Adsorption of Copper (II) Ion by *Leucaena Leucocephala* Pods

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***Abstract*— Agriculture solid waste was used to recovery of valuable material such as *Leucaena leucocephala* pods that finds the significant role in adsorption. Agriculture solid waste was used to recovery of valuable material such as *Leucaena leucocephala* pods that finds the significant role in adsorption. The objective of this paper is to study on adsorption of copper metal ions by *Leucaena leucocephala* pods. ICP-AES ensures the optimizations of the influences of the effective parameters including contact time, pH and adsorbents. The different instrumental analysis like TGA, FTIR, XRF and zeta potential measurement which additionally authenticated the sorption phenomenon describe the features of the biomass. The best condition of adsorption happened at pH 8.0 and the process adsorption was quite fast at 0.75 g dosage and within time 140 min. From the Fourier Transform Infrared (FTIR) Spectra result, it was showing that the *Leucaena leucocephala* pods had indicate the contribution of carboxyl groups with the binding of cu (II) ions which presented that the carboxylic group peak shifted from 1609 to 1644 cm^{-1} after copper metal ions binding. The best rate of adsorption of copper by *Leucaena leucocephala* pods within 140 min. The study established that *Leucaena leucocephala* pods can adsorb copper and altogether showing that the adsorption method was used to successfully execute post adsorption elution of the loaded metal.**

I. Introduction

Nowadays, the presence of the heavy metal in industrial and wastewater has been arise giving high toxicity of concentration that give impact to the public health. The concentration of heavy metal is the main thing that has been focused in the Malaysia is the due to the coastal resources, agriculture and economic activities and human population. (Sakai N., Yoneda M., 2018). Thus, it is an effective idea of removing the heavy metals from wastewater for a better future.

The increasingly usage of heavy metals over the years actually gave big impacts such as an enlarged of metallic constituents in the seas or oceans (aquatic environment). The main source of heavy metals usually comes from industrial activities. Other than industrial activity, ore mining, volcanic activity, forest fire, acid rain and also agriculture also donated to the high percentage in producing heavy metals in water content. Heavy metals is may result to the cancer and other health diseases due to the bio-accumulation of the body when exposed to the heavy metals through consumption. Amongst all the heavy metals, copper metal is one of the popular heavy metal that content high concentration in water resources that becoming water contaminants. In addition, copper metal also contribute to the heavy health diseases such as *haemolysis*, cirrhosis, *anaemia*, nephrotoxic and hepatotoxic effects and even can causing death. However, the efforts to overcome or prevent as far as possible the high content of heavy metals in surrounding are by carrying out the initiative methods for examples, chemical precipitation (Chen et al., 2018), electrolytic recovery (Ebbers, Ottosen, & Jensen, 2015), adsorption/ion exchange (Dong et al., 2018), and solvent extraction/liquid membrane separation (Chen et al., 2018). Among all of these, adsorption is the most efficient way due to its high reliability, have simple design and sludge free operation. The most widely used absorbent so far is activated carbon which is very expensive. Therefore, there is a need to search of other adsorption potential that would provide low cost. .

Most agriculture wastes or by-products are considered to be low value products. Different types of biomass have been investigated for biosorption of heavy metals (Genson Murithi & Muthakia, 2007). One of the agricultural content that has received attention in the present study is the *Leucaena leucocephala*, which is able to the tune of tons per annum in Malaysia. There is an estimated 15% of total waste generation consists of agriculture waste in Asia and Malaysia contribute 0.122 kg/cap/day consists of waste generation (Natural Resources Wales, 2012). It is easily found, abundant, readily available at low cost and also environment friendly substance. Therefore efforts have been made in this paper to study about the adsorption of copper metal ion by *Leucaena leucocephala* pods.

The objective of this paper is to access the ability *Leucaena leucocephala* pods to adsorb Cu (II) ions in aqueous solution, which are considered environmentally safe and low cost. The adsorbent dosage, solution pH, effect of contact time on the removal of Cu (II) ions were studied.

II. METHODOLOGY

A. Materials

The adsorbent of the heavy metal is using the biomass which is *Leucaena leucocephala* pods that is obtained from nearby areas which is Section 7, Shah Alam. The same size of particle of *Leucaena leucocephala* pods were obtained and were grinded into small pieces and sieved at a mesh size of 400 µm using sieve shaker (Endecotts Octagon 2000 Digital), then put into sealed plastic bag to be stored in a desiccator. Then, copper (II) solution of 1000 mg/L are prepared by dissolving Copper (II) nitrate, $Cu(NO_3)_2$ that obtained from chemical laboratory Faculty of Chemical Engineering, UiTM Shah Alam and pour into the deionized water.

B. Methods

1) Preparation of Leucaena Leucocephala Bio-adsorbent

To dispose of dust other disturbing particles, the bio-adsorbent will be washed with methodically first tap water then use the deionized water. Then it will dried at 100°C using oven dried until the weight becoming constant for 72 hours. After that, the bio-adsorbent is keep in dehydrated state for the next experiment.

2) Modification of Leucaena Leucocephala Bio-adsorbent

a) Removal of chlorophyll content

200 mL of distilled water in the 250 mL of beaker was boiled until it reached 100ºC. The hot water is basic 100 g of dried *Leucaena leucocephala* pods biomass of 400 µm was the added into the beaker. The mixture was stirred at 220 rpm and at 200ºC for 10 minutes. It was filtered after cooling and the residue was oven dried overnight to a constant weight at 105ºC. After that, 500 mL of 96 vol. % ethanol (to avoid damaging pigment) was poured into a 1000 mL beaker equipped with thermometer and stirrer. The powder of *Leucaena* pods was added with ratio 2:1 (ethanol: powder) (Storey, 2012) after the beaker was heated up to the 60ºC of temperature and stirred at the desired agitation speed which is 300 rpm for 3 hours. The extracted powder was separated from the ethanoic solution by filtering after cooling and the residue was oven dried 24 hours at 105ºC. The filtrate was then analysed to measure the chlorophyll content (Putra, Darmawan, Wahdini, & Abasaeed, 2017).

b) Removal of lignin

0.1 N HCL solutions was mixed with a 100 g of powdered *Leucaena leucocephala* pods (free from silica and chlorophyll contents) in a beaker (1000 mL). After that, the mixture was stirred for 3 hours at 50 °C with a 300 rpm. The residue was filtered and rinsed thoroughly with distilled water until neutral pH was reached. Then for 48 hours, it was oven dried preparing for the next experiment (Ngabura, Hussain, Ghani, Jami, & Tan, 2018).

3) Adsorption experiment

In the experiment, 250 mL volumetric flask with stopper cork along with 100 mL solution desired 50 ppm Cu (II). To produce a stock solution of 50 ppm, the flask was then filled with distilled water until reached the marked level. Thus, in the supernatant, the remaining concentration of copper had been analysed by Inductive Coupled Plasma Atomic Emission Spectrophotometer (ICP-AES). Then measure the adsorption capacity of *Leucaena leucocephala* pods for copper using a mass balance equation as detailed by (Basu, Guha, & Ray, 2017)

$$q = (C_i - C_f)/W \times V \quad (1)$$

in this equation q is the amount of copper uptake (mg/L), C_i and C_f are initial and final metal ion concentrations (mg/L), W symbolises for weight of bio-sorbent (g) and V the volume of solution (L). This shows the study and research concerning of maximum adsorption capacity of *Leucaena leucocephala* pods for copper is investigated at different pH from 2 to 12, different sorbent dosage from 0.5 g to 2.0 g and different contact times from 10 to 180 min at optimum temperature. The pH values have been adjusted with 0.1 M HCl or/and 0.1 M NaOH. The pH values of Cu (II) solutions were measured by pH meter (Type Schott, CG 841 model).

4) Infrared Spectroscopy (FTIR) Analysis of Leucaena Leucocephala Bio-adsorbent.

Fourier Transform Infrared Spectroscopy (Perkin Elmer Spectrum One FT-IR Spectrometer) is to study the functional groups inside the sample of *Leucaena leucocephala* pods that is used for the removal of copper (II) metal within the range of 500 to 4000 cm-1.

5) Thermo Gravimetric Analysis (TGA) of Leucaena Leucocephala Bio-adsorbent.

Thermo-Gravimetric Analysis (TGA) (Mettler Toledo TGA851/1600) is used to determine chemical composition inside the adsorbent by heating the biomass. As a function of temperature, the chemicals can be indicated by weight loss of the biomass during heating process. TGA is conducted by using nitrogen gas. The temperature range is from 0 to 1000°C and will be setting up and the heating rate used in TGA is setting up to 20°C/min.

6) X-Ray Fluorescence Spectrum (XRF)

The Cu (II) concentrations of supernatant sample were determined by using atomic absorption spectrometry (Model AA6800). The X-ray fluorescence (XRF) spectrum analysis (Model Axios PW4400, PAN analytical) was conducted for the element composition of raw *Leucaena* pods and treated *Leucaena* pods.

III. RESULTS AND DISCUSSION

A. Characterization of the adsorbents

1) FTIR

By identifying the different types of functional groups existing on *Leucaena* pods was by studying the FTIR analysis of the sample. The FTIR spectra in Fig. 1 shows the raw, modified and after Cu (II) adsorption of *Leucaena leucocephala pods*. The FTIR spectra of raw *Leucaena leucocephala* pods showed broad and intense absorption peak at 3281.60 cm^{-1} which was due to stretching vibrations of -OH group (Rao & Ikram, 2011). The –OH stretching vibrations occur within a broad range of frequencies indicating the presence of free hydroxyl groups and bonded -OH bands of carboxylic acids (Anirudhan & Sreekumari, 2011). Besides, the broad peak observed at 1019.07 cm^{-1} was assigned to the carboxylate anions (–COO–) (Rao & Ikram, 2011). The broad and short peak appearing at 1609.41 cm^{-1} was due to the stretching vibrations of C–OH group.

FTIR spectra of modified *Leucaena leucocephala* pods shows the shifting peak from 1019.07 cm^{-1} to 1030.9 cm^{-1} which shows an increasing in stretching of C-O-C.

FTIR spectra of *Leucaena leucocephala* showed shifting in absorption peaks around 3281.6 cm^{-1} and 1609.41 cm^{-1}. These peaks has been shifted to 3320.6 cm^{-1} and 1644.7 cm^{-1}, respectively showing interaction of Cu (II) with the functional groups of adsorbent which are amine N-H stretch and aromatic C=C bending, respectively. The peak that is appear after Cu (II) adsorption at 1506.3 cm^{-1}, 1423.6 cm^{-1} and 1365.6 cm^{-1} indicating that some modifications in functional groups of *Leucaena leucocephala* might have taken place after treatment with NaOH which might be C=O (carboxylic, anhydride, lactone and ketone) at 1506.3 cm^{-1}; C–O stretching and O–H bending (lactonic, ether, phenol, etc.) at 1423.6 and 1365.6 cm^{-1} (Anirudhan & Sreekumari, 2011).

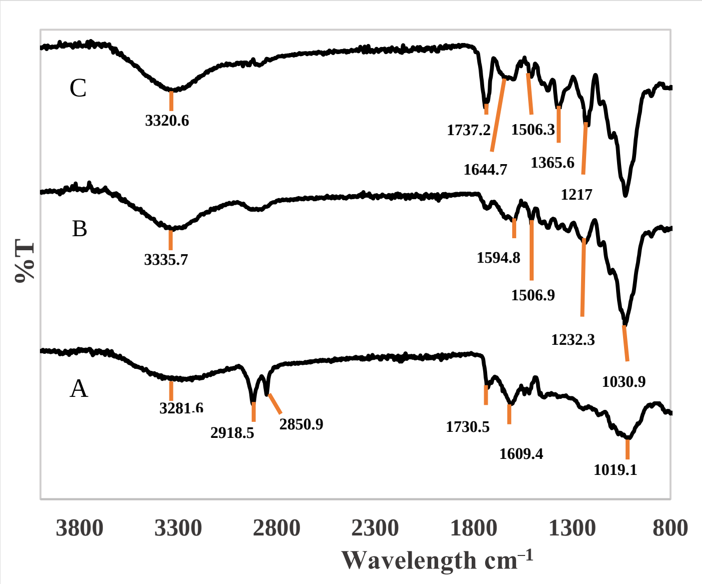

Fig. 1. FTIR spectra raw l*eucaena leucocephala* pods and after Cu (II) adsorption, A = raw *Leucaena leucocephala* pods, B = modified *Leucaena leucocephala* pods, C = after adsorption

2) TGA Analysis

The temperature that had been investigated is up to 996.1 ºC for thermogravimetric (TG) and differential Thermal Gravimetric (DTG). TGA for the thermal behaviour of *Leucaena leucocephala* pods that had been plotted is presented in Figure 2.1 and 2.2. The thermogravimetric (TGA) analysis was assessed to evaluate the thermal stability of the *Leucaena leucocephala* pods for raw and modified pods studied in this research. There are two steps that have been studied that shown in the graph Figure 2.1 and 2.2 for all the samples. The initial shows the weight loss in range temperature from 20ºC to 50ºC in sample which is about 5.4%. From the previous study, (Yousefi et al., 2013) state that the weight loss from 20 – 80 ºC in all samples is attributed to the evaporation and removal of absorbed and bound water in the fibres.

In the next step, the maximum weight loss in the region of 280ºC (which is too small) that attributed to the degradation of hemicellulose. The weight loss in percent is about 3.8% as stated by (Arora & Joshi, 1985) which is in a very small portion. Another researcher mention that the degradation of hemicellulose may occur because of the thermal depolymerisation in the region of 220 – 315 ºC (Yang, Yan, Chen, Lee, & Zheng, 2007).

While the weight loss in the temperature of 328ºC and 367ºC that represent raw (39.96%) and modified *Leucaena leucocephala* pods (59.5%) respectively due to the pyrolysis of cellulose and the fibre residue, indicated the carbonaceous residue that was present because the analysis was performed under nitrogen atmosphere (Alemdar & Sain, 2008). Considerable weight loss also could be explained by organic material decomposition cellulose and hemicellulose material (Ben-Ali, Jaouali, Souissi-Najar, & Ouederni, 2017).

The residue of the weight loss from region 400ºC to 550ºC as shown in the Fig. 2.1 and 2.2 refer to the degradation of the lignin. By comparing the lignin content for the raw and modified *Leucaena leucocephala* pods, the weight loss percent for hemicellulose and cellulose is increases as the amount of hydroxyl group also increases. This is because of the lignin in raw *Leucaena leucocephala* pods is more stable than the modified pods. There are many factors for thermal stability of the. The high stability of lignin on *Leucaena leucocephala* pods also because of the strong covalent linkage between cellulose and lignin. Many kind of aromatic rings, ether and double carbon bonds is a form of lignin that represent for a temperature between 400 till 600 ºC. There are several influences of the crystallinity of cell on the thermal stability that had been reported by researchers. For heat transfer, it can be recovered more on the thermal stability of lignocellulosic fibres by the crystalline regions of cellulose that act as a barrier (Espinosa et al., 2017).

Furthermore, the weight loss is still happened but in a lesser amount than other weight loss and the residue of the weight is about 32% and 53.6% at the modified adsorbent and raw adsorbent respectively at above 550 °C as shown in the Fig. 2.1 and 2.2. It is meaning that the lignin is decreasing after the adsorbent had been modified as mentioned by (Burhenne, Messmer, Aicher, & Laborie, 2013), all lignin is known to be very stable and more difficult to decompose than cellulose or hemicellulose and lignin decomposes slowly over a large temperature. Besides, the activation temperature of 600 °C was recommended for raw materials from the TG study, since the curve depicts a straight line, which means a stable state. Therefore, at the heating temperature of 600°C, no remains could be found (Lemraski & Sharafinia, 2016).

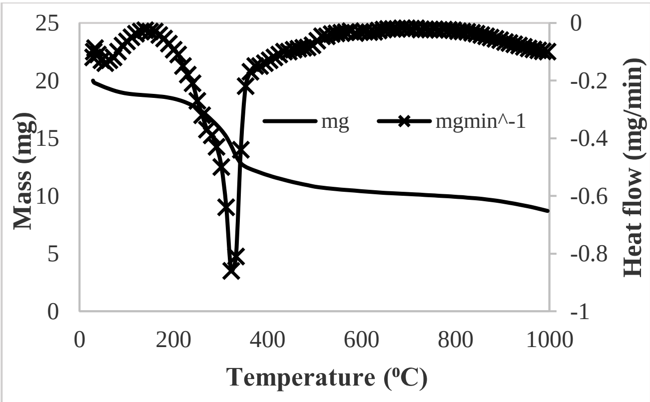

Fig 2.1 TGA Analysis for raw *Leucaena leucocephala* Pods

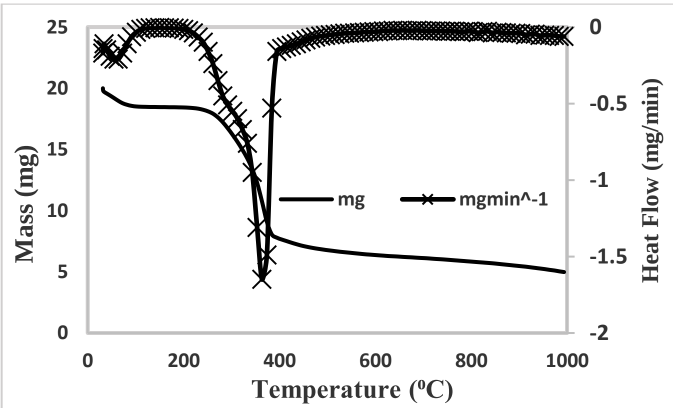

Fig 2.2 TGA Analysis for Modified *Leucaena leucocephala* Pods

3) *XRF Analysis*

On the other hand, XRF as a well-established spectro-chemical analytical technique offers some unique advantages as being fully non-destructive, requiring minimal sample preparation, simple and suitable for in-situ use with portable equipment. The main goal of this research work is to confirm the adsorption efficiency of *Leucaena leucocephala* pods for Cu (II) metal. Adsorption isotherms and kinetics studies were reported to account for *Leucaena leucocephala* pods as an effective adsorbent of copper as shown Fig. 3.

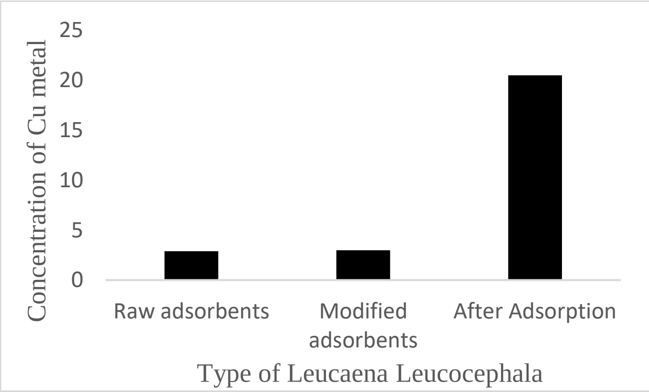

Fig. 3. XRF on *Leucaena leucocephala* pods.

4) *Zeta Potential Measurement*

By determining the particle velocity in the electric field, it can measure the zeta potential which is the electrical potential at the surface of a particle (Ertugay & Bayhan, 2010). At zeta potential measurement discovered that surface charge of *Leucaena leucocephala* pods has a negative surface charge that form R-COO$^-$ (organic functional groups) resulting from the separation of hydrogen ions (H^+) (Sahmoune, 2018) according to Eq (2) and Eq (3)

R–COOH = R–COO- + H+ (2)

R–OH = RO- + H+ (3)

The highest value of negative after Cu (II) adsorption is at pH 8 solution as it is a favorable for positive metal ion through attraction on the active sites which form an electrostatic interaction. At pH 8 also shows the *Leucaena leucocephala* pods was indicating the major binding, major groups because of its characteristics which were deprotonated and negatively charged. The major groups include carboxyl, carbonyl, hydroxyl and other anionic ligands would also interact with copper metal ion through physiochemical interactions for bio-sorption process as the surface of *Leucaena leucocephala* pods is confirmed negatively charged (Sahmoune, 2018). So it shows that as higher pH values that have negativity value on surface on sorbent, thus, the greater the level of adsorption of the metal. The negative surface charge of *Leucaena leucocephala* pods would improve the adsorption process as its surface leads to deprotonation of functional groups of the biomass as H^+ (aq) and H_3O^+ (aq) and acts as binding sites. So, the functional groups become easily attachable to metal ions. Hence, the applicable pH for adsorption of Cu (II) ion in this experiment was pH 8 as it is the highest negatively charge in zeta potential in mV as shown in Fig. 4 (Pb, Buangan, Serbuk, & Kelapa, 2018).

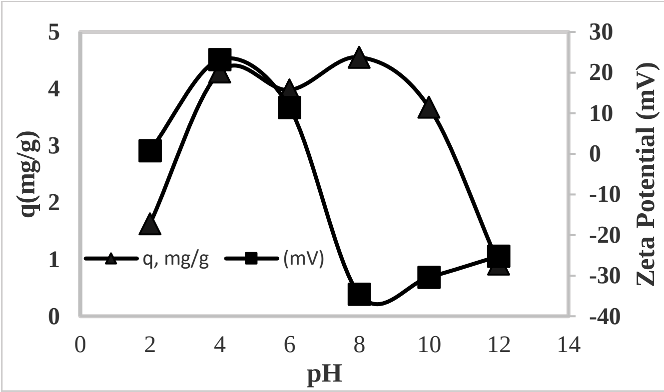

Fig. 4 Zeta potential of copper metal on *Leucaena leucocephala* pods.

5) *Point Zero Charge pH (pH_{pzc})*

To verify the adsorbent surface charge, determining the pH with a net total point at zero charge (pH_{pzc}) is one of the parameter that important to count on as it can affect the adsorption capacity. Based on pH_{pzc}, it can describe and determine the effect of pH of adsorption of heavy metals on sorbent surface such as *Leucaena leucocephala* pods and also whether the surface of adsorbent is positively or negatively charged (Lee & Choi, 2018). Based on the Fig. 5 below, the point zero charge is at pH 6 so bio-sorption of Cu (II) would be higher as mentioned by (Anirudhan & Sreekumari, 2011), pH below than point zero charge, ($pH < pH_{pzc}$) is the positively charge on the adsorbent surface and become positively charged when it is above pH_{pzc} ($pH < pH_{PZC}$). (M. Dharmendirakumar, G.Vijayakumar, Vijayakumar, Tamilarasan, & Dharmendirakumar, 2015) also stated that through the electrostatic force of attraction, the surface of the adsorbent that becomes negatively charged would improves the adsorption of positively charged copper cations.

Cu^{2+} and Cu $(OH)^{2+}$ ions are the main classes of metal in solution. The increase in metal removal with increase in pH values can be explained on the basis of a decrease in competition between proton and the metal cations for the same functional groups and by the decrease in positive charge of the adsorbent which results in a lower electrostatic repulsion between the metal cations and the surface. So, *Leucaena leucocephala* pods is a good adsorbent and it remove very high quantity of copper metal that was found in this investigation which is 96.3% removal compared to other pH solution.

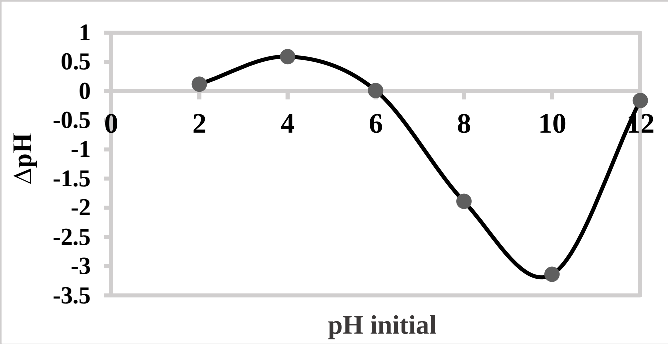

Fig. 5 Point Zero Charge of *Leucaena leucocephala* pods.

B. Effect of pH

The various solution of initial pH was in range 2 to 12 to study the effect of this parameter in controlling metal ion of adsorption process. Fig. 6 depicts the increasingly Cu (II) sorption on *Leucaena leucocephala* pods powder by increasing the solution pH. As refer to the graph in Fig. 6, the best adsorption of Cu (II) ion is at pH of 8. At low pH values, there is a decreasing in the number of negatively charged on surface sites on *Leucaena leucocephala* pods and also an increases of number of positive charge because of an electronic repulsion. Other than that, the lower adsorption of copper metal ion at acidic pH due to the competing between copper metal ion and excess of proton. On the other hand, high adsorption of copper metal ion favor at high value of pH because of an increment number of negatively charged on surface sites through electrostatic attraction.

However, once pH became more basic (around pH 10), adsorption declines as metal hydroxides precipitate as shown in Fig 6. The reduction in uptake rate at pH values higher than 10.0 may be explained to metal hydroxylation yielding metal hydroxides or hydrated oxides which can cause metal passivation (Arshadi, Amiri, & Mousavi, 2014). Figure 6 shows that varying the pH values have considerable difference in removal efficiency for 50 mg/L of Cu, allowing for a wider range of efficiency. It was determined that pH 8 (Cu) is the most favorable condition for the adsorption of copper on *Leucaena leucocephala* pods. The maximum percentage removal of the copper amounts to approximately 90.3% at 50 mg/L Cu.

It has been shown that maximum sorption values for *Leucaena leucocephala* pods was recorded at initial pH (pH_{pzc}). Therefore, electrostatic attractions between negatively charged surface of these sorbents and Cu^{2+} ions could take place and contribute to sorption. Maximum sorption is obtained at initial pH around 8 which is quite far from the pHpzc (6.8).

On considering the pHpzc of *Leucaena leucocephala* pods and the speciation of Cu (II) in the solution another plausible explanation for Cu (II) adsorption can be provided. At a pH below 6 (pHpzc), the surface of the chestnut shell is positively charged due to protonation. This protonation effect is more pronounced at low pH values due to the presence of high concentration of H^+ ions in the solution and results in more unfavorable for Cu (II) adsorption at a lower pH value owing to the electrostatic repulsion between both positively charged adsorbent surface and the metal ions. At optimum pH value (pH 8.0), the surface of *Leucaena leucocephala* is negatively charged plausibly due to the dissociation of the –COOH groups and favorable to the adsorption of Cu^{2+} and $Cu(OH)^+$ which are dominating species of the Cu (II) in the solution at pH 8.0. Copper may most likely be bound on the surface of the *Leucena leucocephala* via ion exchange mechanism as following equations:

$$2(\text{–RCOOH}) + Cu^{2+} \rightarrow (RCOO)_2Cu + 2H^+ \quad (4)$$

$$\text{–RCOOH} + CuOH^+ \rightarrow (\text{–RCOO})CuOH + H^+ \quad (5)$$

(where –R represents the matrix of the *Leucaena leucocephala* pods). In addition, the HCl was used to adjust the solution pH value.

The Cl^- added may result in a decrease of the free Cu^{2+} species and an increase in the formation of complex $CuCl^+$. This chloro-complex has larger molecular size than the free Cu^{2+} and is adverse to the bio-sorption, leading to a decrease in copper uptake (Yao, Qi, & Wang, 2010).

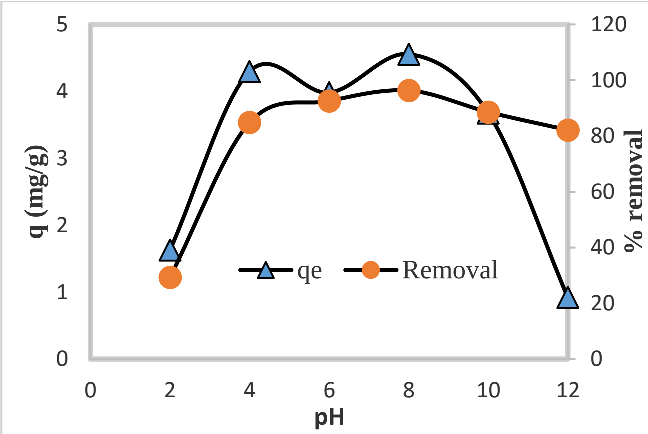

Fig. 6. Effect of pH on adsorption capacity and percentage adsorption on *Leuceana leucocephala* pods: $C_0 = 50$ ppm, temperature = 25 °C

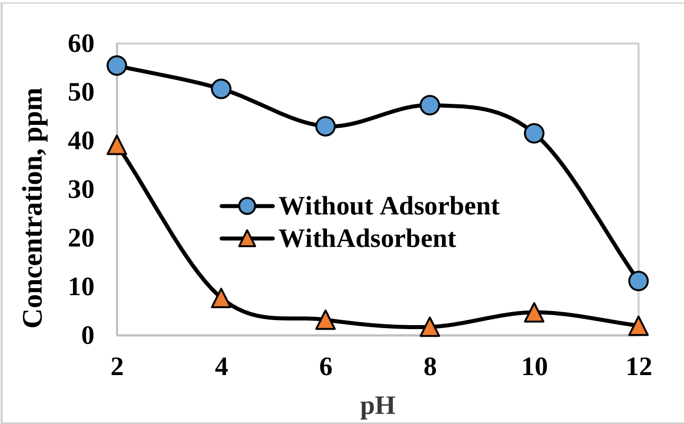

Fig 7. Effect of pH on the removal of Cu^{2+} with adsorbent and without adsorbent. $C_0 = 50$ ppm, temperature = 25 °C, particle size 400 µm, contact time = 24 h, dosage = 0.25g

C. Effect of contact time

The contact time parameter for the adsorption of copper metal (II) on *Leucaena leucocephala* powder was investigated from 10 to 180 min. According to the Fig. 8 shown below, the contact times at 140 min almost to be stable and constant. Meanwhile, from the 100 – 120 min of contact time, there is an excessive number of active sites on the surface of adsorbent that represent the highest percentage in adsorption of copper metal. Thus, the copper metal removal capability of

Leucaena leucocephala pods increased within the contact time. This leads the accumulation of heavy metal in the pore of active sites and begin offering resistance to diffusion of accumulated copper metals ions in the adsorbents.

The higher rate of metal removal from *Leucaena leucocephala* for adsorption process causing a surface area on *Leucaena leucocephala* pods becomes larger thus, the rate of adsorption also increases. It may because of the pore diffusion of copper metal on the adsorbent bulk (Lucy Semerjian, 2018). According to the (Al-Senani & Al-Fawzan, 2018), the equilibrium process of using modified banana peels at 300 minutes, therefore, the adsorption process using the *Leucaena luecocephala* pods was efficient since it need just a 140 minutes to reach equilibrium state.

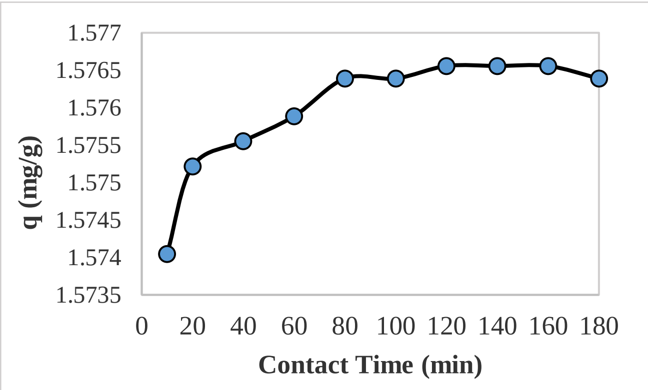

Fig. 8. Effect of time on the bio-sorption of Cu (II) by LLP: C_0 = 50 ppm, particle size 400 µm, contact time = 180 min, temperature = 25ºC, pH = 8 for Cu (II)

D. *Effect of sorbent dosage*

The sorbent dosage is varies from 0.5 g to 1.0 g by keeping the same value of initial metal concentration which is 50 mg/L, at room temperature (25ºC), contact time (24 hours), and pH (pH 8) for the sorption of copper metal on sorbent pods. The equilibrium adsorption, q decrease when the dosage of adsorbent rises from 0.05g up to 0.5g in 250 mL of test solution and became constant from 0.5g to 1.0g.

The effect of adsorbent dosage in percentage adsorption and equilibrium uptake is shown. The best condition for adsorbent dosage shown in Fig. 9 is 0.75 g because there is more accessibility of binding sites on the adsorbent surface for a complexation of copper metal ions. Significant improvement in adsorption will not happen if there is a further increase in adsorbent dosage. This is because the binding of almost all ions to the sorbent and the establishment of equilibrium between the ions bound to the sorbent and those remaining are not adsorbed in the solution. However, a reverse trend to the percentage adsorptions has been depicted by copper uptakes. The rise in adsorbent dosage from 0.05 to 0.25g caused in a decrease from 95% to 84% in adsorption of copper (II) ions. There are many factors that can contribute to this adsorbent concentration effect. The most essential factor is that adsorption sites remain unsaturated during the adsorption reaction. This is because of the fact that as the dosage of adsorbent is increased, there is less commensurate increase in adsorption resulting from the lower adsorptive capacity consumption of the adsorbent. The second cause may be the agglomeration of sorbent particles at higher concentrations, which would cause a decrease in the surface area and an increase in the diffusional path length. The particle interaction at higher adsorbent concentration may also help to desorb some of the loosely bound metal ions from the sorbent surface. As a result, the removal of a given amount of solute can be accomplished with greater economy of adsorbent (Özer, Özer, & Özer, 2004).

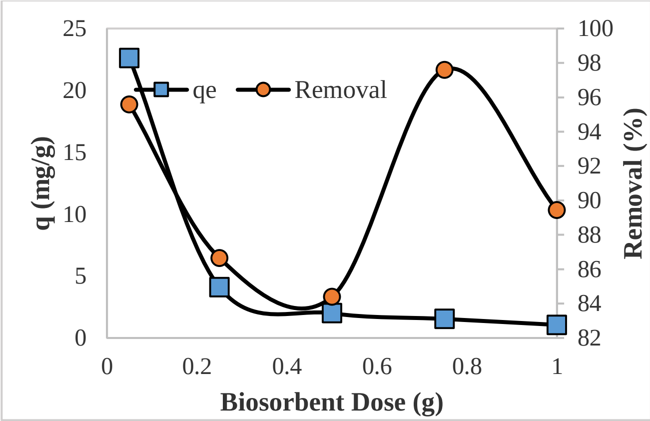

Fig. 9. Effect of bio-sorbent dosage on the bio-sorption of Cu (II) by LLP: C_0 = 50 ppm, particle size 400 µm, contact time = 4 h, temperature = 25ºC, pH = 8 for Cu (II)

IV. Conclusion

The effectiveness of the *Leucaena leucocephala* pods as a promising adsorbent is proven as the Cu (II) are removed. Based on the results obtained, Cu (II) is depending on the adsorbent dosage, contact time and pH.

From the batch studies it was found that 0.75 g *Leucaena leucocephala* pods adsorbent has shown the maximum removal in removing lead ion which is 97.6 % compared to other adsorbent's type and dosage. The best optimum condition for this adsorbent to remove copper (II) ion from solution is at pH 8 with 0.75g of dosage and reached equilibrium at 140 minutes. From this present study, it can be concluded that *Leucaena leucocephala* pods have a potential to remove the copper (II) ion in aqueous solution.

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