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Removal of copper (Cu^{2+}) ions from aqueous solutions by adsorption on activated macadamia carbon using H_3PO_4 activating agent

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ABSTRACT

The study aims to investigate the possibility of processing copper metal (Cu^{2+}) with activated carbon prepared from macadamia shell. Activated carbon is prepared from Macadamia shell by chemical agent H_3PO_4 with coke ratio: H_3PO_4 = 1:1, optimal temperature condition is 500^0C and burning time is 60 minutes. Using the assumed Cu^{2+} metal treats materials in the laboratory with a concentration of 30ppm. The research to result ability material adsorbed Cu^{2+} metal achieve good performance 95.92% handle, corresponding to the concentration of Cu^{2+} reduced from 30 mg/l to 1.2mg/l in optimal conditions is pH = 4.5 , dosage 1.8g/l, time 30 minutes. The results showed that activated carbon prepared from macadamia husk with chemical agent H_3PO_4 was capable of treating copper metal in wastewater.

Keywords: *activated carbon, adsorbed Cu^{2+}, H_3PO_4 , copper, Macadamia*

1. Introduction

In 1857, botanists discovered macadamia trees in the 25-31°C South latitude of Australia (Nguyen Cong Tan, 2009). In Vietnam, macadamia trees are grown long from

Ba Vi (Hanoi) to Tay Nguyen. It is estimated that by 2020, the area used to grow Macadamia will reach 10.000ha (Ministry of Agriculture and Rural Development, 2015). Each ton of Macadamia has 70-77% of the shell residue, Macadamia shells can be burned at very high temperatures to produce activated carbon or directly used as charcoal. Macadamia shells are known to have a higher surface area than other seed pods and their ash content is very low (less than 1%) (Georgiou et al., 2003). The main components of macadamia nut powder are cellulose (41.2%), which can be denatured to become activated carbon (Rakesh Kumar et al., 2013).

The composition of the elements in activated carbon is usually 88% C, 0.5% H, 0.5% N, 1% S, 6-7% O, (Tran Thi Xuan Mai, 2013). Activated carbon usually has a surface area of about 800 to 1500 in m^2/g and a porous volume from 0.2 to 0.6cm^3/g. The area of activated carbon surface is mainly due to small holes with radius smaller than 2nm (Tran Thi Xuan Mai, 2013). Therefore, they are used for purification, decontamination, deodorization, chlorination, separation and concentration to allow restoration and filtration, removal or modification of harmful components from gases and liquid solutions (Tran Thi Phuong, 2012). Activated carbon is made when burning raw materials to produce carbon (Nguyen Van Son, 2010), low cost and high available materials, so there have been many researches both at home and abroad about making activated carbon from many other sources of raw materials such as: Bagasse (Sibel Tunali Akar et al., 2012), coconut, rice husk (Ningchuan Feng et al., 2011), tea residue (Hefne et al., 2008), banana peel and orange (Shahidul. Islam & Masaru Tanak, 2004), rice husk (Jing-Xiu Han & Yu Du, 2009),...

Copper is an important non-ferrous metal for industry, agriculture and engineering (Tran Thi Phuong, 2012), however, when copper content exceeds the need to enter the human body, they become toxic. With copper concentration in drinking water of about 3 mg/L has been able to cause effects on the body such as inflammation and swelling of the esophagus tube, urinary retention, acute irritation to the stomach, vomiting, convulsive nerves, pulse weak...

2. Research methodology

2.1. Means of research

Research subjects: Copper solution (Cu^{2+}) ($CuSO_4.5H_2O$ 98% China).

Research chemicals: NaOH (China, 96%), HCl (1N), H_3PO_4 (85%, China).

Research material: Macadamia activated carbon from macadamia nut shell harvested in Lam Dong province (Doan Nguyen Hoang Anh et al., 2018).

2.2. Arrangement of experiments

Experiment 1: According to Mustafa Imamoglu & Oktay Tekir (2008), Badruddoza et al., (2011), Smia Ben-Ali et al., (2017), Surveying pH: 2.5, 3, 3.5, 4, 4.5, 5, 5.5. Concentration 30ppm, volume 25ml, fixed dose 0.3g/l, fixation time 60 minutes.

Experiment 2: According to Mustafa Imamoglu & Oktay Tekir (2008), Badruddoza et al., (2011), Smia Ben-Ali et al., (2017), Dosage survey: 0.2, 0.4, 0.6, 0.8, 1, 1.2, 1.4, 1.6, 1.8, 2g/l. 30ppm concentration, optimal pH, fixation time of 60 minutes.

Experiment 3: According to Mustafa Imamoglu & Oktay Tekir (2008), Badruddoza et al., (2011), Smia Ben-Ali et al., (2017), Surveying time: 0, 10, 20, 30, 40, 50, 60 minutes. 30ppm concentration, 25ml volume, optimal dosage, optimal pH.

2.3 Evaluation methodology

- Determination of pH is directly measured by Mettler Toledo pH meter (2017). ISO 10526: 2008 quality of water
- Cu metal meter is used with AAS (atomic absorption spectrometer) according to atomic absorption spectrometry

3. Results and discussions

3.1. Investigate the appropriate pH for processing

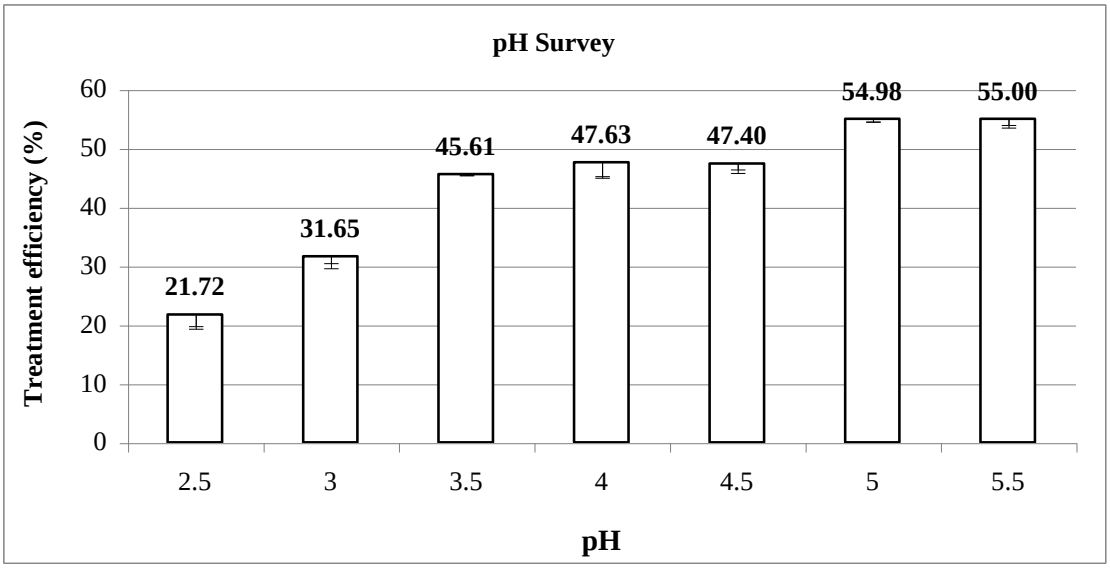

Figure 1. *Result of determining the effect of pH on copper metal performance of activated carbon Macadamia H_3PO_4*

The research results capable of processing metals At the material under Fig 1, shows that pH in the range 2.5 – 5.5 processor performance lowest at pH = 2.5 (21.72%) and the highest at pH = 5.5 (55%) , indicating that pH affects the copper metal adsorption process of the material. During the treatment process at pH = 5, the treatment efficiency is high (54.98%), when increasing pH = 5.5, the absorption capacity is saturated.

Research results show that activated carbon prepared from macadamia shell has the best ability to handle copper metal at pH = 5 with a treatment efficiency of 54.98 % lower than with some other studies such as: the research result of Onundi (2010) bagasse ash adsorption capacity for Copper metal at pH = 5, the treatment efficiency of bagasse ash reaches 97%. Research results of Lokendra Singh Thakur & Mukesh (2013) adsorption of tea residue to a solution containing copper metal at pH = 5 is 89% . However, additional factors must be examined dose and time to increase the ability to handle the copper metal in the solution of the material.

3.2. Investigate the appropriate dosage for the treatment process

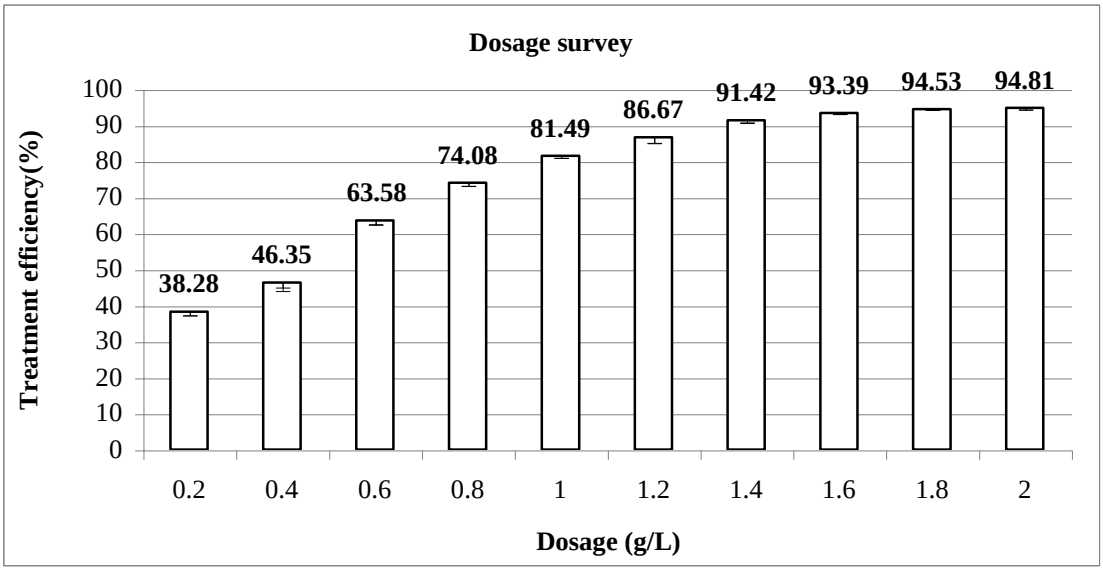

Figure 2. *Result of determining the effect of dosage on copper metal removal performance of activated carbon Macao H_3PO_4*

The research results capable of processing copper metals at the material at pH = 5 is expressed on Fig 2 shows, in the range of doses of 0.2, 0.4, 0.6, 0.8, 1, 1.2, 1.4, 1.6, 1.8, 2g/l has the following performance: 38.28%, 46.35%, 63.58%, 74.08%, 81.49%, 86.67%, 91.42%, 93.39%, 94.53%, 94.81%. During treatment at 1.8g/l, the treatment efficiency was high at 94.53% when increasing the dosage to 2g/l, the saturation adsorption capacity. The study shows that the optimal metal treatment dose is 1.8g/L with a processing efficiency of 94.53%.

The results of the adsorption of adsorbent is the macadamia activated carbon H_3PO_4 from macadamia shell, the results are lower than the study of Mustafa Imamoglu and Oktay Tekir (2008) using rice husk to remove Cu(II) and Pb(II) show that after 60 minutes, dosage 0.3g/25ml treatment efficiency is 97.2 - 99.6% higher than study of Nasernejsf et al., (2004) adsorption capacity of bagasse ash for Copper metals in doses of 2 g/l, the processor performance only reach 35%.

Metal treatment of coal is effective at pH = 5 and the dosage is 1.8g/l with a removal efficiency of 94.53%. For best results we need to handle additional survey processing time to have a good performance press the best performance.

3.3. Surveying the appropriate time for processing

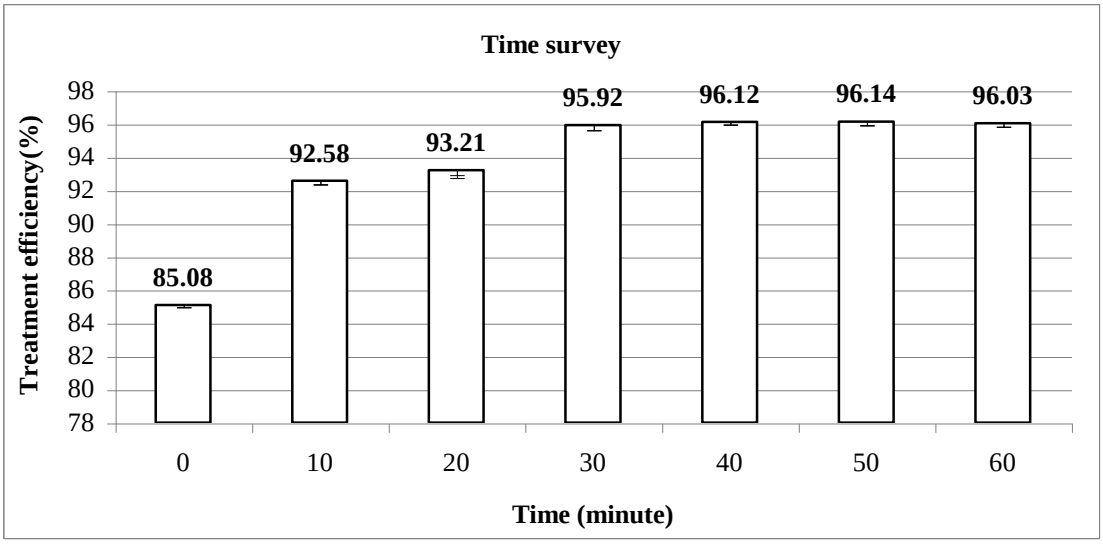

Figure 3. *Result of determining the effect of time on copper metal processing efficiency of activated carbon Macadamia H_3PO_4*

The research results processing capability of the material Copper metal at pH = 5, the dose of 1.8g/l is expressed on Fig 3 shows, in the interval of 0, 10, 20, 30, 40, 50, 60 minutes, the performance is as follows: 85.08%, 92.58%, 93.21%, 95.92%, 96.12%, 96.14%, 96.03%. During the 30-minute processing period, 95.92 % high processing efficiency increases the time to 40 and 50 minutes , the adsorption capacity is saturated and decreases at 60 minutes. The study showed that the optimal metal processing time is 30 minutes with 95.92% processing efficiency.

The research results have high processing efficiency, compared to the research of Nasernejsf et al., (2004) the ability of carrots to absorb copper metal only reaches 75% efficiency in 10 minutes and after 10 minutes the adsorption capacity is saturated, no Increased performance even further. Research of Mustafa Imamoglu and Oktay Tekir (2008) using witch hazel to remove Cu(II) efficiency is 87%.

Show that activated carbon Macadamia prepared from macadamia shell by chemical agent H_3PO_4 has the best ability to handle Copper metal at pH = 5, dosage 1.8g/l and time handle 30 minutes to reach the processor performance is 95.92% is assumed in laboratory with 30ppm concentration.

4. Conclusion

The results of the study show that the bioactive coal material successfully processed from agricultural waste is macadamia shell by chemical method using H_3PO_4 chemical agent with the maximum activation conditions such as a temperature of 500°C for 60 minutes.

The results of determining the three factors that affect the performance show that at pH = 5, the dose of 1.8g/l, within 30 minutes, can treat the efficiency up to 95.92% for copper metal contaminated water 30mg/L concentration.

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