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DETERMINATION OF THE ADSORPTION CAPABILITY OF ACTIVATED CARBON DERIVED FROM *ZIZIPHUS MAURITIANA* FOR THE REMOVAL OF LEAD AND COBALT

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ABSTRACT

This study was carried out to evaluate the efficiency of the removal of meals ions (Pb and Co) of metals ions (Pb and Co) from solution using *Ziziphus mauritiana* as adsorbent. The effect of initial concentration and adsorbent dosage on the adsorption process of these metals were studied, the percentage removal of these metals increased with increase in weight of carbon dosages (0.5 - 2.5g) in 50ml of the solution and the adsorption efficiency increased with increasing initial metal ion concentration (0.01-0.05 moldm^{-3}), the optimum percentage removal of the was found to be 62% and 60% for Pb and Co respectively at the highest weight (2.5g). The adsorption fitted to Langmuir models and the coefficients indicated favorable adsorption of Pb^{2+} and Co^{2+} ions on the adsorbents. The adsorption of Pb^{2+} and Co^{2+} in aqueous solution was in the following order (1400µm>420µm>150µm). In this study more than 55.4% of lead cations were removed by 1400µm, 47.2% by 420µm and 29.8% by 150µm respectively. While for cobalt cations only 53.2% by 1400µm, 38.6% by 420µm and 24% by 150µm respectively. Therefore, lead can be better using activated carbon derived from *Ziziphus mauritiana* seed.

Keywords: Adsorption, Carbon, Cobalt, Lead, Ziziphus mauritiana

INTRODUCTION

Pollutants are generally release from different industries like petroleum, paint, ternaries, textile, pharmaceutical, rubber, electroplating, iron and steel industries into water (Grish, 2018). Releases of these industrial activities are the major sources of water pollution due to their high content of several heavy metals ions. Several work have been reported on the remediation of different toxic metal from the environment, methods available to treat these chemicals are as biodegradation, chemical oxidation, biosorption, solvent extraction, liquid membrane methods, coagulation and adsorption using adsorbent (Shah, *et al*., 2009; Mahejabeen, 2009). Heavy metals are major toxicants found in industrial wastewater (Lovanese *etal.*, 2007). They may adversely affect the treatment of wastewater. Conventional methods for the removal of heavy metals from wastewater are often costly, hence, there is a need for suitable methods of removing this toxic materials from water, that is easily reliable, non-toxic and cost effective (Gaya, 2010).

The plant *Ziziphus mauritiana* is commonly known as magarya in Hausa and whuya in Kilba (Nigeria) (Dahiru *etal.*, 2005) Masau fruit in Zimbabwe (Lovanese *etal.*, 2007), Chinese date,ber, Chinee/Chinkee apple, jujube, Indian plum, (Thailand), Regipandu, Indian jujube, dunks (in Barbados) is a tropical fruit tree species belonging to the family Rhamnaceae. *Ziziphus mauritiana* is a spiny, evergreen shrub or small tree up to 15 m high, with trunk 40 cm or more in diameter; spreading crown; stipular spines and many drooping branches. The leaves of the plant species are believed to have originated in Indo-Malaysian region of South-East Asia. It is now widely naturalized throughout the Old World tropics from Southern Africa through the Middle East to the Indian Subcontinent and China, Indo-Malaya, and into Australasia and the Pacific Islands used in the treatment of diarrhea, wounds, abscesses, swelling and gonorrhea (Thanach and Pranee 2011). They are also used in the treatment of liver diseases, asthma and fever (Lovanese *et al.*, 2007).

MATERIALS AND METHODS

Sample collection

Sample of *Ziziphus mauritiana* seeds was collected from Rimi Market Kano, Kano State, Nigeria

Sample Preparation

Ziziphus mauritiana seeds were washed with hot tap water and then with distilled water and allowed to dry in an oven at 105ºC for five hours. The dried samples were burned in a muffle furnace (Santi Furnace Tech. STM 12-17CE,ISO) at 400ºc for one and half hour. However, activation was carried out by soaking the carbonized samples in potassium hydroxide (0.1M KOH) overnight. The activated carbon were then filtered, washed with standard solution of HCl and finally with distilled water and dried in an oven for 30 minutes. After drying, the samples were then ground and passed through sieve series in which three different samples of activated carbon were obtained in powdered and two granular sizes respectively. Different sizes of activated carbon (150µm, 420µm and 1400µm) were used to test the capabilities of heavy metal removal in aqueous solution (lead and cobalt).

Batch adsorption experiment

The adsorption studies for heavy metal solutions were determined by using batch adsorption experiment: (50 ml) of heavy metal solution (lead or cobalt) of known concentration in the range (0.01M) to (0.05M) were added separately to reagent bottle containing (5g) of the adsorbent prepared At a temperature of 30℃ and optimum pH of adsorbent solutions, the flasks were shaken in a mechanical shaker at a constant speed (200rpm) for 15 minutes. The samples of each experimental set up were filtered by using (No.42) Whatman filter paper. The metal equilibrium concentrations were measured by using Atomic Absorption Spectrometer (AAS) and comparing the experimental data with the calibration curve. The amount of heavy metals adsorbed was calculated from the initial and final concentrations of heavy metals and the volume of solution according to the following equation,

$Qe = V\,(Ce - Co)/m$

Where, V = Volume of solution (dm^3) Co = initial concentration ($moldm^{-3}$) Ce = equilibrium concentration ($moldm^{-3}$) m = weight of adsorbent (g) respectively.

RESULTS AND DISCUSSION

The study finds that the pH, concentration and carbon dose plays an important role in adsorption of heavy metals (i.e. lead (Pb) and cobalt (Co)) from waste water.

Table 1: pH Reading of Various Concentration of the $Pb(NO_3)_2$ and $CoCl_2.6H_2O$

S/NO	Various concentration of $Pb(NO_3)_2$ and $CoCl_2.6H_2O$	pH	
		$Pb(NO3)_2$	$CoCl_2.6H_2O$
1	0.01	4.43	5.71
2	0.02	4.21	5.62
3	0.03	4.03	5.42
4	0.04	4.00	5.38
5	0.05	3.78	5.25

Effect of Concentration of Aqueous Solution of $CoCl_2.6H_2O$ and $Pb(NO_3)_2$ on the Rate of Adsorption at different Activated carbon concentration.

Percentage degradation (as in Figure 1, 2 and 3) revealed a decrease with increase in the concentration of both $Pb^{2+}$and Co^{2+}This extreme point results from the conflicting effects of this parameter on the adsorption efficiency, the increase in contaminant (Pb and Co) loading decrease the adsorption capacity of the adsorbent. The optimum percentage removal was 97% obtained at 0.01 Pb^{2+} concentrations at 150µm activated carbon size.

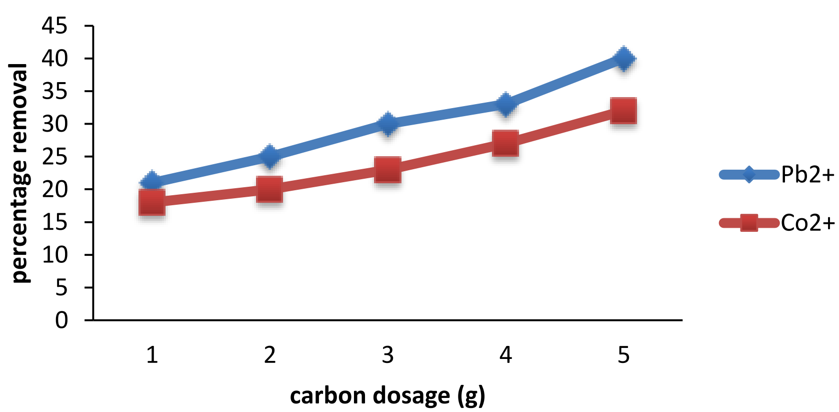

Fig. 1: Effect of carbon dosage (150µm) on the rate of adsorption at constant concentration (0.01M) of Pb^{2+} and $Co^{2+.}$

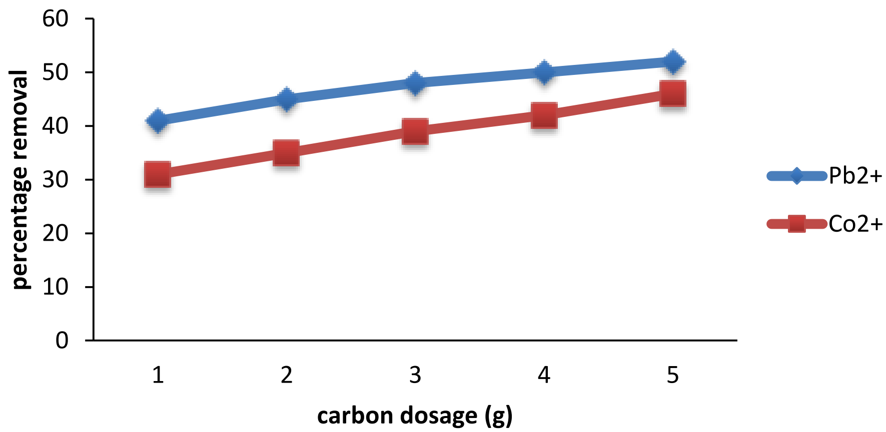

Fig. 2. Effect of carbon dosage (420µm) on the rate of adsorption at constant concentration (0.01M) of Pb^{2+} and Co^{2+}.

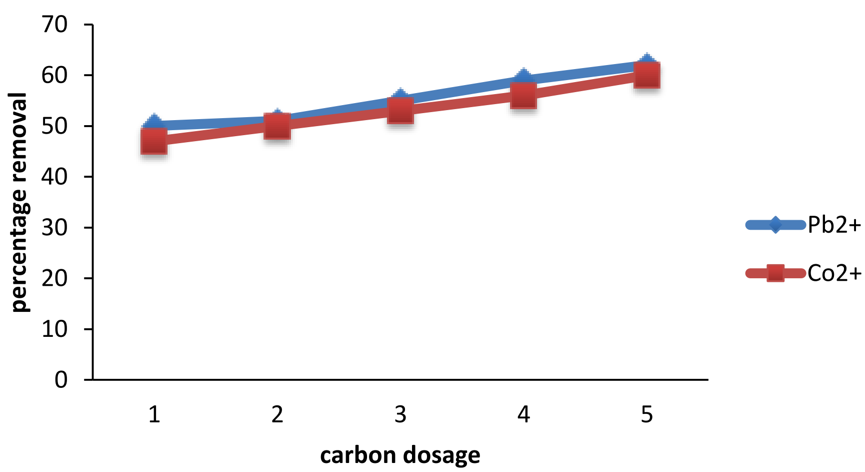

Fig. 3: Effect of carbon dosage (1400µm) on the rate of adsorption at constant concentration (0.01M) of Pb^{2+} and Co^{2+}

Effect of Carbon Dosage on the Rate of Adsorption of Pb^{2+} and Co^{2+}

The effect of the mass of the adsorbent was determined (ranging from 0.5 to 2.5g) as shown in Table 2, 3 and 4 respectively. From the result, there was increase in the rate of adsorption with increase in dosage for both Pb^{2+} and Co^{2+} respectively. This explain that carbon dosage influence the rate of adsorption, similarly the adsorption equilibrium concentration decreases with increase in carbon dosage.

Table 2: Effect of Carbon Dosage (150µm) on the Rate of Adsorption Of $Pb(NO_3)_2$ and $CoCl_2.6H_2O$ atConstant Concentration (0.01M) and Contact time (15 minutes)

Mass (grams)	Equilibrium concentration (Moldm^{-3})		Percentage removal %	
	Pb^{2+}	Co^{2+}	Pb^{2+}	Co^{2+}
0.5	0.0071	0.0080	21	18
1.0	0.0072	0.0078	25	20
1.5	0.0070	0.0072	30	23
2.0	0.0065	0.0071	35	27
2.5	0.0055	0.0065	40	32

Table 3: Effect of Carbon Dosage (450µm) On the Rate of Adsorption of $Pb(NO_3)_2$ and $CoCl_2.6H_2O$ at Constant Concentration (0.01M) and Contact time (15 minutes)

Mass (grams)	Equilibrium concentration ($Moldm^{-3}$)		Percentage removal %	
	Pb^{2+}	Co^{2+}	Pb^{2+}	Co^{2+}
0.5	0.0058	0.0068	41	31
1.0	0.0056	0.0064	45	35
	0.0051	0.0061	48	39
1.5				
2.0	0.0054	0.0057	50	42
2.5	0.0048	0.0054	52	46

Table 4: Effect of Carbon Dosage (1400µm) on the Rate of Adsorption of $Pb(NO_3)_2$ and $CoCl_2.6H_2O$ at Constant Concentration (0.01M) and Contact time (15 minutes)

Mass (grams)	Equilibrium concentration ($Moldm^{-3}$)		Percentage removal %	
	Pb^{2+}	Co^{2+}	Pb^{2+}	Co^{2+}
0.5	0.0050	0.0052	50	47
1.0	0.0048	0.0050	51	50
1.5	0.0044	0.0046	55	53
2.0	0.0041	0.0043	59	56
2.5	0.0038	0.0-040	62	60

Isotherm Study

The activated carbon isotherms in this study best fit the Langmuir model (Table 3). The Langmuir model assumes that adsorption sites on the adsorbent surface are occupied by the adsorbate in the solution therefore the Langmuir constant (K_L) represents the degree of sorption affinity; the adsorbate has to the adsorbent.

Table 3: Parameters of Langmuir and Freundlich models

Isotherms	Langmuire		Freundlich	
	Lead			
Activated Carbon (µm)	K_L	R^2	K_F	R^2
150	0.264	0.980	0.808	0.994
420	0.144	0.981	0.168	0.990
1400	0.191	0.982	1.732	0.992
		Cobalt		
150	0.131	0.983	1.899	0.959
420	0.173	0.986	1.296	0.991
1400	1.703	0.955	1.186	0.940

CONCLUSION

The efficiency of metal removal from aqueous solution of heavy metal using *Ziziphus mauritiana* as adsorbent was carried out. Initial metal ion concentration, adsorbent dosage and factors that affect adsorption process of Pb and Co ions onto *Ziziphus Mauritana* were studied. The percentage removal of the metal ions studied increased with increase dosage of *Ziziphus Mauritana*, it was shown that from the results obtained Pb^{2+} show the highest percentage removal (i.e. 97%) than Co^{2+} (95%) all at optimum conditions of 5g of 150µm carbon dosages for 15 minutes reaction time.

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