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# Removal of Lead from Industrial Wastewater with Sodium Hydroxide Activated Melon Husk

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**ABSTRACT:** *Melon (Citrullus colocynthis) husk, a readily available agricultural waste products in Nigeria was used as a low-cost potential adsorbent to get rid of lead from industrial wastewater. Adsorption studies were carried out on NaOH activated melon husks at constant adsorbent mass and adsorbate concentration. The contact time was varied from 1 to 100 minutes at 10 minutes interval. Lead removal was found to be rapid from the first minute and equilibrium was attained within 10 minutes. Lead adsorption by NaOH activated melon husk was found to be less dependent on contact time. Adsorption isotherms correlated well with both Langmuir and Freundlich isotherm models and their $R^2$ values are 1. Experimental data were also evaluated to seek out out kinetic characteristics of the adsorption process. Adsorption process for the heavy metal ion was found to follow pseudo-second order adsorption kinetics with the $r^2$ value of 0.8697. Activated melon husk was found to be efficient as adsorbent in the uptake of Pb(II) ions in industrial wastewater, thus, predisposing it as a suitable alternative for the removal of heavy metals from wastewater.*

**KEY WORDS:** adsorption, melon husks, wastewater, lead, heavy metal

## INTRODUCTION

Even though it appears to be in bountiful supply on the surface of the earth, water is a rare and valuable commodity, and only a minute portion of the water reserves on earth, which is around 0.03%, comprises of the water resource which is out there for human use. Due to a growing world's population and increase in the number of industries, the demand for available water has equally risen in proportion to the available supply (which stays constant). Therefore, there is a need to ensure reduction in consumption and reduction in contamination of the water is (seeing that water has a limit to its ability for self-purification); consequently, the need for treatment process of wastewater arises (Awaleh and Soubaneh, 2014). Heavy metals, which are metallic elements with atomic density of more than 6 g/cm$^3$, are one among the principal persistent water contaminants. Their uniqueness lies in their ability to resist degradation, but rather has the ability to accumulate in living organisms, which eventually leads to negative biological health challenges and disturbances. (Akpor and Muchie, 2010). Due to the fact that the world is now becoming a global village, the impact of heavy metals in one part of the world will fundamentally affect another part, thus leading to global penalties (Agwarangbo et al, 2013). As, Cu, Cd, Pb, Cr, Ni, Hg and Zn are the heavy metals commonly witnessed in contaminated water (Akpor and Muchie, 2010).

The contamination of Pb to the environment is a global health challenge, demonstrated by high dosage of Pb metal in the blood among persons living within areas contaminated by the metal. Lead poisoning has serious adverse health effects that mainly affect children where it has been particularly associated to neurological, neuro-behavioural and developmental problems, and iron deficiency anaemia (Makokha et al, 2008). Precipitation with chemical and electrochemical methods or occasionally by the use of sulphides are the analytical methods that are mostly used for the removal of ions of metals. A significant difficulty with this kind of practice is in how the precipitated wastes are disposed of. Another second most generally used method for metal ions removal is by ion exchange. This method can minimally reduce metals contamination. This method does not have a problem in disposing the sludge; and also has the advantage of reclaiming $Cu^{2+}$ ion. Nevertheless, this sort of treatment procedure does not seem to be cost-effective. Even though activated carbon is as well effective in wastewater for removing trace elements, nevertheless its wide usage has been limited because it is cost-intensive. The adsorption procedure for the removal of poisonous metals from wastewater continues to be more cost-effective, by employing some adsorbents under best possible conditions of operations (Dursun and Pala, 2007).
The aim of this study, therefore, is to use sodium hydroxide activated melon husk to remove Pb from industrial wastewater.

## MATERIALS AND METHODS

### Collection of Adsorbent
The melon husks were collected from the melon sellers at Main Market in Ogbomosho town of Oyo State, Nigeria.

### Preparation of Adsorbent
After collecting the melon husks from the sellers, stone and debris were removed from the husks. The husks were then washed well with water from the tap, rinsed with distilled water, dried in the sun, milled, and then the particles of the husks were sieved to even sizes.

### Modification with NaOH
The modification was carried out according to the method adopted by Raghuvanshi et al (2004) and Habib-ur-Rahman et al (2006). For the next twelve hours, the milled husks were sodden in 0.5mol/dm$^3$ NaOH, after which distilled water was used to wash off excess NaOH on the husks. To prevent any colour interference from occurring during the activation process, the husks were sodden in 1% formaldehyde at 50$^o$C for four hours.. Afterwards, the distilled water was used to rinse the husks in order to get rid of free formaldehyde; after which the husks were dried at 60$^o$C for the next two hours. It was further milled and sieved to 500μm particle size. This was

to provide a larger surface area for the adsorption procedure. The melon husks were now well corked and kept in a container ready to be used.

**Adsorption Procedure**

After treating the simulated wastewater with the husks (which has been modified with NaOH), the equilibrium/contact time, dosage effect of the adsorbent and effect of the concentration of the adsorbates effect were considered.

**Preparation of stock solution**

A stock solution of 100mg/L Pb $(NO_3)_2$ in1 Litre volumetric flask was prepared.

**Treatment of the wastewater with the Adsorbent**

Two hundred and fifty millilitres of the stock solution was measured into Erlenmeyer flask (which has a volume of 250 mL), and contains 3 g of the adsorbent. The mixture was meticulously shaken to allow for proper mixing. Twenty millilitres each of the mixture was instantaneously weighed and poured into eleven different 100 mL Erlenmeyer flasks. The first 20 mL sample was immediately filtered into a sample container with Whatman filter paper. To make adsorption more effective, the other samples, each containing 20 mL, were stirred with magnetic stirrers at different time interval (which is between one and a hundred minutes) (Clesceri et al, 1998). The concentration of the Pb ion-treated wastewater were analysed at interval of 10 minutes, between 1 and 100 minutes.

The stock solution concentration was used as the initial concentration. After adsorption, Atomic Adsorption Spectrophotometry (AAS) (model 9100, Philips, England) was used to determine the concentration of the $Pb^{2+}$ in the filtrate. The amount of $Pb^{2+}$ adsorbed qt, (mg/L) at time (t) were calculated with the following equation:

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

$C_o$ and $C_e$ = metal ion concentration (mg/L), at initially, and at a given time, t respectively, V is the volume of the adsorbate and m is the mass of the adsorbent in gram.

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

The metal ions percentage removed ($R_{metal}$, %) from solution was calculated by using the following equation:

$$\mathbf{R}_{\mathbf{Pb(ii)}}\,\mathbf{(\%)} = \frac{(Co-Ce)100}{Co}$$

$$\mathbf{q_e} = C_o - C_e$$

**Sorption Isotherms**

Langmuir and Freundlich isotherms are the earliest and simplest known relationships which describes the adsorption equation. Adsorption isotherms generally shows the equilibrium studies that gives us the capacity of the adsorbent and the equilibrium relationships between the adsorbent and adsorbate. These isotherms are usually the ratio between the quantity adsorbed and the residual in solution at fixed temperature at equilibrium. (Muhamad et al, 1998; Jalali et al, 2002). These two isotherm models find their use in studying different isotherms and their ability to compare data from experiment.

## Sorption Kinetics

The rate of adsorption of a molecule unto a surface is an important factor when designing batch sorption systems, consequently for such systems it's important to determine the time dependence under different process conditions. Two kinetic models were applied to the experimental data; the first model being on the assumption that sorption of metal ions onto the melon husk was reversible and followed a first order rate kinetics. The two models was in an attempt to describe the sorption rate, and to confirm the reaction mechanism of the lead ion onto melon husk (Vinod and Anirudhan, 2002). The experimental data were further calculated founded on the pseudo-second order kinetic rate model proposed by Ho et al (1995).

## RESULT AND DISCUSSION

Figure 1 showed that NaOH activated melon husk had great effect on the Pb polluted industrial waste water. The sorption of lead by the adsorbent was very high. The adsorption of Pb by activated melon husk recorded 100% adsorption at all the time intervals except at the 40th and at the 90th minutes where the percentage adsorption dropped to 68.18 and 63.38% respectively. The largest dosage mass recorded the highest percentage removal of 53.0368%. The adsorption of the metals showed to be dependent on adsorbate concentration with very little fluctuations. The lower the adsorbate concentration, the higher the percentage of Pb removal.

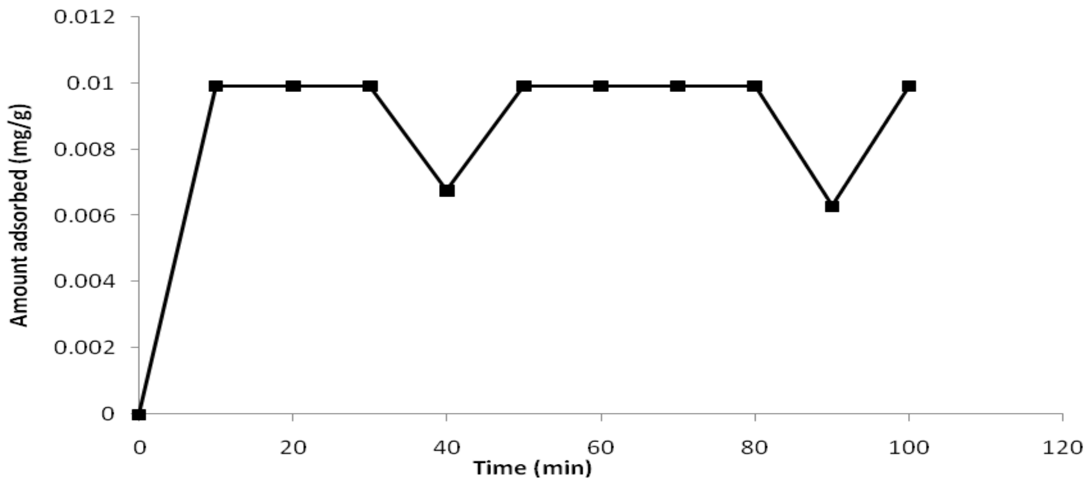


**Fig.** 1: Effect of contact time on adsorption of $Pb^{2+}$; NaOH (volume, 250 mL; adsorbent dose, 3g)

Adsorption isotherm models are widely employed to present the quantity of solute adsorbed per unit of adsorbent, as a function of equilibrium concentration in bulk solution at constant temperature. The equilibrium data obtained from Pb sorption capacities of the adsorbent were fitted to Langmuir and Freundlich isotherms. A plot of qe against Ce (Figure 2) yielded a line and indicates an honest fit of the isotherm to the experimental data. The linear plot of 1/qe against 1/Ce shows that adsorption followed the Langmuir model (Figure 3). The linearized sort of Freundlich adsorption isotherm was wont to evaluate the connection between the concentration of Pb adsorbed by the adsorbent and Pb equilibrium concentration in wastewater. The plot of Log qe against Log Ce showed that adsorption also followed the Freundlich model (Figure 4). The coefficient of correlation $R^2$ is 1 for sorption of Pb(II) by NaOH activated melon husk,

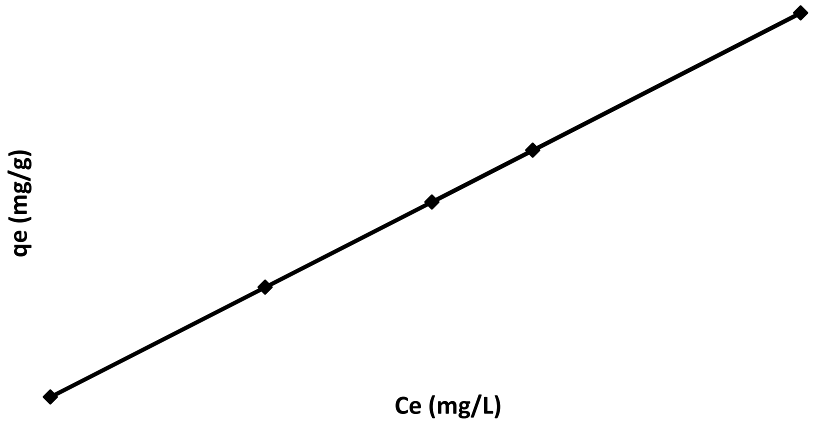


**Fig.** 2: Adsorption isotherm model for sorption of $Pb^{2+}$

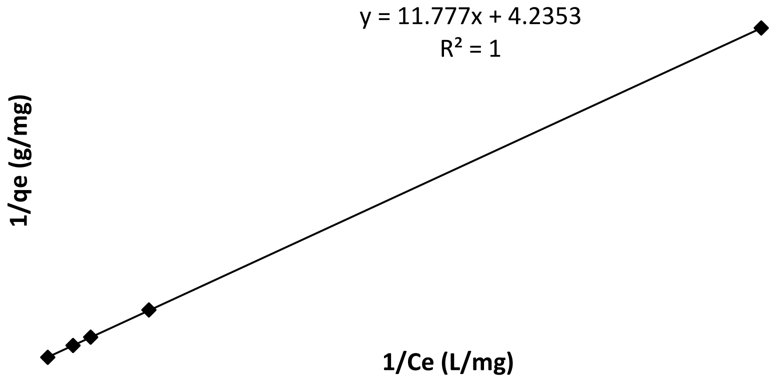


**Fig.** 3: Langmuir equilibrium isotherm model for sorption of $Pb^{2+}$

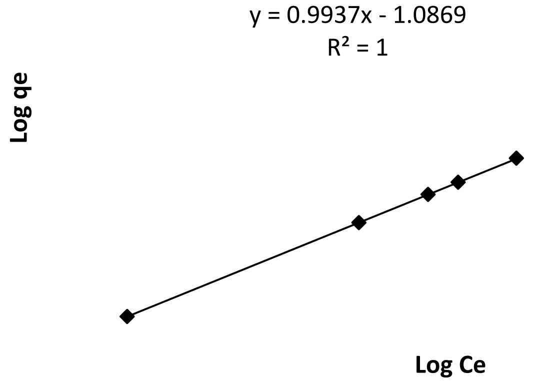


**Fig.** 4: Freundlich equilibrium isotherm model for sorption of $Pb^{2+}$

The experimental data were fitted into pseudo-second order adsorption kinetics. The data showed that, modified melon husk enhanced the equilibrium sorption capacity of the melon husk towards the metal ion. Figure 5 show the pseudo-second order sorption kinetics of the metal ion by the adsorbent.

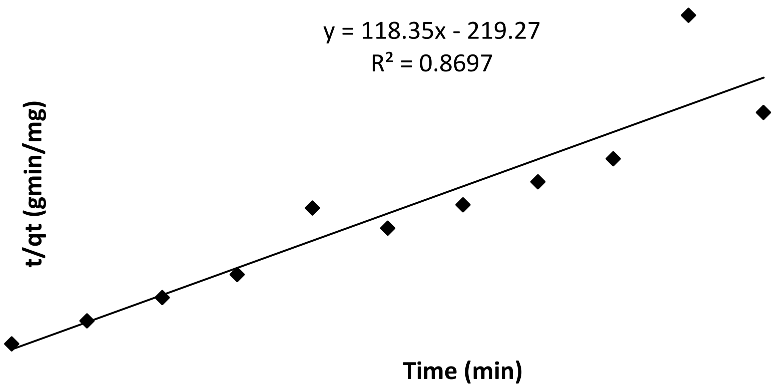


**Fig.** 5: Pseudo-second order sorption kinetics of $Pb^{2+}$

## CONCLUSION

The result of this research has shown that NaOH modified melon husks is capable of removing Pb from wastewater, like a number of other agricultural waste products. Nasim et al (2004) in their review showed that waste products from agriculture such as rice husk, coconut husk, oil palm shell, neem bark, sugarcane bagasse, and so on, have a high ability in removing heavy metals from waste water. Nwankwo et al (2014) found out that activated melon husk was efficient in the removal of $Cd^{2+}$ and $Pb^{2+}$ in industrial effluents. Results obtained also showed that the removal of Pb metal from waste water does not really depend on time.

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