Bioremediation of Toxic Lead from Industrial Effluent Using an Agricultural Waste, Melon Husk Activated With Urea

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***Abstract*:- Lead which is toxic to the environment because of its threat on living organisms is one of the common components of industrial effluent. Urea-activated melon husk was used as an adsorbent to remove lead from simulated industrial effluent. Exposure times, adsorbate concentrations and adsorbent dosages were varied for the most suitable set of conditions for the adsorption process. The Adsorption isotherms correlated fine with the Langmuir and Freundlich isotherm models, with their R^2 values 0.9999 and 1 respectively. Data from the experiment were also assessed to discover the kinetic characteristics of the adsorption process. Adsorption process for the target heavy metal ion was found to follow pseudo-second order adsorption kinetics with r^2 value of 0.9995. Urea-activated melon husk, a readily available adsorbent, was found to be efficient in the uptake of Pb^{2+} ions in industrial effluents, thus, indicating an excellent alternative for the removal of heavy metals from industrial waste water.**

***Keywords:* Adsorption, Heavy metal, Lead, Waste water, Melon husk, Urea**

I. INTRODUCTION

The significance of water for the support of life cannot be overstated. Its importance in our homes, in agriculture, and in industry, is very enormous. Therefore it is necessary to know that when there is a reduction of water due to pollution, or inconsiderate use will lead to grave penalties (Owa, 2013). Water pollution as a result of heavy metals contamination from activities of industries is growing immensely and at a global alarm (Tripathi and Ranjan, 2015); thus, it is becoming a concern due to their toxicity to vegetation and animals. Retrieval of heavy metals generated from industrial effluents continue to be more and more essential as the society understands the need for reusing and preservation of metals that are important (Salehzadeh, 2013). Lead (Pb), Hg, Cu, Cd, Zn, Ni, Cr belong to the most common contaminants in industrial effluents. These metals can be poisonous to man and other living entities, even at low concentrations. Lead (Pb), when found at a higher concentration will result to severe impairment to the nervous system and affects the function of the brain cells. Lead, for instance, is very poisonous to human beings; triggering mental deficiency, anaemia, brain damage, as well as behavioural challenges (Gour et al, 2016).

Amongst the easiest, safest, and most economical approaches to the removal of these metals is by adsorption (Okoye et al, 2010). Commercially available ACs (Activated Carbons) are costly. Therefore, in a growing economy like Nigeria, it is better to make use of a less expensive, effective, environmentally friendly and yet economical waste water treatment adsorbent; e.g. activated melon husk.

Therefore the objective of this research is to convert waste melon husk into usable material which will then be employed in the treatment of an industrial effluents containing Pb metals.

II. MATERIALS AND METHODS

Collection of Adsorbent

The melon husks were obtained from the local market traders in south western Nigeria.

Preparation of Adsorbent

After rubbishes and stones were separated from the melon husks, they were properly washed and rinsed with clean water, sun-dried, ground and sieved to an even particle sizes.

Modification with Urea

The sieved melon husks were sodden in 0.6 mol/dm^3 Urea solution for six hours, it was dried overnight at 50^{0}C and was further activated at 120^{0}C for 4 hours using Memmert oven. Distilled water was used to remove excess Urea. Extra moisture was dried off from the husk, overnight, at 105^{0}C. It was further grounded and sieved to 500µm particle size. This was to provide a larger surface area for the adsorption. The melon husks was well preserved and kept for usage.

Adsorption procedure

The prepared waste water was treated with the melon husks (modified with urea). Studies on the effect of the concentration of adsorbates, the dosage effect of the adsorbent and the contact/exposure time were carried out.

Preparation of stock solution

A stock solution of 100 mg/L of Pb^{2+} was prepared using a 1 Litre volumetric flask from $Pb(NO_3)_2$.

Treatment of the Wastewater with the Adsorbent

250ml of the stock solution was measured into 250ml Erlenmeyer flask containing 3g of the adsorbent and the mixture was thoroughly shaken for proper mixing. Twenty milliliters each of the adsorbate and adsorbent mixture was instantly weighed into 100 mL Erlenmeyer flasks, that are eleven in number. Whatman filter paper was used to instantly filter the first 20 mL of the sample into a container. Between the period of one minute to a hundred minute, the remaining 20 mL samples were stirred (using a magnetic stirrer), by standard procedures (Clesceri *et al.,* 1998), to make adsorption more effective. The analysis of the Pb^{2+} concentration of the treated waste water was taken at ten minute interval, between one and a hundred minutes.

Succeeding experiments on adsorption were undertaken by means of enhanced parameters. By employing twenty millilitres of the stock solutions at twenty minutes for Pb^{2+} on the husk (activated with urea), the dosages of the adsorbents were varied between 0.2 g and 1.0 g at 0.2g interval, while the exposure time and adsorbate concentration were kept constant. The effect of adsorbate concentrations were studied using six different concentration, 0.0 to 0.12 mg/L at 0.02 interval, the adsorbent dosage and exposure time were kept constant. Finally, at constant adsorbate concentration and adsorbent dosage, the exposure time was varied at interval of 10 minutes between 0 to 100 minutes. Spectrophotometric method was used for the determination of the concentration of the adsorption of Pb^{2+} at any of these experimental conditions following standard procedure (Clesceri *et al.,*1998).

The stock solution concentration was gotten, which is used as sample for control or for initial concentrations. After adsorption, the filtrate, containing the remaining concentration of the Pb^{2+} were measured using model 9100 (Philips, England) Atomic Adsorption Spectrophotometry (AAS). The quantity of Pb^{2+} adsorbed, q_t, (mg/L) at time (t), was determined by the equation below:

$$q_{t(mg/L^{-1})} = \frac{(Co-Ce)V}{m}$$

C_o and $C_{\underline{e}}$ = the concentration of the metal ion in mg/L, at first and at a particular time (t) correspondingly.

V = volume of the adsorbate

m = the mass of the adsorbent in gram.

$$\mathbf{q}_{t(mg/g)} = \frac{(Co-Ce)(\frac{V}{1000})}{m}$$

The percentage of the Pb^{2+}removed (R_{metal} %) from the solution was determined by the equation below:

$$\mathbf{Rp_{b(ii)}} \, \mathbf{(\%)} = \frac{(Co-Ce)100}{Co}$$

$$\mathbf{q_e} = C_o - C_{\underline{e}}$$

Sorption Isotherms

Adsorption isotherms are regularly the ratio between the amount adsorbed and the residual in solution at a definite temperature at equilibrium. According to studies of equilibrium, the adsorption isotherm shows the ability of the adsorbent and equilibrium relationships between the adsorbate and the adsorbent. Isotherms of the Freundlich and the Langmuir are the most primitive and simplest known relationships which describes the equation for adsorption (Muhamad *et al.,* 1998; Jalali *et al.,* 2002). The two models for isotherm were employed to study the sundry isotherms and their capability to compare data from experiment.

Sorption Kinetics

Adsorption rate of a molecule unto a surface is an important parameter in the preparation of batch sorption systems, thus it is vital to establish the time dependence of such systems under various process conditions. In an effort to describe the sorption rate and to confirm the reaction mechanism of metal ion onto the husk, two kinetic models were applied to the experimental data. The first model was based on the supposition that sorption of metal ion onto the husk was reversible and followed a first order rate kinetics (Vinod and Anirudhan, 2002). The experimental data were further evaluated based on the pseudo-second order kinetic rate model proposed by Ho *et al,* (1995).

III. RESULTS AND DISCUSSION

From Figure 1, there was speedy adsorption of the metal ion in the first twenty minutes. The highest sorption being 97.6 %, after which the sorption capacity dropped to 89.5 % and then fluctuates between 89.5 % and 91.7 %.

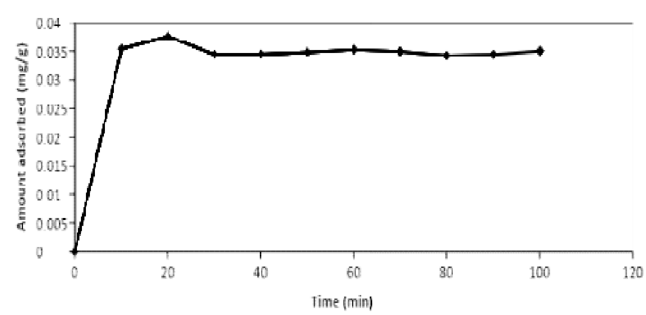

Fig. 1: Effect of contact time on adsorption of Pb^{2+}; Urea (Volume 250mL, adsorbent dose, 3g)

The results of the effects of the adsorbent dosage on Pb^{2+} sorption is presented in Figure 2. There was no considerable effect of adsorbent dosage as shown even though the highest adsorption was achieved by the highest dose.

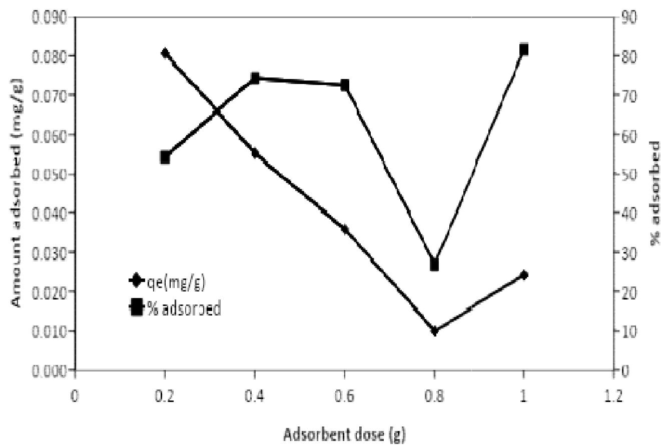

Fig. 2: Effect of adsorbent dose on adsorption of Pb^{2+}; Urea (Volume 250 mL).

The adsorption of lead (fig.3) did not exhibit much dependency on concentration. This could be attributed to the nature of the metal (Pb) under investigation. This study has shown that lead can be highly removed even at higher concentration.

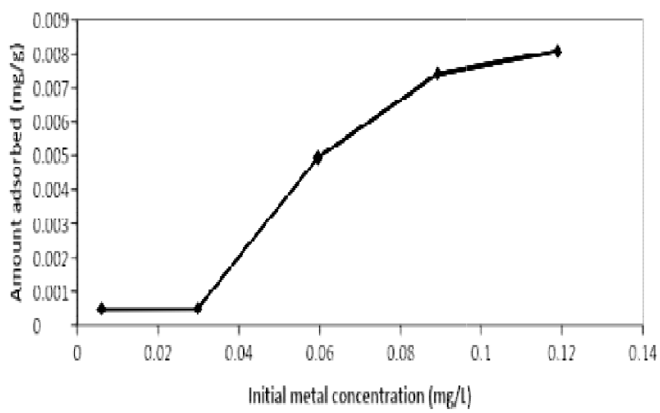

Fig. 3: Effect of initial metal concentration on adsorption of Pb^{2+}; Urea (Adsorbent Dose 3 g, Volume 250 mL).

Adsorption isotherm model for sorption of lead is presented in fig. 4. The equilibrium data obtained from Cd and Pb sorption capacities of the adsorbent were fitted to Langmuir and Freundlich isotherms.

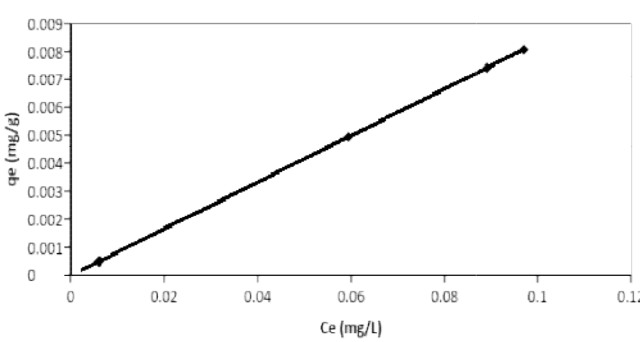

Fig. 4: Adsorption isotherm model for sorption of Pb^{2+} (Urea)

A plot of q_e against C_e (Fig. 4) yielded straight line and indicates a good fit of the isotherm to the experimental data. The linear plots of $1/q_e$ against $1/C_e$ show that adsorption followed the Langmuir model (Fig. 5). The correlation coefficient R^2 is 0.999.The plots of Log q_e against Log C_e show that adsorption also followed the Freundlich model with the R value of 1.

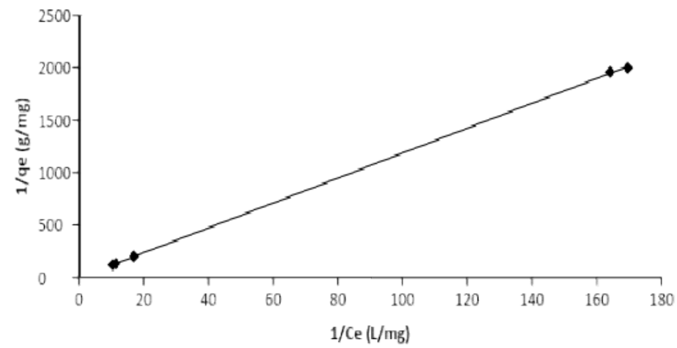

Fig. 5: Langmuir equilibrium isotherm model for sorption of Pb^{2+} (Urea)

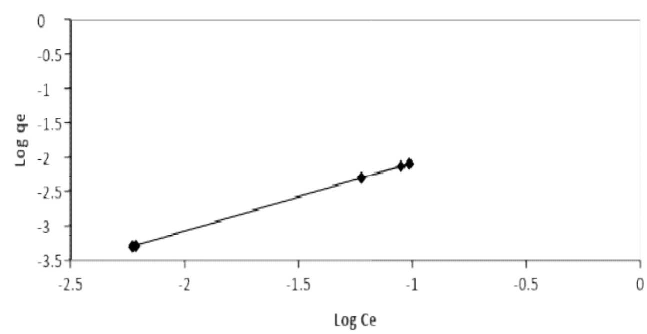

Fig. 6: Freundlich equilibrium isotherm model for sorption of Pb^{2+} (Urea)

The rate of adsorptions of Pb^{2+} onto urea activated melon husk were fitted into pseudo-second order adsorption kinetics. The data showed that, activated melon husk enhanced the equilibrium sorption capacity of the melon husk towards the metal ion. The r^2 values (coefficient of determination) for the pseudo-first and second orders are 0.6026 and 0.9995 respectively (Fig.7 and 8).

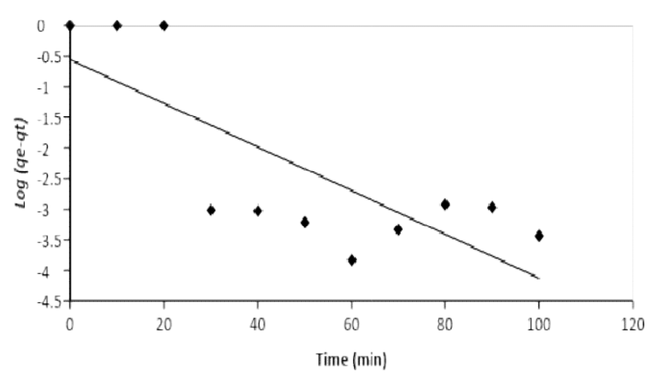

Fig. 7: Pseudo-first order sorption kinetics of Pb^{2+} (Urea)

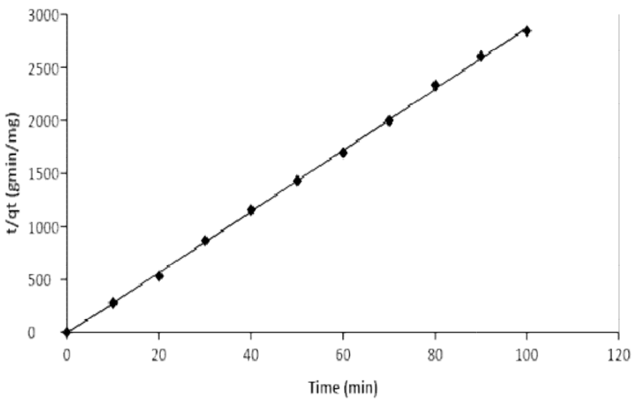

Fig. 8: Pseudo-second order sorption kinetics of Pb^{2+} (Urea)

IV. CONCLUSION

The outcome this study indicated that modified or activated melon husk has the capacity of eliminating Pb from waste water, like several other waste products from agriculture. Nasim *et al.* (2004) in their review revealed that agricultural waste products like sugarcane bagasse, rice husk, coconut husk, oil palm shell, neem bark etc. have a great potential for the removal of heavy metals from waste water. Nwankwo *et al.* (2014), discovered that activated melon husk was effective in the uptake of Cadmium ion of effluents from industries.

Findings from the analysis of filtrates when contact time of the adsorbent was varied with the adsorbate, showed that the removal of Pb from the waste water increased with increasing contact time.

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