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COCONUT PALM (*COCOS NUCIFERA*) HUSK AS A POTENTIAL ADSORBENT FOR LEAD, CADMIUM AND ZINC IONS IN INDUSTRIAL WASTE EFFLUENTS

J. A. Omgbu, N. S. Ohochuku, V. Iweanya* and E. M. Obaseki*

Department of Chemistry, School of Sciences, College of Education Warri, Nigeria

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Sorption of lead, cadmium and zinc ions from aqueous effluents by coconut (*Cocos nucifera*) husk is reported. Results show that more than eighty percent removal could be achieved in the column experiments. The sorption of the metal ions vary markedly with the type of metal ion and follows the order lead> cadmium> zinc ions and its initial concentration. Its use for binding lead, cadmium and zinc ions in mining waste effluents is recommended.

Key words: Coconut husk, Adsorbent, Industrial waste, Toxic minerals.

Introduction

Several research workers have shown that some agricultural by-products can bind substantial amounts of toxic heavy metals in aqueous solutions. Kumar and Dara [1] showed that as much as 63% of potassium ions and 99.8% mercury II ions uptake could be achieved by polymerized red onion skins treated with 39% methanol and 0.2 N tetraoxosulphate VI acid for two hours. Ogbeifun *et al.* [2] reported that groundnut (*Arachic hypogea*) husk could adsorb 2.8 mg g^{-1} of lead, 4.0 mg g^{-1} of copper and 3.8 mg g^{-1} of cadmium ions from aqueous solutions containing 200 mg g^{-1} of metallic ions with 5 g of modified groundnut husk. Okieimen *et al.* [3] using maize (*Zea mays*) cobs reported that as much as 2.4 mg g^{-1} of cad mium, and 5.7 mg g^{-1} of lead ions removal could be achieved from 800 ml of metallic solutions containing 40 mg g^{-1} of metal ions. Omgbu and Iweanya [4] also showed that 2.3 mg g^{-1} of lead and 1.6 mg g^{-1} of zinc ions removal could be achieved from 100 ml of metallic solutions containing 5 mg g^{-1} of metal ions by modified palm (*Elaesis guineensis*) kernel husk.

Materials and Methods

Coconut palm (*Cocos nucifera*) husks were obtained at Abraka. It was air dried for three months then cut into small pieces, milled and sieved with a 500 mm meshscreen. The part that fell below the meshscreen was hydrolyzed with 1% v v^{-1} aqueous hydrochloric acid (HCl) at room temperature for 6 hrs to remove any metal ion present and to obtain a clear solution in the column and equilibrium sorption experiments [3,4]. This husk was stored as an unmodified adsorbent.

The modified adsorbent was obtained by hydrolyzing with fifteen times its weight of aqueous 7% tetraoxosulphate VI acid for 24 hrs at room temperature. The mixture was washed thoroughly with deionized water, filtered and dried at 50°C in an oven. Fifty grammes portion of the dry hydrolyzed substrate, 300 mm of pyridine and 56.7 g of EDTA were heated under reflux at 70°C for 3 hrs On cooling 300 mm of deionized water was added to the reaction mixture and filtered. The EDTA modified substrate was washed several times, first with the filtrate and finally with deionized water. The filtrate was dried in an oven at 50°C for 24 hrs [3,4].

Solutions of various concentrations of metal ion were prepared by dissolving 5, 10, 15, 20 and 25 mg in 1 mm of deionized water of lead trioxonitrate V, Cadmium II iodide and zinc II chloride. Two g of the unmodified and modified substrate were used in each experiment to determine its sorbtive power.

In the column experiments 100 mm of each metal ion solution was allowed to pass through a glass column of 20 mm internal diameter and 50 cm length, containing 2 g of the substrate. This was tapped gently to promote even distribution of packing. Glass wool was put at the top of packing to prevent substrate from separating and floating. The packing was wetted with a slow water flow and equilibrated for several hrs with static water. The first 15 mm of the solution passing through the tap was discarded. Flow rate of test solution was adjusted by a stopclock to 2ml min^{-1}. The eluate was titrated with standard 0.01M EDTA solution using xylenol orange indicator and hexamine crystals as buffer to determine the amount of unsorbed ion.

In the equilibrium experiments 2 g of each husk powder were shaken for 90 mins. with 100 mm of any of the metal ion solutions in a stoppered pyrex reagent bottle using an electronic flask. The mixture was filtered and the solution analyzed for trace unsorbed metal ions as above. The amount of metal ions adsorbed by the unmodified husk and EDTA modified husk was calculated by the difference obtain-ed between the initial and final concentration of the solution.

* Department of Chemistry, Bendel State University, Abraka Campus, Nigeria.

Results and Discussion

Results of column and equilibrium sorption experiments conducted with modified and unmodified coconut (*Cocos nucifera*) husk are shown in Tables 1 - 4.

Coconut palm (*Cocos nucifera*)husk, a cellulosic material represents a structurally complex adsorbent with multiple non-identical and perhaps independent binding sites, which are capable of interacting with metal ions by ion-exchange, chelation and adsorption. The material can effectively bind lead, cadmium and zinc ions at the same or different binding sites by the same or different mechanisms as is evident from sorption studies.

The results of the column experiment shown in Tables 1 and 2 show that adsorption of 25.4-91.7% lead, 62.2-95.5% cadmium and 35-92.1% zinc ions was achieved from 5-25 mg metal ion solutions with unmodified and modified coconut palm husk. The adsorptive capabilities of the husk for lead, cadium and zinc ions are similar to results obtained for other agricultural by-products such as maize cobs and palm kernel husk. In the column experiments with both types of adsorbents uptake of metal ions increased with metal ion concentration in solution, except in few cases, being the highest in the 25mg of zinc and 20 mg of cadmium ions. At low metal ion concentration, the variation in the amount of metal ions removed from solution is not clear cut. However at high metal ion concentration, the level of uptake by coconut palm husk is similar to levels reported for other agricultural by-products that are cellulosic. The adsorptive pattern of coconut palm follows this order lead > cadmium > zinc.

In the equilibrium experiments 68.5-84.2% lead, 2.9-64% cadmium and 26.2-55.5% zinc ions uptake was achieved. The amount of lead ions sorbed from the solution is greater than that of cadmium and zinc ions because; the metals have different affinities for active groups on substrate; the distribution of the active groups on the adsorbent and the nature of the anion of salt affect metal ion uptake. For example, the level of a divalent metal ion uptake by polymerized onion skin is significantly increased if an acetate salt is used instead of a nitrate, sulphate or chloride [1]. Results of the study show a potential for the use of coconut palm husk for removing heavy metal ions in mining waste effluents before being discharged into the immediate environment.

TABLE 1. COLUMN SORPTION OF METAL IONS BY UNMODIFIED COCONUT PALM.

Volume of metal ion solution (ml)	Amount of metal ion in solution (mg)	Metal ion sorbed: Lead (a)	Lead (b)	Cadmium (a)	Cadmium (b)	Zinc (a)	Zinc (b)
100	5	25.4	0.63	91	2.28	89.5	2.24
100	10	91.7	4.59	93.2	4.66	73.9	3.69
100	15	86.2	6.46	94	7.05	59	4.43
100	20	87.6	8.76	64	6.04	48.3	4.83
100	25	90	11.3	62.2	7.78	35	4.39

(a) Percentage of metal ion sorbed from solution.
(b) Amount of metal ion sorbed mg g^{-1} substrate.

TABLE 2. COLUMN SORPTION OF METAL IONS BY MODIFIED COCONUT PALM.

Volume of metal ion solution (ml)	Amount of metal ion in solution (mg)	Metal ion sorbed: Lead (a)	Lead (b)	Cadmium (a)	Cadmium (b)	Zinc (a)	Zinc (b)
100	5	75.1	1.88	91.5	2.29	92.1	2.3
100	10	87.6	4.38	95.5	4.77	75.5	3.76
100	15	88.9	6.67	95.5	7.16	62.1	4.69
100	20	89.6	8.96	70.8	7.1	54.2	5.42
100	25	90	11.3	61	8	42.5	5.31

(a) Percentage of metal ion sorbed from solution.
(b) Amount of metal ion sorbed mg g^{-1} substrate.

TABLE 3. EQUILIBRIUM SORPTION OF METAL IONS BY UNMODIFIED COCONUT PALM HUSK.

Volume of metal ion solution (ml)	Amount of metal ion in solution (mg)	Metal ion sorbed: Lead (a)	Lead (b)	Cadmium (a)	Cadmium (b)	Zinc (a)	Zinc (b)
100	5	83.4	2.09	41.6	1.04	34.6	0.87
100	10	72.3	5.43	26.6	1.99	32	2.4
100	15	68.5	8.56	2.9	0.36	26.2	3.3

(a) Percentage of metal ion sorbed from solution.
(b) Amount of metal ion sorbed mg g^{-1} substrate.

TABLE 4. EQUILIBRIUM SORPTION OF METAL IONS BY UNMODIFIED COCONUT PALM HUSK.

Volume of metal ion solution (ml)	Amount of metal ion in solution (mg)	Metal ion sorbed: Lead (a)	Lead (b)	Cadmium (a)	Cadmium (b)	Zinc (a)	Zinc (b)
100	5	84.2	2.11	64	1.6	55.5	1.39
100	15	75.1	5.63	32.5	2.44	46	3.45
100	25	71.8	8.98	16	2.05	38.8	4.85

(a) Percentage of metal ion sorbed from solution.
(b) Amount of metal ion sorbed mg g^{-1} substrate.

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