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Industrial Waste Water Treatment using Activated Carbon from Waste Bamboo Stems

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***Abstract*: The treatment of effluents from Port Harcourt refinery using locally made activated carbon from Nigerian Bamboo was carried out. To check the performance evaluation of the activated carbon produced from this bamboo, the local Nigerian bamboo obtained was carbonized at 300-400℃ and then activated using $ZnCl_2$ at 800℃ to produce the granulated activated charcoal used as adsorbent. Adsorption of the heavy metal ions such as Cu^{2+} and Pb^{2+} from the refinery at 28℃ in the fixed bed column have been carried out with different operating conditions, contact time, carbon dosages and pH. The metal ions concentrations before and after adsorption in the adsorbent, were used in determining the amount of metal uptake in mg/g, percentage removal efficiency, R% and the dosage amount used. The results shows that the bamboo activated carbon have similar characteristics to commercial activated carbon in-terms of adsorption capacities. The experiment shows that Bamboo stems can be activated and used as adsorbent for treatment of effluents, byefficient and effective removal of metal ions and other dissolves solutes in the wastewater. The result indicates that Pb and Cu ions are removed to a bare minimum for the wastewater, and then followed by distillation of the treated wastewater for domestic usage.**

***Keywords*: Industrial Wastewater, treatment, refinery, bamboo stems, activated carbon and local.**

1. Introduction

Industrial wastewater is extremely complex, multi component solutions, which contain soluble and insoluble, reactive, toxic, flammable and explosive substances; the petrochemical and refining companies are chemical processing plants which make use of a wide range of reactants and intermediate products, its wastewater are polluted with all kinds of organic and inorganic impurities [1]. Lubricating oils, fuel oils, resins, phenol, chromium, surfactants, Sulphide, amine, suspended solids, dissolved solids nutrients, heavy metals, wastes from radio-activities are most of the effluents obtained from this plants that should be treated to an environmentally acceptable standards set by the Federal Environmental Protection Agency (FEPA) to monitor and promote proper health man and its environ [2]. All industrial operations produce some wastewater, which must be returned to the environment. Industrial wastewater contains a vast array of pollutants, in soluble colloidal and particulate forms, both Organic and inorganic or mixed with foreign particles like chemicals, microbes, toxic chemicals, agricultural wastes etc. which must be treated based on environmental guidelines and discharge limits friendly to the environment when disposed thereby reducing the concentrations of the pollutants to barest minimum. These contaminants pollute the atmosphere, rivers, lakes, oceans and ground water through domestic, agricultural, municipal and industrial activities of Petroleum upstream and downstream exploration and exploitations. In the industries, like the Petrochemicals and the Refineries, the total amount of wastewater produced and disposed into the rivers and seas is estimated to be about 450m^3 annually [3].The activities of Petroleum industries, both onshore and off-shore field operations produces major effluents which contributed major percentage of the world effluents produced [4].For effluents to be pollutants, then the concentrations in wastewater must exceed the acceptable limits, it becomes hazardous to the environment and need to be treated in other to reduce its concentrations to minimum, acceptable limits within the safety guidelines and regulations standard values set by Federal Environmental Protection Agency (FEPA) [5].Therefore, the essence of this work is to conduct experimental tests and investigations upon the capacity of adsorbent (local bamboo as activated carbon)to adsorbed heavy metals mainly Pb and Cu ions from refinery effluents and further apply distillation process to purify the wastewater to drinkable form and compare its adsorptive capacity with that of activated carbon. Different authors work on related work and some of these works are thus: [6] researched on the experimental production of activated carbon from local waste Bamboo for treatment of effluents. The Bamboo was pyrolyzed at 350^{0}C and activated with $ZnCl_2$ at 800^{0}C to produced granulated activated charcoal; Warri Refinery and Petrochemical plant, where the data were collected and activated carbon was used to adsorbed the impurities such as pH, metal ion concentration and the comparison of removal efficiency (R%). Bamboo activated carbon compared to activated carbon is a good adsorbent and adsorbed metals ion from effluents; [7] carried out Treatment of organic Contaminants using activated carbon from waste Nigerian Bamboo. The Bamboo was transformed to carbon ash at 450^{0}C and then acidized with sulfuric acid at 800^{0}C to give activated carbon for the adsorption of the pollutants from refinery and such adsorption works effectively at lower temperatures (28^{0}C). The batch experimental data was correlated with isotherms models such as Freundlich and Langmuir. The results fitted well. The COD i.e. chemical oxygen demand reduced from 378mg/l to 152mg/l compared to 150mg/l of refinery specifications. Thus, waste Nigerian Bamboo is recommended as good should be used as adsorbent because of its capacity and characteristics as good adsorbent for removal of heavy metals and other pollutants from effluents; [8] researched on batch adsorption of Fe^{2+} from aqueous solution using activated carbon from Nigerian Bamboo with the aim of study the kinetics of adsorption. The Bamboo stems was crushed, dried and grinded and burned 400-500^{0}C to form ash and then reacted with nitric acid at 800^{0}C to give activated carbon for adsorption. It was noticed that the effects of particle size, carbon dosage, initial concentration of adsorbate and contact time affects the adsorption capacity. The adsorption process obeyed Temkin, Freundlich and Langmuir isotherms models and was found out that Langmuir model had a better fit than Temkin and Freundlich with maximum monolayer saturation capacity of 166.7mg/l of Fe^{2+} adsorbed per gram of Bamboo activated carbon. Kinetic data were modeled using pseudo-first order and 2nd-order kinetic equations and intra particle diffusion model. The pseudo 2nd-order was the best applicable model to describe the sorption process and became the rate determining step. The adsorption process of a single compound from an aqueous solution at the surface of activated carbon sites has been performed experimentally with different systems. Activated carbon adsorbed highly odorous dissolved organic compounds from industrial wastewater [3]. Colour and phenol were adsorbed using activated carbon, the adsorption equilibrium and kinetics of methylene blue-dye on such carbon were then examined at 30^{0}C [9]. The physical and chemical processes are useful for adsorption process as a result of the adsorbent is vital because it dissolved and is difficult to splits organic substances in particular and carefully and selectively taken away by activated carbon [10]. The adsorption of pollutants from an aqueous waste stream into chemical adsorbent is an important effluent treatment process [11]. Metal ions of particular significant include antimony An, barium Ba, cadmium Cd, lead Pb and Copper Cu which are not biodegradable heavy pollutants are problematic and be treated to an environmentally acceptable limits [12]. Cyanides and Nitrates ions have strong affinity to hemoglobin and bounding actions that could have carried oxygen, thereby impairing oxygen transports to the central nervous system ([13], [1]), compared the adsorption efficiency of coconut shell-based granular activated carbon (Acid and Barium Chloride activation), and the adsorption efficiency of commercial carbon, (Calgon carbon F-300), using organic matter from a beverage industrial wastewater. Freundlich adsorption isotherm analyze the adsorption efficiencies of the two activated carbons gave better adsorption with coconut-shell; [14] researched on adsorption of methylene blue on Malaysia bamboo activated carbon. The adsorption of the methylene blue gave data that were fitted well with the Langmuir model given maximum monolayer capacity of 454.2 mg/g. The adsorption of methylene blue was a pseudo second order equation with kinetic parameters best fit model obtained and discussed; and [15] compared aqueous phenol adsorption trend using local granular activated carbon produced from palm date pits and commercial sample (filtrasorb-400). Phenol exhibited a slight higher adsorption than the local granular. Local prepared activated carbon from palm date pits is more efficient and adsorbed more of the pollutants than the commercial sample which was investigated at several pH values, carbon dosages and contact times. The characteristic of adsorption of the metal ions in wastewater effluent are tend to be different uptake rate attributed to two adsorption processes, they are; fast ion exchange rate and sharp increase ion removal rate [4]. The pH of the solution depends on the controlling parameter in the adsorption process [16] and the role of hydrogen ion concentration was carried out at different pH samples covering range. This research is to evaluate the performances of the activated carbon produced from local waste bamboo stems for treatment of industrial wastewater effluent to the limited standard of recovery of impurities and toxic heavy metal ions removal by using adsorption process. Processing of local waste bamboo stems and carbonization to produce activated carbon (charcoals) and experimentally determine the capacities of various operating parameters e.g. pH, carbon dose and contact time, and the metal uptake (mg/l) and the removal efficiency R (%) of ions. Tabulation of results, report discussion and evaluation performances of the simulated models. The comparison of activated carbon produced from local waste bamboo stems with other similar forms of activated charcoals produced in terms of metal uptake and efficiency of removal. The aim of this research is to treatment of industrial wastewater using activated carbon from bamboo stems. The objectives of this study are to: experimentally determine the level of: Metal ion uptake (mg/l) and removal of metal ions efficiency R (%) by local activated carbon (bamboo stems), use modified models such as Langmuir and Freundlich to obtain the adsorption effects of the contaminants in-terms of profiles and tables, developed distillation design models for the separation of impure water pure and drinkable water, simulation of the models developed numerically to obtain desired results, and comparison of activated carbon produced from local waste bamboo stems with other forms of activated carbon in-terms of adsorptive capacity and efficiency.

2. Materials and Methods

A. Materials

Activated carbon obtained from Nigeria local waste bamboo stems, industrial wastewater samples from Eleme Refining and Petrochemical Company Limited (IEPL), bybatch adsorption process are the materials for this experiment Materials used are: hand knives/machete, distilled water hand watching basins with cover, mortar/pistol; hand turning crushing machine, laboratory electric oven, top loading weighing balance (± 0.01), local fabricated reactor, condenser, sample bottles, spatula, sievers of mesh sizes, analytical weighing balance (± 0.001), pH meter, mechanical shaker, thermocouple with temperature sensors, round conical flasks, beakers. Other materials are: concentrated hydrochloric acid HCl, sodium hydroxide NaOH, measuring cylinders, pipette 25.0cm^3, burette dropping funnel 100lm, filter papers, retort stand, magnetic stirrer, atomic absorptive spectrophotometer, (AAS).

B. Methods

1) Carbonization of Bamboo Stem and Carbon Production

The local waste bamboo stems cut into short mesh sizes of 1.0-0.7cmwide and length with the help of hand cutting knives and machete which were washed with distilled water for the removal of impurities that might have adhered. Then the washed materials (bamboo pieces) were dried in a laboratory electric oven at 105^0C for 24 hours. 2.200g of well dried material (bamboo pieces) was then weighed on the balance (± 0.01) before introduced into local fabricated reactor for pyrolysis. They were pyrolyzed at about (300-400^0C) for 2 hours and 30 minutes. The distillate formed after pyrolysis was collected via the condenser to avoid air pollution. The charcoal or charred was cooled at room temperature for 5 hours before send to containers. They were then precisely poured into hand turning machine and crushed properly to powder formed and the use of siever of 1.18mm mesh to get the particles of uniform sizes into beakers.

2) Conversion of Ash to Activation of Carbon

200g of the well screened carbonized charcoals from local waste bamboo was weighed using weighing balance (± 0.001) which was fractioned to two (2) equal portions of 100g.One part was transferred to a beaker and well mixed with 150mlof 0.1m ($ZnCl_2$)until a paste is formed. The paste was taken to a dry crucible and oven for one (1) hour at 105^0C, then removed and put into the muffle furnace where it was heated at 800^0Cfor two (2) hours without air for increase surface area of the activated carbon. The activated carbon was cooled at room temperature and washed with distilled water. The filtrate should of pH 7. The washed activated carbon was dried for three (3) hours in a laboratory using electric oven at 150^0C to form the adsorbent. The converted ash to carbon activated was kept in an air-tight polyethylene bag for usage. Similar procedure was repeated to the other 100g sample.

3) Sample Collection

The treatment process used in this work is batch adsorption process. The adsorbents (activated carbon) investigated for the purpose of this project with effluent samples and the collecting point were limited to two sampling points from Eleme Refining and Petrochemical Company Limited (IEPL), Rivers State, Port Harcourt, while the effluent samples labeled A and B are collected at different location and time intervals for two hours along the effluent flow line input-valve from the biological treatment basin and output of clarifier water from the observation pond, an average feed flow rate of 0.048m^3/s was maintained by the input-valve. The initial pH and temperature at inter and inlet flow rates are measured and recorded as well.

Random sampling methods was adopted, where sampling containers were placed at the water level and also immersed in the flow line. Though mechanical and biological treatment has been carried out on sample A and B data at the refinery before collection, there were so many amounts of pollutants present before this treatment.

C. Adsorption Models

$$q_t = \frac{V}{m}(c_{0-c_f}) \ [8] \qquad (1)$$

$$R\% = \frac{V}{C_0}(c_{0-c_f}) \ x\ 100\% \ [8] \qquad (2)$$

The adsorption models were adopted by Freundlich and Langmuir adsorption isotherms models as:

$$C_S^* = a_f \ C_p^{1/n} \ [\text{freundlich}] \qquad (3)$$

$$C_S^* = \frac{a_l C_p}{1 + b_l C_p} \quad (\textit{Langmuir model}) \qquad (4)$$

Where; C_S^* = *Equilibrium concentration of adsorbatein solution after adsorption*

C_p = *The concentration of liquid in equilibrium with that of the solid phase.*
a_f = *Constant (freundlich capacity factor)*
$1/n$ = *constant (freundlich intensity parameter).*
a_l & b_l = *Emperical constants from langmuir model.*

Linearizing models (3) and (4) gives:

$$\ell n C_S^* = \frac{1}{n}\ell n C_p + \ell n a_f \qquad (5)$$

$$\frac{1}{C_S^*} = \frac{1 + b_l C_p}{a_l C_p} = \frac{1}{a_l} + \frac{1}{C_P} + \frac{b_l}{a_l} \qquad (6)$$

$$\frac{1}{C_S^*} = \frac{1}{a_l}\left(\frac{1}{C_P}\right) + \frac{b_l}{C_P} \qquad (7)$$

$\frac{1}{C_S^*}$ *vs* $\frac{1}{C_P}$ *Plot gives slope of* $1/a_t$ *and intercept of* b_t/a_l

These constants for both Freundlich and Langmuir models are obtained by fitting in the experimental data. After which the values of the constants are inserted into the Freundlich and Langmuir models and various adsorption profiles plotted and explained.

D. Design of Striping Column (Distillation Column)

The impure water mixture at the bottom of the Absorber Column enters the striping column at a particular temperature, say 60^0C.

The material balance for the stripping column is given below:

$$\left\{\begin{matrix} Rate of Accumulation \\ of water Mixture \\ in the column \end{matrix}\right\} = \left\{\begin{matrix} Rate of inflow \\ of water \\ Mixture into the \\ column \end{matrix}\right\} + \left\{\begin{matrix} Rate of outflow \\ of water \\ Mixture from the \\ column \end{matrix}\right\} \qquad (8)$$

Assumptions:

No Accumulation of impure water mixture.

For one mole of material entering the column, equation (8) becomes;

$$F=D+B \quad (9)$$

$$R = {}^{L_n}/_{D} \quad (10)$$

The general material balance will be given as:

$$V_n y_n + L_{n-1}X_{n-1} + F_n z_n = V_n y_n + L_n X_n + S_n X_2 \quad (11)$$

The Energy balance is given by:

$$V_{n-1}H_{n-1} + L_{n-1}h + Fh_f + f_n = V_n H_n + L_n h_n + S_n h_n \quad (12)$$

The Basic Equations for the stripping section According to [17], are stated thus:

Material balance: Total flows

$$V_{n-1} = L_n + D \quad (13)$$
$$V_{n-1}y_{n-1} = L_n x_n + DX_d \quad (14)$$

Energy Balance

$$V_{n-1}H_{n-1} = L_n h_n + Dh_d + q_c \quad (15)$$

The upper operating line equation is given as by combining equations (14) and (15).

$$\text{UOL}: y_{n-1} = \frac{L_n}{L_n+D}x_n + \frac{D}{L_n+D}x_d \quad (16)$$

While equations (15) and (14) combines to gives:

$$V_{n-1}H_{n-1} = (L_n + D)H_{n-1} = L_N h_n + Dhd + q_c \quad (17)$$

According to [18], molar liquid and vapour flow rates are assumed constant via out the stripping and rectifying sections of the column. The bottom operating line equations is given:

$$y_m = \frac{L'}{V'}x_m - \frac{B}{V'}x'_b \quad (18)$$

Where $L' = L_m$ = bottom Liquid flow
$V' = V_m$ = bottom Vapour flow rate
$x'b$ = impurity composition at the bottom product.

[19] development the relationship of the mol composition fraction of the more volatile components of the Distillation Column to give equilibrium line from equilibrium data in other to determine the number of stages/trays.

The y-intercept is given

$$\boldsymbol{\phi} = \frac{x_D}{1+R} \quad (19)$$

Once the stages number is gotten from the McCabe Thiele diagram, then with a given efficiency, the actual plates number can be obtained as:

$$\text{Actual No. of plates} = \frac{\text{No. of theoritical plate}}{\text{Efficiency of the column}} \quad (20)$$

Plate Efficiency can also be predicted using the murphree plate Efficiency, Em. This is related to the overall Efficiency of the Column by:

$$E_0 = \frac{\log\left[1 + E_{MV}\left(\frac{M_V}{L} - 1\right)\right]}{\log\left(\frac{MV}{L}\right)} \quad (21)$$

1) Plate Area Design

Diameter

For high plate efficiencies, a high vapour velocity (u_f) is needed and will normally be between 70% and 90%, but for design a value of 80 to 85% of the flooding velocity should be used.

[21], work on fractional entrainment and at $\psi = 0.1$, results to an optimum design value.

$$y_n = \frac{L_n}{V_n}x_n + D\,{}^{y_D}/_{V_n} \quad (23)$$

LOL:

$$y_m = \frac{L_m}{V_m}x_m - \frac{Bx'_f}{V_m} \quad (24)$$

q line:

$$y_q = \left(\frac{q}{1-q}\right)x_q - {}^{-x_f}/_{q} - 1 \quad (25)$$

$$P_T = \rho_{gh} x \text{No. of stages} + P_{atm} \quad (26)$$

$$FL_V = \frac{L_m}{V_m}\sqrt{{}^{\rho_v}/_{\rho_i}} \quad (27)$$

Plate spacing of 0.45m

$$k'_1 = k_{1t}(\sigma_u/0.02)^{0.2} \quad (28)$$

$$U_f = k'_{1b}\sqrt{\frac{\rho_l - \rho_v}{\rho_v}} \quad (29)$$

85% flooding:

$$U_n = 0.85U_f \quad (30)$$

Volumetric flow rate calculation

$$\hat{U}_i = \frac{V_n MW_b}{\rho_v} \quad (31)$$

Net area calculation

$$A_{n_i} = {}^{\hat{U}b}/_{u_n} \quad (32)$$

$$A_{cb} = \frac{A_{nb}}{0.88} \quad (33)$$

Column diameter (Dc)

$$D_c = \left(\frac{A_c x 4}{\pi}\right)^{1/2} \quad (34)$$

2) Mechanical Design of the Column

The thickness of the column can be determined using formulae obtained from [22] as follows:

For cylindrical shell

$$t = \frac{P_i D_i}{2ft - P_i} + e \quad (35)$$

For Ellipsoidal doomed head:

$$t = \frac{P_i D_i}{2fJ - 0.2P_i} + e \quad (36)$$

Equations (35) and (36) are the main design models of thickness for any column as it gives the best, cheap and affordable cost of the column.

3) Cost Estimation of Distillation Column

$$VesselCost = BarevesselcostxMFxPF \quad (37)$$

$$CostofTrays = Costpertrayxno.oftrays \quad (38)$$

$$DistillationCost = Vesselcost + Costoftrays \quad (39)$$

E. Input parameters

Table 1
Waste water analysis before treatment with bamboo activated carbon

S/N	C_U (ppm)	Pb (ppm)	pH
1	3.511	5.969	3.011

Table 2
Adsorption effect on PH, metal ion and removal efficiency

S/N	pH	Cu(ppm)	q_t (mg/g)	R%	Pb (ppm)	q_t (mg/g)	R%
1	2	3.013	8.00	9.01	2.672	20.12	30.17
2	4	1.56	53.13	58.82	1.000	50.51	68.95
3	6	0.041	82.625	95.38	0.068	72.11	93.87
4	8	<0.005	87.18	99.89	<0.002	72.80	99.85

Where: pH = degree of Acidity/alkalinity; C_U = Copper (metal ion); Pb = Lead (metal ion); R = Removal Efficiency and q_t = metal uptake.

F. Solution Techniques

The Design equations are solved using any programming software especially MS. Excel spread sheets or MATLAB Computer program.

3. Results and Discussions

A. Overview

The effect of different dependent variables (contact time, dosages and pH) on bamboo stems activated carbon and the removal of heavy metal ions from effluents was considered. Tables 2-5 present the result of the experimental investigation and the corresponding metal removal studies were calculated using equations 1 and 2. Figures 1-4 presents the effects of these variables on the removal of metal ions.

B. Results and Discussions

Table 3
Adsorption Effect on contact time, metal ion and Removal Efficiency

S/N	pH	Cu(ppm)	Q $_t$(mg/g)	R%	Pb (ppm)	q_t (mg/g)	R%
1	2	3.013	8.00	9.01	2.672	20.12	30.17
2	4	1.56	53.13	58.82	1.000	50.51	68.95
3	6	0.041	82.625	95.38	0.068	72.11	93.87
4	8	<0.005	87.18	99.89	<0.002	72.80	99.85

The activated carbon produced from local Nigerian bamboo stems was used as an adsorbent for the removal of metal ions, Cu^{2+} and Pb^{2+} from waste water effluents of Port Harcourt Refinery. The removal process carried out in a fixed bed column was influence by various operating parameters (effects of pH, contact-time, and activated carbon dose). The initial metal ions concentrations were analyzed and results tabulated in Table 1 before adsorption processes. Tabulated results after the adsorption from waste water refinery of Port Harcourt Refinery as shown in Figure 1.

Table 4
Adsorption Effects on Dosages, Metal ions and Removal Efficiency

S/N	pH	Cu(ppm)	q_t (mg/g)	R%	Pb (ppm)	Q $_t$(mg/g)	R%
1	2	3.400	3.66	4.2	2.261	19.60	26.15
2	4	1.211	56.88	62.58	0.883	53.85	70.00
3	6	0.025	87.56	95.89	0.060	75.01	98.70
4	8	<0.001	89.00	100	<0.001	75.26	100

Table 5
Distillation Column Specification

Parameter	Specification
Column Diameter (m)	1.5
Column Height (m)	6
Flow rate (m^3/hr)	0.148
Volume of Packings (m^3)	25
Cost of the Column ($)	300
Active holes	700

Table 5 indicates the summary of dimensions of the distillation column used for the purification of water from impure waste waters. The column height, diameter and the cost of column are shown after manual calculations.

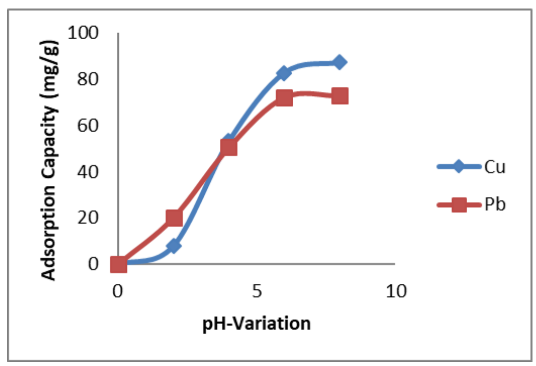

Fig. 1. Graph of Adsorption Capacity against pH Variation

Figure 1 indicates the variation of adsorption capacity with pH on Cu and Pb ions removal. The plot shows that the adsorption of Cu increased like a sigma curve (s-curve) and is sharply while that of Pb increased linearly and steady towards pH of 6-8, there attaining respectively maximum value of 87mg/g and 72.80mg/g. initially, the respectively metal uptake over 8.00 mg/g and 20.12mg/g. pH is a vita parameter for adsorption of metal ions as it affects the solubility of the metal ions, concentration of the counter ions due to the functional groups of the adsorbent and the degree of ionization of the adsorbate during reaction. pH affects the surface charge of adsorbate, which in-turns affect the removal of metal ions from effluents. pH resulted from the aqueous solution depends mainly on the controlling parameter of the adsorption process [16]. $[H^+]$ was carried out at different samples and differs to pH range from 2-8 as shown in Figure 1.[23] investigated that pH-values of the adsorbent are in close surface contact with the H_3O^+ (Hydroxonium ion) and this decreases the % removal of metal ions. Increase in pH results to metal hydrolysis and precipitation as this begins when pH >7 [16], lead to increase in de-protonation of the adsorbent surface, which intends leads to a decrease in H^+ on the adsorbent surface. More negative charges results on the adsorbent surface, and this favours adsorption of positively charge species on the positive sites of the adsorbent surface [24], [25].

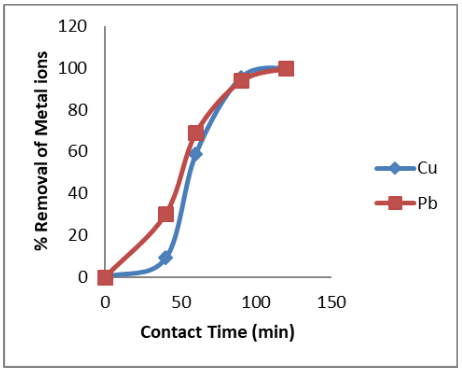

Fig. 2. Percent (%) Removal of Mental ions against Contact Time

Figure 2 depicts the effects of removal of metal ions (Copper and Lead) with contact time in minutes. This effect is measured with Bamboo adsorbent to removed Cu^{2+} and Pb^{2+} ions from waste water effluents. The results shows that the removal of Pb was rapid than Cu ions within the first 40 minutes and continues exponentially same fort the next 50minutes with Lead ion removal more than Cu^{2+} removal. Then the last 30 minutes, more Cu^{2+} was adsorbed than Pb. The adsorption of lead metal ion occurs at the reactive sites since when the sites are progressively filled, the difficult the sorption becomes and the process tends to be more unfavorable for the uptake [26]. As a results of quick ion exchange and chemisorption, difference rate of metal ion uptake resulted [4].

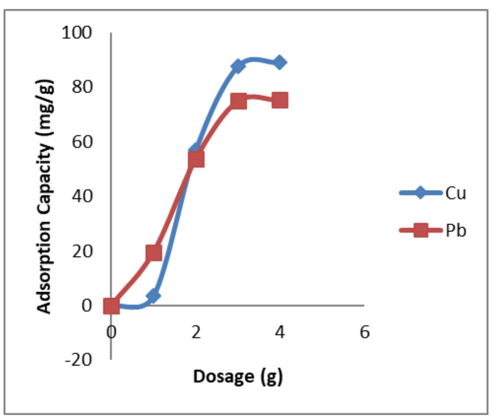

Fig. 3. Adsorption Capacity versus Dosage

Figure 3 show the variation of Adsorption capacity of metal ions with Bamboo activated (Dosage) carbon. Dosage investigation plays a vital role in adsorption of heavy metals ions as it determines the capacity of the adsorbent for a given concentration of metal ion in effluents as shown from the experimental analysis conducted, the results informed us that 1g of activated carbon removes 3.46 mg/g of Cu and 19.60mg/g of Pbions from effluent. Absorbent dose effects on the percentage removal of Pb and Cu with concentration say 50 mg/L indicates that increasing the absorbent dose for both adsorbents will leads to increase in percent removal up to 100% as observed on4g dosage shown in Figures 3 and 4.

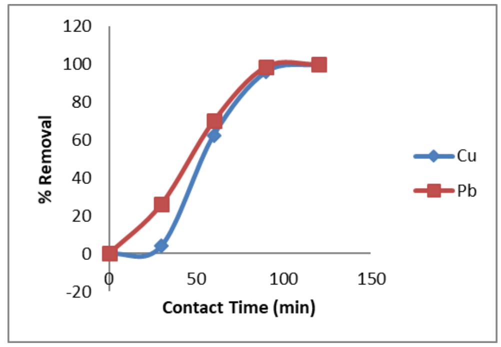

Fig. 4. Percentage Removals of metal ions against Contact Time

Figure 4 demonstrates the relationship between the percentage removal of metal ions and contact time. Increase in contact time leads to increase in % removal of the Cu and Pb metal ions as shown in the graph. More of the Pb metal ions are removed from the effluents compared to the Cu metal ions. But generally, the adsorbent is a good one and shows that the heavy metals ions are efficiently removed to bear minimum and hence the effluents can be used for domestication.

4. Conclusion

The research, industrial waste treatment using activated carbon from bamboo stems was successfully carried out. The bamboo stems was activated using $ZnCl_2$ to produce an adsorbent for efficient and effective adsorption of heavy metal ions (Cu and Pb) from effluents which were pH and metal uptake dependent. Langmuir and Freundlich Isotherms models were adopted, linearized and used for simulations of the experimental results obtained from the laboratory to generate the software results used for plots as shown in Figures 1- 4. The results indicate that adsorption concentration of both metals are maximum at pH of 8 and gave results that are lesser than (<) 0.002ppm.This implies that adsorption capacity increases with increased in pH value of the solution and the order of percentage increase of removal shows that Pb> Cu for both adsorbents. Hence the optimum adsorption occurs at pH equals 8and contact time of 120minutes and additional increase in adsorbent dose will leads to increase in percentage removal of the metal ions.

The characterization of the activated carbon produced from bamboo stems informed us that wastes Bamboo stems when activated are suitable adsorbent used for removal of heavy metal ions from polluted water or effluents. Other metal ion may be effectively removed. The research work plays a vital role on the purification of waste water effluents after adsorption of heavy metals ions has been carried out. The design models for the distillation column was developed using conservation principles of material balance and models were resolved manually to obtain the dimension of the column. Also, the cost of the column was obtained from the [22]. Experimentally the waste bamboo was carbonized at 450^{O}C and activated at 500^{O}C using $ZnCl_2$ to produced granular activated carbon (GAC). The GAC was then used as adsorbent in a packed bed column where waste water effluents from the refinery were passed through it and adsorption of essential metals ions i.e. Cu^{2+} and Pb^{2+} was carried and results in-terms of metal uptake, % removal efficiently dosage of the activated carbon used and the remaining amount of metal ions from the waste water effluents in-terms of contact time, and pH were tabulated in Tables 2-4.

Nomenclature and Abbreviation

Symbol	Meaning	Unit
q_t	metal uptake	mg/g
C_o:C_f	Initial and final Conc.	mg/$_L$
R	Efficiency	-
C_S^*	Equilibrium concentration of Adsorbate	mg/$_L$
a_f	Freundlich Capacity factor	-
$1/n$	Fraundlish Intensity Parameter	-
a_l&b_l	Emperical constants from langmiur model	-
C_p	Concentration of liquid in Equilibrium with that of solid phase	mg/$_L$
q_s	Heat to vaporize 1mole of feed	
ρ,μ	Density of liquid and vapour	kg/m^3
σ	Surface tension	N/m
[H$^+$]	Hydrogen ion concentration	M
FEPA	Federal Environmental Protection Agency	
COD	Chemical Oxygen Demand	
BOD	Biological Oxygen Demand	
TSS	Total Suspended Solid	
SS	Suspended Solid	
DS	Dissolved solids	
TN	Total Nitrogen	
TP	Total Phosphorus	
AAS	Atomic Absorptive Spectrophotometer	
ERPCL	Eleme Refinery and Petrochemical Company Limited	
OUL	Upper Operating Line	
LOL	Lower Operating Line	
MATLAB	Matrix Laboratory	
MF	Material Factor	
PF	Pressure Factor	
GAC	Granular Activated Carbon	

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