

# Sorption Potential of Domestic Waste as A Low-Cost Absorbent for Removal of Cu (Ii) And Pb (Ii) Ions from Aqueous Solution of Industrial Waste Effluents.

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**Abstract-** The indiscriminate discharge of Cu and Pb ions to the environment is a major concern in most industrial cities of the world. The adsorptive removal of Cu (II) and Pb (II) from aqueous solution from industrial effluents using melon shell, an agricultural waste, modified with 10% phosphoric acid was investigated. The residual metal ion concentration was determined using Atomic Absorption Spectroscopic, AAS. Batch mode experiments were conducted to study the effects of concentration, pH, contact time and temperature on Cu (II) and Pb (II) adsorption. The adsorbent was characterized by FTIR spectroscopy. The study revealed that the adsorption efficiency of activated melon shell was dependent on the pH of Cu (II) and Pb (II) solution, with pH 8 being optimal. The contact time for the adsorption was found to be at 80 minutes for both metals. Adsorption of Cu (II) and Pb (II) on the activated melon was found to increase with increase in concentration, with removal efficiency of 98.8% and 83.9% for 26mg/l. Equilibrium adsorption isotherm, kinetic and thermodynamic studies were investigated. The experimental data were analyzed by the Langmuir and Freundlich models and the isotherm data fitted well to the Langmuir isotherm with R<sup>2</sup> of 0.985 and 0.727 and monolayer adsorption capacity of 0.034mg/g and 0.180mg/g for Cu (II) and Pb (II) respectively. The kinetic data obtained at different contact time was analyzed using pseudo first order and pseudo second order equation. The experimental data for both Cu (II) and Pb (II) fitted very well for pseudo second order kinetic model. The adsorption process was thermodynamic feasible and spontaneous as  $\Delta G$  values were negative (-2.7353Kj/mol for Pb and -6.8877KJ/mol for Cu). The negative and positive values of  $\Delta H$  (-2.6089KJ/mol and +16.6446KJ/mol) showed that adsorption process was exothermic and endothermic for Cu (II) and Pb (II) respectively. This study revealed that

activated melon shell is a viable agricultural waste for the removal of Cu (II) and Pb (II) ions from aqueous solution.

**Indexed Terms-** Melon Shell, Absorption, Contact Time, Aqueous Solution, Spontaneous.

## I. INTRODUCTION

Industrialization is considered as the cornerstone of development strategies as it has significant contributions to the economic growth and human welfare, but the increase of industrial activities in the world has intensified environmental pollution and deterioration of the ecosystem with accumulation of organic and inorganic pollutants (Benti et al, 2016: Omuku et al, 2016: Omuku et al, 2012). Environmental pollution constitutes a great health hazard to human, animals and plant both biotic and abiotic component with local, regional and global implications (Omuku et al 2010).

Eco-toxicity on living organism has become a prime concern from the last few decades. Massive urbanization are continuously releasing waste and wastewater to the ecosystem and, causing pollution to environment and eventually toxicity to living being (Hossain et al., 2012; Abugu et al, 2015)). Heavy metals released to the environment have continuously increasing trends as a result of industrial activities and technological development, which is a significant threat to the environmental and public health due to their toxicity, accumulation in food chain and persistence in nature ( Abugu et al 2013: Onwumelu, et al, 2016: Asiagwu et al, 2011). Toxic heavy metal ions introduced to the aquatic streams by means of various industrial activities viz. mining, refining ores, fertilizer industries, tanneries, batteries, paper industries, pesticides etc. The important toxic metals are Cd, Zn, Pb, Ni, Cr, Cu, Fe and Hg etc. Several

episodes due to heavy metal contamination in aquatic environment have increased the awareness about the heavy metal toxicity.

## II. MATERIALS AND METHODS

### Adsorbent Preparation

Melon shells used were collected at Ochanja Market Onitsha South, Anambra, Nigeria. They were washed to remove dirt and other particulate matter and were allowed to dry at sunlight in the shade for 24 hours. The melon shells were oven dried at 250°C for 2hrs, and the pulverized clean melon shells were activated using 10%  $H_3PO_4$ . The activated melon shell were repeatedly washed with distilled water to remove any free  $H_3PO_4$ . Then the activated melon shells were oven dried at 100°C for 12hrs and stored in air-tight container, ready for use.

### Adsorbate Preparation

Analytical grade chemicals were used throughout the study. Stock solutions of  $Pb^{2+}$  and  $Cu^{2+}$  were prepared from lead nitrate  $Pb(NO_3)_2$  and copper sulphate  $CuSO_4$  respectively using distilled water. For 1000mg/l solution preparation dried salts of 1.599g of  $Pb(NO_3)_2$  and 2.511g of  $CuSO_4$  were separately dissolved in 1000ml of distilled water. Working solution of different concentration, as required, were prepared from the stock by dilution process.

Dilution formula  $C_1V_1 = C_2V_2$

$C_1$  = initial concentration,  $V_1$  = initial volume,  $C_2$  = final concentration and  $V_2$  = final volume.

### Adsorbent Characterization

The FT-IR technique was used identify some important functional groups present in the adsorbent. Characterization was done with help of Fourier-transform infrared spectrophotometer (Bulk model 530). Pressed pellets were prepared by grinding the powdered activated melon shell with spectroscopic grade KBr. The FTIR spectra of the activated melon shells were obtained before and after adsorption of Cu (II) and Pb (II) and the result were used to determine the vibrational frequency changes in the functional groups in the adsorbent.

### Batch Adsorption Experiments:

#### Study of Contact Time

20ml of 13mg/l aqueous solution of lead was measured into four different conical flasks and mixed with 2g of the activated melon shell. The mixture was occasionally stirred with spatula and allowed to stand for different time interval of 20, 40, 60 and 80 minutes. After each contact time, the suspensions were passed through filter papers and the resultant filtrates were analyzed to determine the concentration of the residual metal ions using atomic absorption spectrophotometer, (Agilent technologies 200 series). The same procedure was repeated for copper.

#### pH studies

13mg/l of aqueous solution of lead was prepared and 20ml was poured into four different conical flasks labeled pH 2, 4, 6 and 8. The pH of solution was adjusted by adding few drops 2M  $H_2SO_4$  and 2M NaOH. 2g of activated melon shells was introduced to each conical flask and manually agitated for 80 minutes. The sample was filtered using filter paper before analysis with Atomic Adsorption Spectrophotometer (Agilent technologies 200 series). The procedure was repeated for copper solution.

#### Concentration Studies

A fixed amount of activated melon shell (2g) was added into a set of each 100ml conical flask containing 20ml of different initial concentration (7, 13, 20 and 26mg/l) of copper solution without adjusting pH. Thereafter the mixture was stirred occasionally with a spatula and allowed for 80 minutes. After which the sample were passed through filter papers and the resultant filtrates were analyzed to determine the concentration of the residual metal ions using atomic absorption spectrophotometer (Agilent technologies 200 series). The same procedure was repeated for aqueous solution of lead.

#### Thermodynamic studies

Thermodynamic studies were carried out to evaluate the effect of temperature on adsorption of Cu and Pb ion from aqueous solution. The temperature range of 25°C, 40°C, 60°C and 80°C were used for the study. 20ml of 13mg/l of copper was poured into four different conical flasks; 2g of activated melon shells was introduced to each conical flask and stirred thoroughly. The conical flask was allowed to stand on

water bath for 80 minutes for the above temperature range. After which the sample were passed through filter papers and the resultant filtrates were analyzed to determine the concentration of the residual metal ions using atomic absorption spectrophotometer. The same procedure was repeated for aqueous solution of lead.

The amount of metal ion adsorbed,  $Q_t$  (mg/g) was evaluated thus:

$$Q_e = \frac{(C_o - C_e)V}{M}$$

$$Q_t = \frac{(C_o - C_t)V}{M}$$

$$R\% = \frac{C_o - C_t}{C_o} \times \frac{100}{1}$$

Where  $Q_e$  and  $Q_t$  = the amount metal ion adsorbed (mg/g) at equilibrium and at time t respectively;  
 $C_o$  and  $C_t$  = the initial concentration (at t=0) and its concentration at time t = t (mg/L);  
 M = the mass of adsorbent (g);  
 V = the volume of metal ion in the solution (L);  
 R = percentage of metal ion removed.

### III. RESULTS AND DISCUSSIONS

Presentation of the FTIR results

The FTIR technique is an important tool to identify some important functional groups, which are capable of adsorbing metal ions. The spectra of the adsorbent before and after adsorption had frequency range of 500–4000 $cm^{-1}$  wave number. The FTIR spectrum of activated melon shell before and after adsorption (Fig. 4.1 and Table 4.1) showed that some peaks were shifted or disappeared and that new peak were also detected. The band around 3476.731 $cm^{-1}$  assigned to the O-H stretching vibration mode of hydroxyl functional group shifting of this peak to 3426.683 for Pb and 3422.935 for Cu was as a result of the adsorption of the adsorbate molecule on the activated melon shell. The band of 2960.039 and 1465.903 assigned to C-H stretching and bending vibration mode of methylene and methyl functional group respectively, but the shifting of these peaks to 2993.264, and 1451.898 for Pb and 2937.173, and 1416.307 for Cu respectively was as a result of adsorption of these metal ions on the surface of the adsorbent. The stretch band of 1612.021 assigned to C=C stretch of alkenes functional group was found to shift to 1625.927 for Pb and 1627.555 for Cu as result

of coordination during the adsorption process. The strong band at 1051.584 assigned to C-O stretching vibration mode indicated the presence of alcohol and ether but the shifting of this band to 984.137 for Pb and 982.851 for Cu, respectively was as a result of adsorption of Pb and Cu on the surface of the adsorbent.

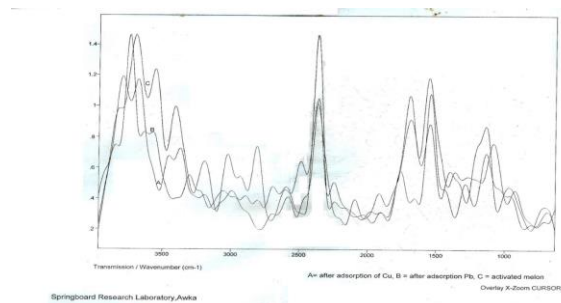


Fig.4.1: FTIR Spectrum of Activated Melon Shell Before and After Adsorption.

Table 4.1: FTIR of Activated Melon Shell Before and After Adsorption

Metals	Frequency ( $cm^{-1}$ )		Assignment of functional group (Derrick <i>et al.</i> , 1999)
	Before adsorption	After adsorption	
Lead	3476.731	3426.683	O-H
	2960.039	2993.264	C-H
	1612.021	1625.927	C=C
	1465.903	1451.898	C-H
	1051.584	984.137	C-O
Copper	3476.731	3422.935	O-H
	2960.039	2937.173	C-H
	1612.021	1627.555	C=C
	1465.903	1416.307	C-H
	1051.584	982.851	C-O

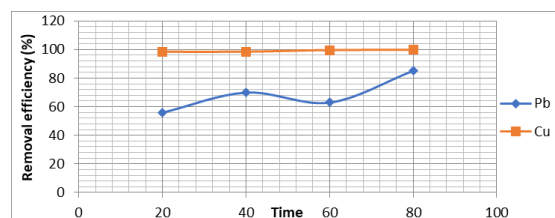


Fig. 4.2: Effect of contact time on Pb (II) and Cu (II) ion removal by activated melon shell.

Table 4.2: Removal Efficiency of Pb (II) and Cu (II) ion by Activated Melon Shell

Time (min)	Removal efficiency (%) of lead (Pb)	Removal efficiency (%) of copper (Cu)
20	56.08	98.56
40	70.04	98.58
60	68.11	99.58
80	85.21	99.67

The effect of contact time on the heavy metal removal efficiency (Fig. 4.2), where the graph plotted, it indicated that Cu (II) and Pb (II) ions adsorption increased with increasing contact time comparable with reports of Okafor et al, 2012. The absorption of copper and lead were rapid for the first 40 min, while the equilibrium was nearly reached after 80 min. The absorption rate of heavy metal ions was faster in the beginning attributable to the larger surface area of the adsorbent availability for the adsorption of the metals. As the surface adsorption sites were used up, the rate of heavy metals uptake reduced as controlled by the rate of transport phenomenon from the exterior to the interior sites of the adsorbent particles. We inferred that the large number of vacant surface sites available for adsorption during the initial stage of the treatment time, and after a lapse of time caused less remaining vacant surface sites on hand. The uptake of adsorbate species was faster in the initial stages of the contact period, and thereafter it became slower near the equilibrium (Nurdin et al., 2015).

Adsorption kinetics

Pseudo-first-order and second-order models were applied to test experimental data and thus elucidated the kinetic adsorption process. Lagergren proposed a method for adsorption analysis which is the pseudo-first-order kinetic equation of Lagergren in the form (Giwa et al., 2013):

$$\text{Log}(Q_e - Q_t) = \text{Log} Q_e - \frac{K_1}{2.303} t$$

Where  $K_1$  (1/min), is the rate constant of pseudo first order adsorption,  $Q_e$  (mg/g) is the amount of solute adsorbed on the surface at equilibrium and  $Q_t$  (mg/g) is the amount of solute adsorbed at any time. The value of  $K_1$  and  $Q_e$  for Cu (II) and Pb (II) ion adsorption by

activated melon shells were determined from the plot of  $\text{Log}(Q_e - Q_t)$  against  $t$  (Fig. 4.3). The parameters of pseudo-first order model were summarized in Table 4.5 along with the corresponding correlation coefficients.

Thus, the pseudo second order kinetic equation is generally expressed as,

$$\frac{T}{Q_t} = \frac{1}{K_2 Q_e^2} + \frac{1}{Q_e} t$$

Where,  $K_2$  is the rate constant of pseudo second order adsorption (g/mg min). The  $Q_e$  and  $K_2$  can be calculated from the slope and intercept of the plots  $\frac{T}{Q_t}$  versus  $t$  (Fig. 4.4). The parameters of pseudo-second order model were summarized in Table 4.6 along with the corresponding correlation coefficients.

Table 4.3: Adsorption kinetics for Pb (II) ion Removal by Activated Melon Shell

T (min)	$C_t$	$Q_t$	$Q_e$	$\text{Log}(Q_e - Q_t)$	T/ $Q_t$
20	5.564	0.071	0.108	-1.432	282
40	3.795	0.089	0.108	-1.721	449
60	4.674	0.080	0.108	-1.553	750
80	1.874	0.108	0.108	-	741

Table 4.4: Adsorption kinetics for Cu (II) ion removal by activated melon shell

T (Min)	$C_t$	$Q_t$	$Q_e$	$\text{Log}(Q_e - Q_t)$	T/ $Q_t$
20	0.18	0.128	0.129	-2.85	156
	7	4	8		
40	0.18	0.128	0.129	-2.85	312
	5	4	8		
60	0.05	0.129	0.129	-4.00	463
	5	7	8		
60	0.04	0.129	0.129	-	616
	3	8	8		

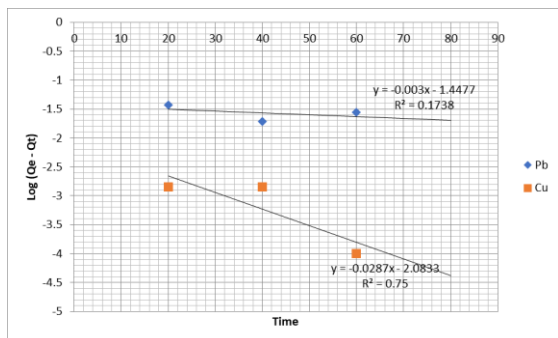


Fig. 4.3: Pseudo First Order Kinetics for Adsorption of Pb (II) and Cu (II) ions on Activated Melon Shells

Table 4.5: Kinetic co-efficient for pseudo first order kinetics for Pb and Cu

Pseudo first order kinetic model					
Metal	$C_t$ (mg/l)	$Q_e$ , exp (mg/g)	$Q_e$ , cal (mg/g)	$K_1$ (1/min)	$R^2$
Lead	12.669	0.108	0.036	0.0069	0.173
Copper	13.023	0.130	0.008	0.0644	0.750

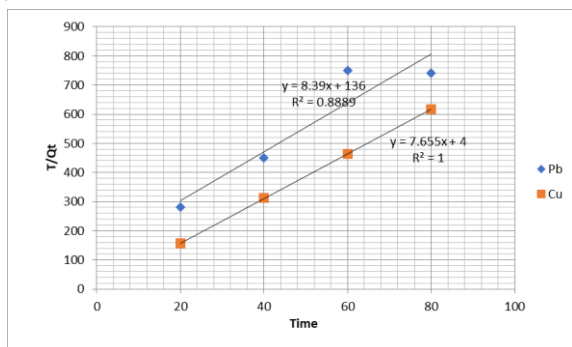


Fig. 4.4: Pseudo Second Order Kinetics for Adsorption of Pb (II) and Cu (II) ions on Activated Melon Shell.

Table 4.6: Kinetic Co-efficient for Pseudo Second Order Kinetics for Pb and Cu

Pseudo second order kinetic model					
Metal	$C_t$ (mg/l)	$Q_e$ , exp (mg/g)	$Q_e$ , cal (mg/g)	$K_2$ (1/min)	$R^2$
Lead	12.669	0.108	0.119	0.519	0.888
Copper	13.023	0.130	0.136	14.657	1.000

Table 4.5-4.6 gave revelation that the  $R^2$  value for the pseudo-second-order model was higher than the pseudo-first-order model, indication that the adsorption of copper and lead on activated melon shells was well-fitted to the pseudo-second-order kinetics model compared to the first-order model. Based on the comparison between experimental and theoretical calculated  $Q_e$  values, it was found also that the pseudo second order model fitted better than pseudo first order model for removal of Cu (II) and Pb (II) ions by the activated melon shells.

#### Effect of pH

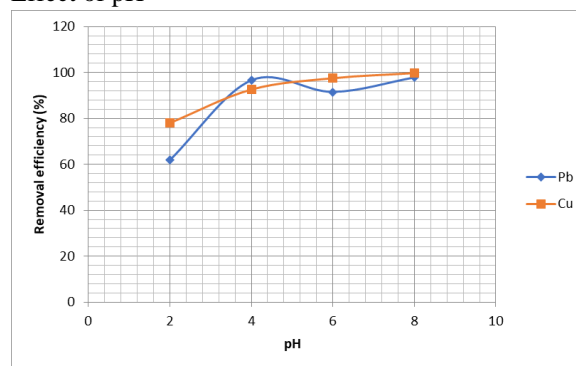


Fig. 4.5: Effect of pH on Adsorption of Cu (II) and Pb (II) ion on Activated Melon Shell.

Adsorption potential of activated melon shells for Cu (II) and Pb (II) were seen to increase with increase in solution pH appreciably up to pH 8.0 as shown in Fig. 4.5. The optimum pH for Cu (II) and Pb (II) ion adsorptions by activated melon shells were found to be 8.0. Lower metal removal at highly acidic pH (pH 2) might be due to the competition for metal binding sites between positively charged Cu (II) and Pb (II) ion, and hydrogen ions. Also at low pH, the adsorbent surface became more positively charged thus reducing attraction between the activated melon shells and the metal ions.

#### Effect of concentration

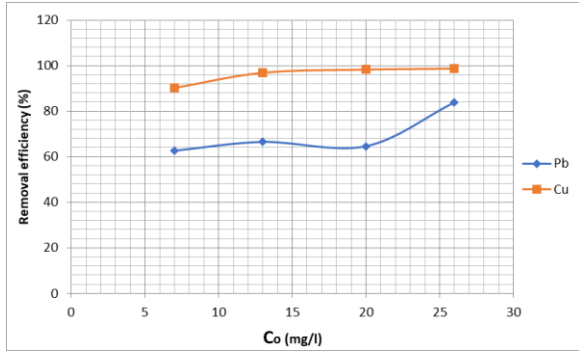


Fig. 4.6: Effect of Initial Metal Concentration on Cu (II) and Pb (II) Removal.

The adsorption of copper and lead by the activated melon shells was observed at the different initial concentrations from 7 to 26 mg/L, contact time of 80 minutes and 2 g of adsorbent. Fig. 4.9 shows the results of various initial metal concentration relates with Pb (II) and Cu (II) removal. The graph (Fig. 4.6) revealed that the amount of Cu (II) and Pb (II) removed increased with increased initial metal concentration.

Adsorption isotherm

In order to establish the most appropriate correlations for the equilibrium data in the design of adsorption system, two common isotherm models were tested: the Langmuir and Freundlich models. The applicability of the isotherm equations was compared by judging the correlation coefficients,  $R^2$ .

Langmuir isotherm: The Langmuir adsorption model was based on the assumption that maximum adsorption corresponds to a saturated monolayer of solute molecule on the adsorbent surface. The linear form of the Langmuir equation can be described by

$$\frac{1}{Q_e} = \frac{1}{Q_m} - \frac{1}{Q_m K_L C_e}$$

Where  $C_e$  (mg/L) is the equilibrium concentration of the adsorbate,  $Q_e$  (mg/g) is the amount of adsorbate per unit mass of adsorbent,  $Q_m$  and  $K_L$  are Langmuir constants related to adsorption capacity and rate of adsorption, respectively.

Freundlich isotherm: Freundlich isotherm model assume heterogeneous surface energy system and was expressed by the following equation

$$\text{Log } Q_e = \text{Log } K_f + \frac{1}{n} \text{Log } C_e$$

Where  $C_e$  is the equilibrium concentration of the adsorbate (mg/L),  $Q_e$  is the amount of adsorbate per unit mass of the adsorbent (mg/g);  $K_f$  and  $n$  are Freundlich constant which are measures of adsorption capacity and intensity of adsorption respectively.

Table 4.7: Freundlich and Langmuir Table for Adsorption of Pb (II)

$C_e$	$Q_e$	$\frac{1}{Q_e}$	$\frac{1}{C_e}$	Log $Q_e$	Log $C_e$
2.37	0.04			-	
1	0	25.0	0.42	1.40	0.37
4.25	0.08			-	
0	4	11.9	0.24	1.08	0.63
6.73	0.12	8.1	0.15	-0.91	0.83
7	3				
4.07	0.21	4.5	0.25	-0.67	0.61
1	3				

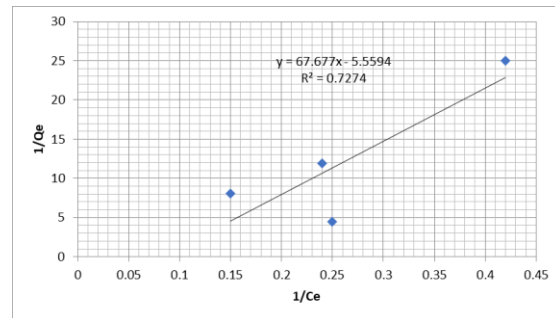


Fig. 4.7: Langmuir Isotherm for Pb (II) Removal by Activated Melon Shell.

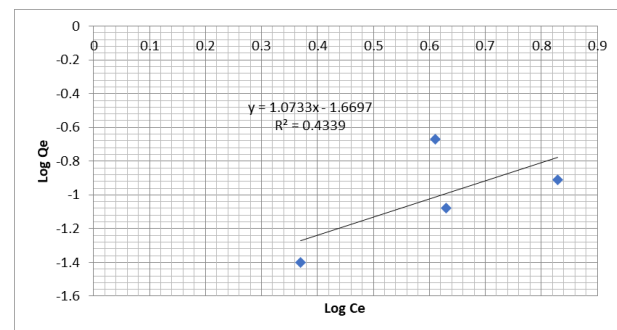


Fig. 4.8: Freundlich Isotherm for Pb (II) Removal by Activated Melon Shell.

Table 4.8: Isotherms Constants and Correlation Coefficients for Pb

Metal	Langmuir isotherm			Freundlich isotherm		
	$Q_m$	$K_L$	$R^2$	$K_f$	n	$R^2$
Lead	-	-	-	0.021	0.932	0.433
	0.180	0.082	0.727			

The Langmuir and Freundlich constants were determined from the slope and intercept of the plot Fig. 4.7-4.8 and presented in Table 4.8. The best equilibrium model was determined based on the linear square regression correlation coefficient  $R^2$ . From Table 4.8, it was observed that the equilibrium sorption data for lead were very best represented by the Langmuir isotherm. The best fit isotherm expressions confirm the monolayer coverage process of lead onto activated melon.

Table 4.9: Freundlich and Langmuir Table for Adsorption of Cu (II)

$C_e$	$Q_e$	$\frac{1}{C_e}$	$\frac{1}{Q_e}$	Log $Q_e$	Log $C_e$
0.637	0.059			-	-
		1.57	16.95	1.23	0.20
0.400	0.126			-	-
		2.50	7.94	0.90	0.40
0.331	0.192	3.02	5.21	-0.72	-0.48
0.326	0.257	3.07	3.89	-0.59	-0.49

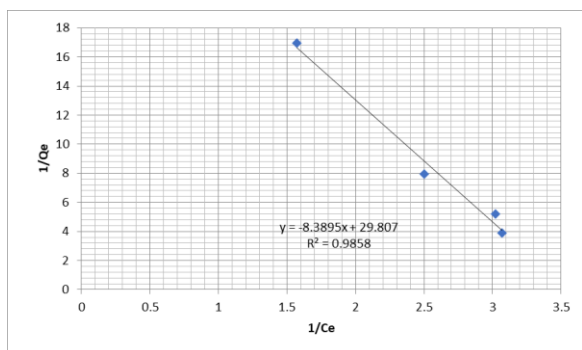


Fig. 4.9: Langmuir Isotherm for Cu (II) Removal by Activated Melon Shell.

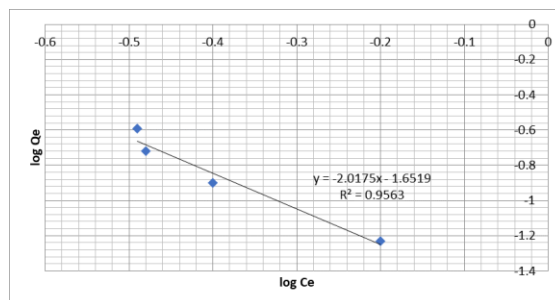


Fig. 4.10: Freundlich Isotherm Cu (II) Removal by Activated Melon Shell.

Table 4.10: Isotherms Constants and Correlation Coefficients for Cu

Metal	Langmuir isotherm			Freundlich isotherm		
	$Q_m$	$K_L$	$R^2$	$K_f$	n	$R^2$
Copper	0.03	-	0.98	0.02	-	0.95
	4	3.50	5	2	2.01	6
			6		7	

The Langmuir and Freundlich constants were determined from the slope and intercept of the plot Fig. 4.9-4.10 and presented in Table 4.10. The best equilibrium model was determined based on the linear square regression correlation coefficient  $R^2$ . From Table 4.10, it was observed that the equilibrium sorption data for copper were very best represented by the Langmuir isotherm. The best fit isotherm expressions confirm the monolayer coverage process of copper onto activated melon shell.

Thermodynamics studies

The effect of temperature on adsorption of Cu (II) and Pb (II) onto activated melon shells was investigated under isothermal condition in the temperature range of 25 - 80°C. Thermodynamic parameters reflect the feasibility and spontaneous nature of the adsorption process. The thermodynamic parameters such as changes in free energy ( $\Delta G$ ) (J/mole), enthalpy ( $\Delta H$ ) (J/mole) and entropy ( $\Delta S$ ) (J/mol.K) were determined using the following equation:

$$K_o = \frac{C_{solid}}{C_{liquid}}$$

$$\Delta G = -RT \ln K_o$$

$$\ln K_o = \frac{\Delta G}{R} - \frac{\Delta H}{RT} \text{ (Von't Hoff Equation)}$$



Where  $K_o$  is equilibrium constant,  $C_{solid}$  is solid phase concentration at equilibrium (mg/l),  $C_{liquid}$  is liquid phase, T is absolute temperature in Kelvin and R is gas constant.  $\Delta H$  and  $\Delta S$  values were obtained from the slope and intercept of plot  $\ln K_o$  against  $1/T$ .

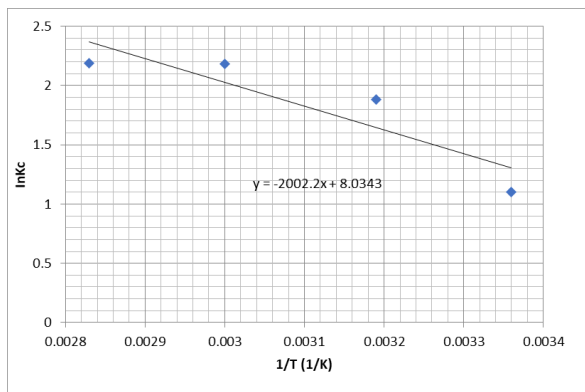


Fig. 4.11: Von' Hoff Plot for Effect of Temperature on Adsorption of Pb (II) onto Activated Melon Shell.

Table 4.11: Thermodynamic Parameter for Pb (II) Adsorption on Activated Melon Shells

Me	$\Delta S$	$\Delta H$	$\Delta G$			
			(KJ.mol <sup>-1</sup> )			
tal	(	(	298	313	333	353
	KJ.mol <sup>-1</sup>	KJ.mol <sup>-1</sup>	K	K	K	K
	)	)				
Pb	66.79	-	-	-	-	-
(II)	16.644	2.7	4.8	6.0	.6.4	
	6	253	923	355	273	

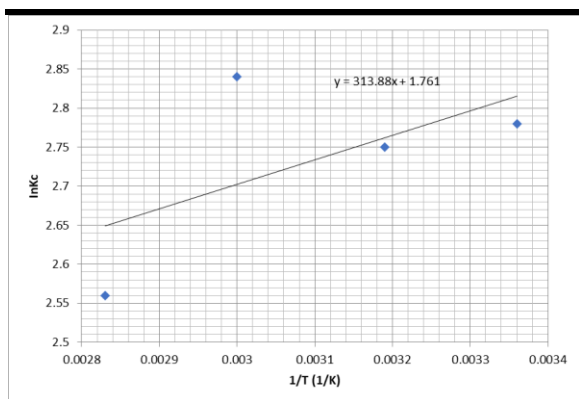


Fig. 4.12: Von' Hoff Plot for Effect of Temperature on Adsorption of Cu (II) onto Activated Melon Shell.

Table 4.12: Thermodynamic Parameter for Cu (II) Adsorption on Activated Melon Shell

Me	$\Delta S$	$\Delta H$	$\Delta G$			
			(KJ.mol <sup>-1</sup> )			
tal	(	(	298	313	333	353
	KJ.mol <sup>-1</sup>	KJ.mol <sup>-1</sup>	K	K	K	K
	)	)				
Cu	14.64	-	-	-	-	-
(II)		2.6089	6.8	7.1	7.8	.7.5
			877	563	627	132

The observed thermodynamic values are listed in Table 4.11-4.12.  $\Delta H$  were found to be positive for Pb (II), this showed that the adsorption process was endothermic in nature, and will be favorable by an increase in temperature while that of Cu (II) was found to be negative showing that the adsorption process was exothermic in nature, and will not be favorable by an increase in temperature. Enthalpy change of physisorption can be measured in the range of 20 KJ/mol (Atkins, 2006). From the results of this study, the  $\Delta H$  values calculated fell within the range implying that the adsorption process involved a physisorption reaction. The positive values of  $\Delta S$  indicate increased disorder and randomness at the solid – solution interface during the adsorption of Cu (II) and Pb (II) on activated melon shell. The negative value of  $\Delta G$  implies that the adsorption process was favorable and spontaneous.

### CONCLUSION

The research indicated that activated carbon produced from melon shells for Cu (II) and Pb (II) removal from aqueous solution was feasible. The operating parameters, pH of solution, contact time, concentration and temperature were effective on the adsorption efficiency of Cu (II) and Pb (II). Equilibrium data agreed well with Langmuir isotherm model with monolayer adsorption capacity of 0.034 and -0.180 for Cu (II) and Pb (II) respectively. The suitability of pseudo-first-order kinetic and pseudo-second-order kinetic models for the adsorption of Cu (II) and Pb (II) onto activated melon shells w also discussed. The kinetic modeling study has shown that the experimental data were found to follow the pseudo-second-order model.



Thermodynamic studies showed that adsorption of Pb (II) onto activated melon shells were endothermic with positive  $\Delta H$  ( $+16.6446 \text{ KJ.mol}^{-1}$ ) while that of Cu (II) was exothermic with negative  $\Delta H$  ( $-2.6089 \text{ KJ.mol}^{-1}$ ). The adsorption of Cu (II) and Pb (II) was spontaneous as evident with the negative value of  $\Delta G$ . The results of the research showed that activated melon shells has high potential as low cost adsorbent for the treatment of wastewater effluents.

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