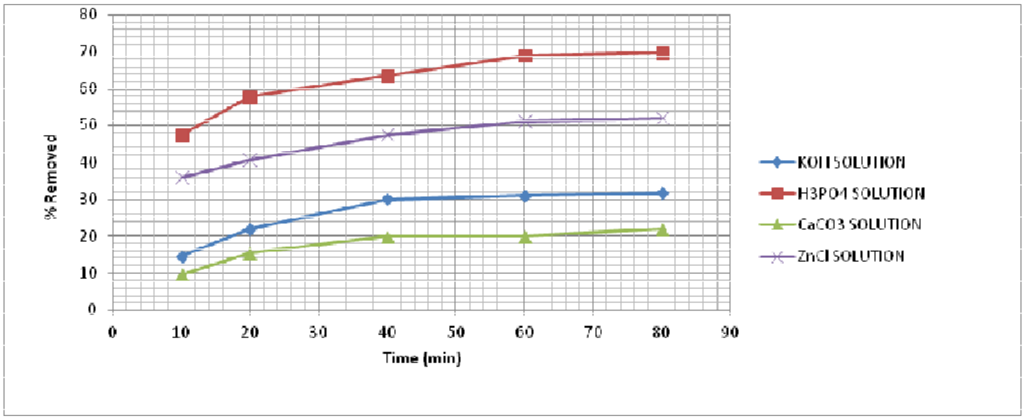

Figure 1. Effect of equilibration time on the adsorption of cadmium (11) ions

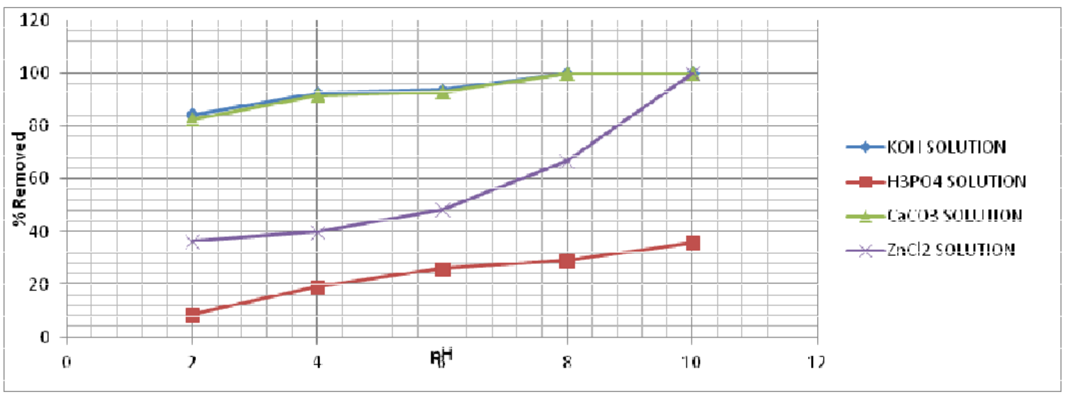

Figure 2. Effect of pH on the adsorption of cadmium (11) ions

prepared and transferred into each of 5.0g of the activated adsorbent (coconut shell activated carbon) containing different activating agents of $CaCO_3$, KOH, H_3PO_4 and $ZnCl_2$ in different 100ml volumetric flasks, corked and labeled. Each of the flask in turn was agitated in an orbital shaker at different equilibration times 10, 20, 40, 60 and 80minutes. After each agitated time specified was reached, the content of each flask was then filtered and the concentration in the filtrate determined by atomic absorption spectrophotometer (AAS).

The effect of pH

The same quantity of 10mg/l Cd (11) ions standard solution was prepared and transferred into each of 5.0g of the activated adsorbent (coconut shell activated carbon) containing different activating agents of $CaCO_3$, KOH, H_3PO_4 and $ZnCl_2$ in different 100ml volumetric flasks, corked and labeled as above. The agitations were carried out at the equilibration time of 80minutes (being the maximum time where maximum adsorption of cadmium was observed in this work) at various pH of 2, 4, 6, 8 and 10 for different activating agents. The contents in the flasks were filtered and each filtrate was analyzed with AAS

RESULTS AND DISCUSSION

The removal of cadmium ion from aqueous solution using activated coconut shell as adsorbent with different activating reagents at different equilibration times is indicated in figure (1) below, while figure (2) showed the effect of pH on cadmium (11) ions adsorption onto activated coconut shell. The amount of the cadmium ion adsorbed onto adsorbent increased with increase in equilibration time. This is similar to report recorded by Gueu, et al, (2007). However, there was rapid increase in the rate of Cd (11) ions adsorption between 10 – 20minutes while the rate slowed down between 20 – 40 minutes. The rate further slowed down between 40 – 60 minutes and gradually approached state of equilibrium at 80 minutes. Hence, the equilibration time may be assumed to be at the neighbourhood of 80 minutes. The adsorption of Cd (11) ions with respect to time in all the activating agents had similar patterns and the order of decreasing in percentage of Cd (11) ions removed according to activating agents used is H_3PO_4 > $ZnCl_2$ > KOH > $CaCO_3$.

The pH of the Aqueous solution is an important controlling parameter in the adsorption process of metals (Baes and Mesmer, 1976). The results indicated that adsorption of cadmium (11) ions increased at a steady rate as the pH increased most especially in $CaCO_3$ and KOH activating agent solutions which is almost tending to 100%. This could also be explained on the basis that at lower pH values, excess concentration of hydrogen ions compete with the cadmium ions on the active sites of the adsorbent. However, according to Low et al, (1995), at lower pH values, the surface of the adsorbent would be closely associated with hydroxonium ions ($H_3O^{+)}$, and by repulsion forces to the surface functional groups, consequently decreasing the percentage removal of metals. At higher pH values, precipitation of metal may occur which could lead to decrease in the adsorption of metal ions. This decrease may be due to the formation of soluble hydroxyl complexes. Thus, the drastic reduction in the adsorption of cadmium ions in H_3PO_4 and $ZnCl_2$ solutions may be due to tendency of the formation of hydroxonium ions and hydroxyl complexes in the media solutions of H_3PO_4 (tribasic) and $ZnCl_2$ respectively.

CONCLUTION

It can be concluded that activated carbons with high adsorption capacities can be produced from coconut shells when they are activated with some reagents such as $CaCO_3$, KOH, H_3PO_4 and $ZnCl_{2.}$ However, the influence of activating agents and pH could either affect the adsorption capacities of the activated coconut shell positively or negatively depending on the nature of the activating agents and the range of the pH.

REFERENCES

Arowolo TA (2004). Heavy Metals and Health. West Indian Med. J., 53: 63-65

Baes GB, Mesmer RE (1976). Hydrolysis of Cations, John Woley and Sons, NY.

Benaissa H (2006). Screening of New Sorbent Materials For Cadmium Removal From Aqueous Solutions. J. Hazaerd. Mater., Vol. 132, pp. 189-195.

Carrein MA, Becker CE (1984). Chelators And Heavy Metal Intoxication. Basic and Clinical Pharmacology. Ratzung, B.G., Lange Medical Publication, Califonia, p.342 – 346.

Cheung CW, Poter JF, McKay G (2000). Elovich Equation And Modified Second-Order Equation For Adsorption Of Cadmium Ions Onto Bone Char. J. Chem. Technol. Biotechnol., Vol. 75, pp. 963-970.

Forsther U (1977). Metal Concentration In Fresh Water Sediments, Natural Background And Cultural Effect. In: Intervention Between Sediment And Fresh Water, Golterman, H.L. (Ed). Junk Publisher, the Hague, pp. 94-103.

Gueu S, Yao B, Adouby K, Ado G (2007). Kinetics and Thermodynamics Study Of Cadmium Adsorption On To Activated Carbons From Coconut And Seed Hull Of The Palm Tree. Int. J. Environ. Sci. Tech., 4(1): 11-17 (7 pages).

Igwe JC, Abia AA (2005). Sorption Kinetics And Intra-Particulate Diffusivities Of Cd, Pb, and Zn Ions On Maize Cob. Afr. J, Biotech. 4(6): 509-512.

Issabayeva G, Arua MK, Sulaiman NM (2007). Continuous Adsorption Of Lead Ions In A Column Packed With Palm Shell Activated Carbon. J. Hazard. Mater., 155 (1-2), 109-113 (5 pages). Production Of Granular Activated Carbon From Waste Walnut Shell And Its Adsorption Characteristic For Copper (II) Ions. J. Hazard. Mater. B., 85: 301-315.

Low KS, Lee CK, Leo AC (1995). Removal Of Metals From Electroplating Wastes Using Banana Pith. Bioresour. Technol., 51, 227.

Nriagu (1996). Toxic Metal Pollution in Africa. Science. 223:272-273.

Olowoyo DN, Oghuvwu MM (2002). International Journal of Environmental Research, Vol. 4 (2) ppb27-30.

Olowoyo DN, Orere EE (2012). International Journal of Research in Chemistry and Environment, Vol. 2(3): 32-35.

Wu J, Lu J, Chen TH, He Z, Su Y, Yao XY (2010). In situ Biotreatment Of Acidic Mine Drainage Using Straw As Sole Substrate. Environ. Earth Sci. vol. 60, pp.421-429.