The effect of temperature on cr (vi) removal by using guava leaves as a biosorbent

Mariana and Farid Mulana

Chemical Engineering Department, Faculty Of Engineering, Syiah Kuala University, Banda Aceh 23111, Indonesia
Coorresponding Author: mariana_hasyim@yahoo.com

Abstract. Preliminary research on Cr(IV) removal in a liquid waste using guava leaves (Psidium Guajava) as a bio-sorbent has been done. The experiments were conducted in a stirred batch reactor. The effect of temperature on efficiency and absorption capacity has been studied. Both the efficiency and absorption capacity are directly proportional to the temperature under the current experimental conditions. The results showed that optimum absorption capacity and absorption efficiency of Cr(VI) use of guava leaves obtained at stirring time 30 minutes.
Key words: sorption, bio-sorbent, Cr(VI) removal.

Introduction

Nowadays, industrial activity in the world has grown very fast. In addition to induces positive impacts, the growth of industry also generates a new problem for the environment and so we need to search an effective and efficient handling ways of negative impacts such as waste. One example of pollutions due to industrial wastes is a pollution caused by waste containing in dissolved heavy metals. Waste with a high content of heavy metals could be dangerous pollutants. One of heavy metals that are harmful is chromium. Chromium contained in waste usually has a valence of three ($Cr^{3+)}$ and valence of six ($Cr6^{+}$). Heavy metals such as chromium waste derived from metal plating industry (electroplating), paints/pigments industry and leather tanning industries. Cr waste (VI) is concerned because of its carcinogenic properties. Interestingly, only Cr(VI) which are carcinogenic, while Cr (III) is not (Mariana, et al, 2006). The toxicity level of Cr (III) is only about 1/100 times that of Cr (VI). Some of handling methods of Cr (VI) waste has been conducted through chemical reduction and ion exchange (Slamet et al. 2003).

In general, the methods used for handling of Cr (VI) waste require high cost and long process. There are other alternatives for removal of chromium from industrial waste by adsorption method using biomaterials. This method is a very promising method for treating industrial waste, mainly because it is cheap and has a high absorption capacity. Some examples of research that has been done by using biomaterials as bio-sorbent to absorb Cr (III) by using seaweed (Sudiarta, 2009), the utilization of peanut shell as a bio-sorbent for reactive dye of Cibacron Red (Aprilia S, 2009), absorption of copper ions using chitosan from crab shell (Maya et al, 2010).

Sutrasno et al. (2008) had previously conducted research by using guava bark to absorb metal ions Cr (VI). The results showed that guava bark had a chromium ion adsorption by more than 90 % at pH = 2. This research uses guava leaves as a bio-sorbent. Leaves are a porous parts of the plant, so it can be used as an adsorbent. Besides guava leaves contain tannins. Tannins can be found in almost all types of green plants both higher plants and lower plants with levels and different qualities. Tannins are polyphenolic compounds that can bind heavy metals and tannin can also absorb pathogenic bacteria so that can cure diarrhea. Beside guava leaves is a porous material, the principle of absorption by tannins underlying the use of guava leaves as a biosorbent in the absorption of heavy metals from wastewater.

Tannin is a natural polyphenolic compound and an important part of plant secondary elements, soluble in water with a molecular weight of 500-3000 g/mol and able to bind alkaloids, gelatin and protein (Wiryawan, 1999). Tannin content in guava leaves as many as 9-12 % (www.litbang.deptan.go.id).

Considering of Cr (VI) metal ions was produced a lot by industry in Indonesia, then this biomaterials has a potential to be developed as a bio-sorbent by utilizing waste of guava leaves and also very environmental friendly. Adsorption of chromium metal ions of Cr (VI) using these biomaterials have greater power adsorption compared with adsorption methods that have been developed previously (Subiarto, 2000). In addition the use of bio-sorbent can also add value to guava leaves that have not been used optimally.This research aims is to study the metal ion adsorption capacity of Cr (VI) by biomaterial of guava leaves at various of contact temperature.

Materials and Methods

Preparation of necessary materials include materials procurement such as: (1) guava leaves, (2) distilled water, and (3) a solution of $K_2Cr_2O_7$ as the source of Cr (VI). While the prepared equipment include: (1) erlemenyer, (2) volume pipette, (3) aluminum foil, (4) separating funnel, (5) measuring cup, (6) magnetic stirrer/water batch; (7) Atomic Absorption Spectrophotometer (AAS), (8) electric oven; (9) mixer; (10) balance; (11) filter paper, and (12) flask.

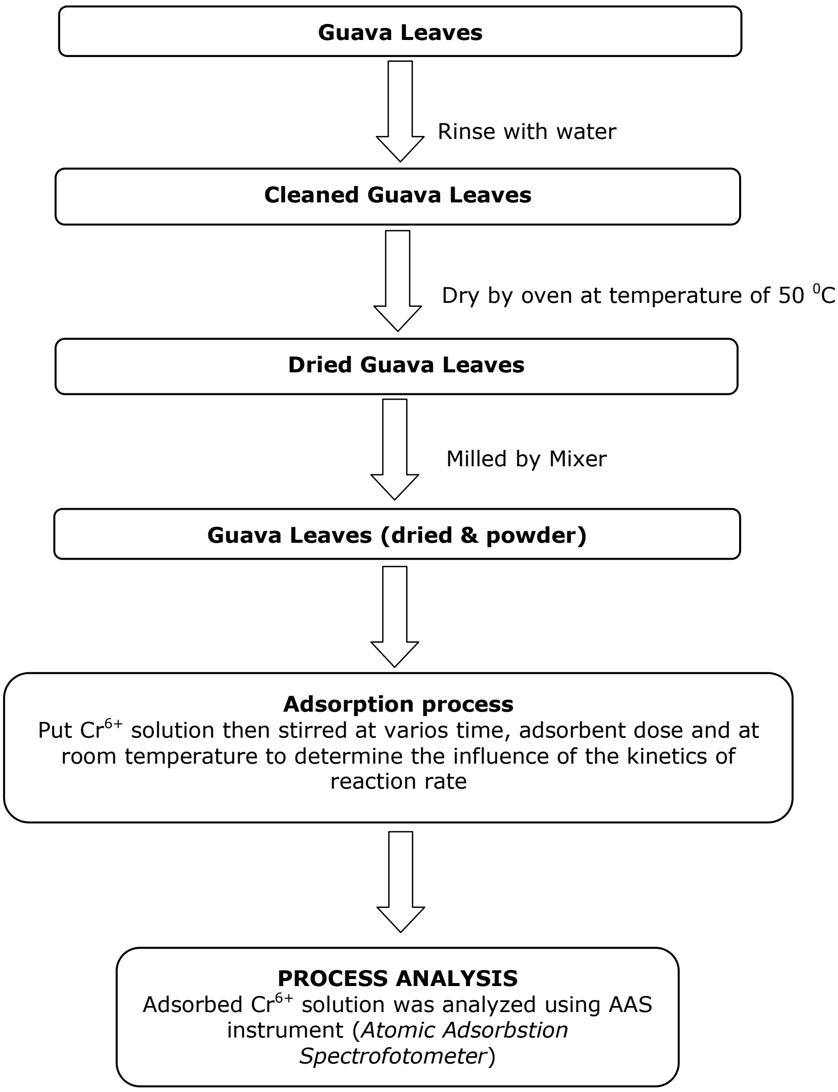


Figure 1 Scheme of Work Research

Initially, raw materials of guava leaves was cleaned from impurities/dirt by clean water. Then guava leaves was dried using oven dryer at temperature of 50°C until a constant weight obtained. Finally, raw material was refined by using mixer with size of more than 25 mesh to increase the surface area of biosorbent. Preparation of Cr (IV) solution with different concentration. $K_2Cr_2O_7$ was weighed at determined amount and dissolved with distilled water. Schematic of experimental procedure is presented in Figure 1.

Chrome samples was tested at different contact temperature. Sample of Cr (IV) with specified temperature was put in erlenmeyer containing adsorbent. Residence time for adsorption process was varied. The experimental conditions are presented in Table 1. The filtrate was filtered by filter paper and ready to be analyzed using atomic absorption spectrophotometer (AAS). Analysis of remaining Cr (IV) is performed by using AAS (Atomic Adsorption Spectrophotometer).

Table 1 Experimental Conditions

Parameters	Value
Initial Cr^{6+} concentration [mg/L]	10, 20, 50
Bio-sorbent dosage (gram)	1
Temperature [^oC]	35, 50
Contact time [min]	50 – 120
Precipitation time [min]	30

Results and Discussion

Effect of Temperature on Absorption Efficiency

To determine the effect of optimum contact time and temperature for the treatment of guava leaves biosorbent then the study was performed by varying contact time and temperature.

Figure 2 illustrates that the contact time and temperature is directly proportional to the absorption efficiency, as seen at a concentration of 10 mg/L with temperature of 35 ºC and contact time of 5, 10, 20, 30, 60 and 120 minutes with the absorption efficiency of 33.77; 36.69; 39.41; 40.32; 42.71 and 43.29%, respectively. At the same of adsorbate concentration and contact time, and temperature of 50 ºC, the absorption efficiency was obtained for 34.07; 38.25; 41.25; 44.91; 46.39 and 48.80%, respectively.

Based on the above figure it can be seen that at temperature of 50 ºC the higher absorption was obtained, it is likely to occur because the pore surface of guava leaves increase so that the metal ion was absorbed quickly. But biosorben that derived from guava leaves have shortcomings as mentioned by Sutrasno (2008) that guava leaves can not be soaked at temperatures higher than 50 ºC because it can damage the biosorben itself, so it can be concluded biosorben is working at optimum temperature of 50 ºC.

Effect of Temperature on Absorption Capacity

To determine the effect of time and temperature on the absorption capacity so that we can understand the optimum temperature at which the adsorption process takes place.

Figure 3 shows the relationship of temperature to absorption capacity of Cr (VI). At temperatures of 35 ºC and 50 ºC, the contact time of 120 minutes and concentration of 50 mg/L, absorption capacity was obtained as much as 1.5256 and 1.6752 mg/g, respectively. Based on these data it can be seen that the higher of applied temperature then the greater of absorption capacity. This is probably due to the empty pores exist in the adsorbent will get bigger. Therefore if it is used to absorb the adsorbate at the same temperature then absorption capacity become greater.

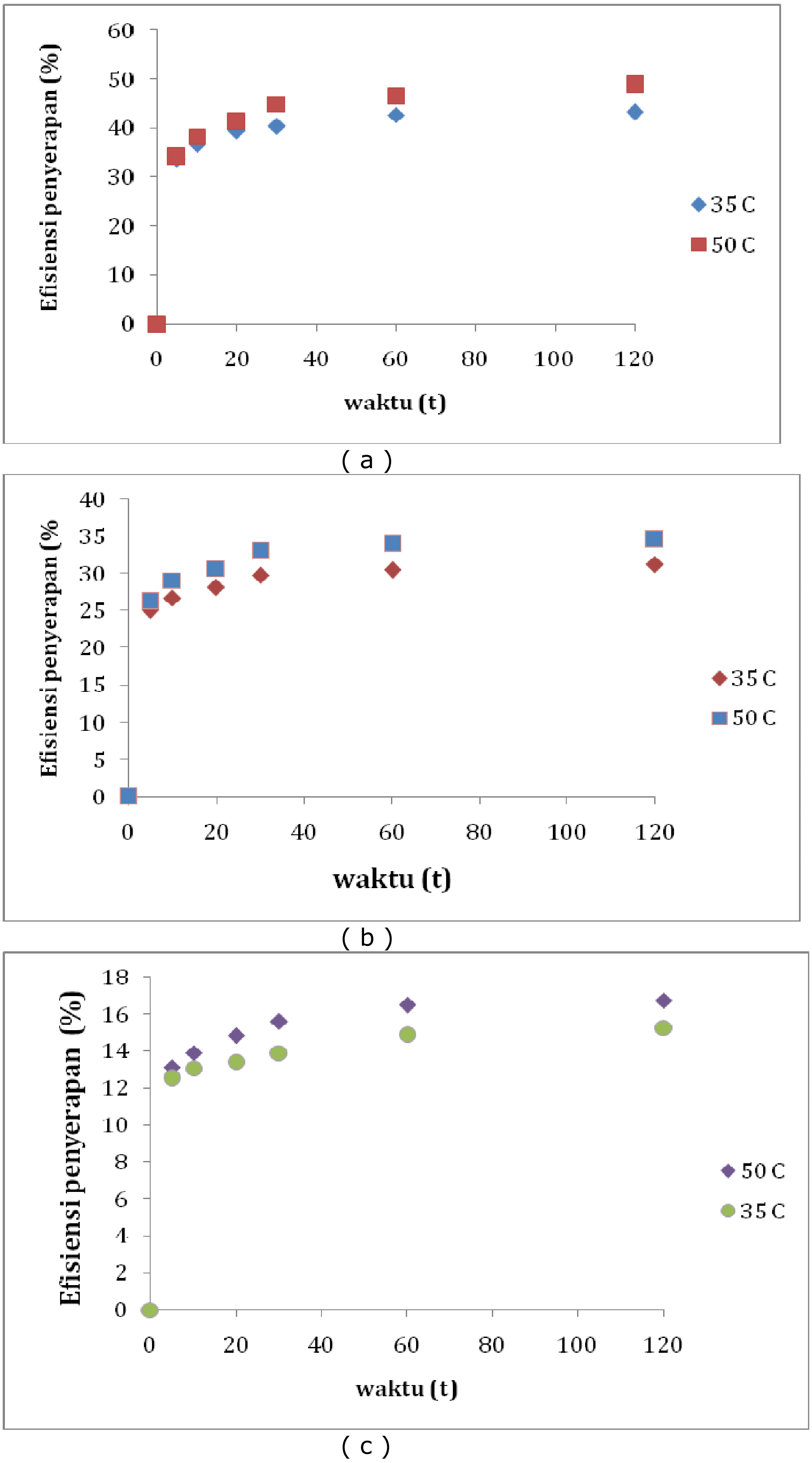
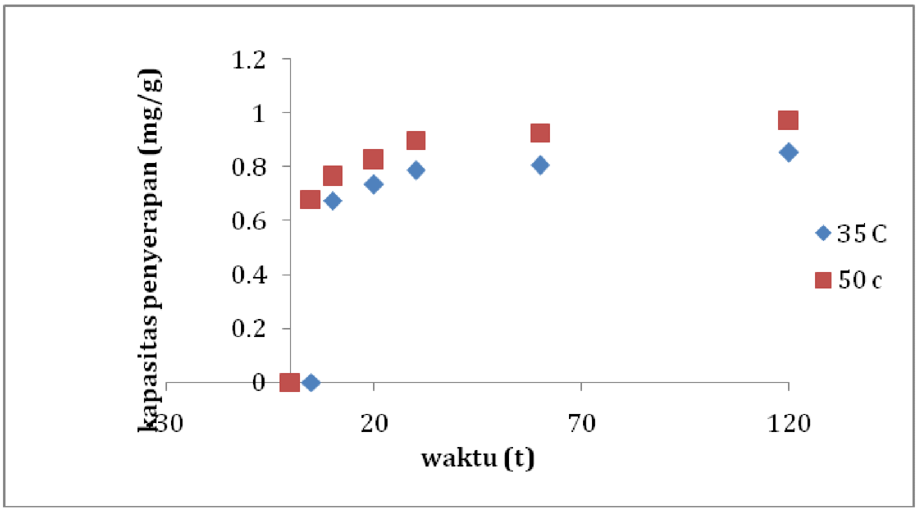
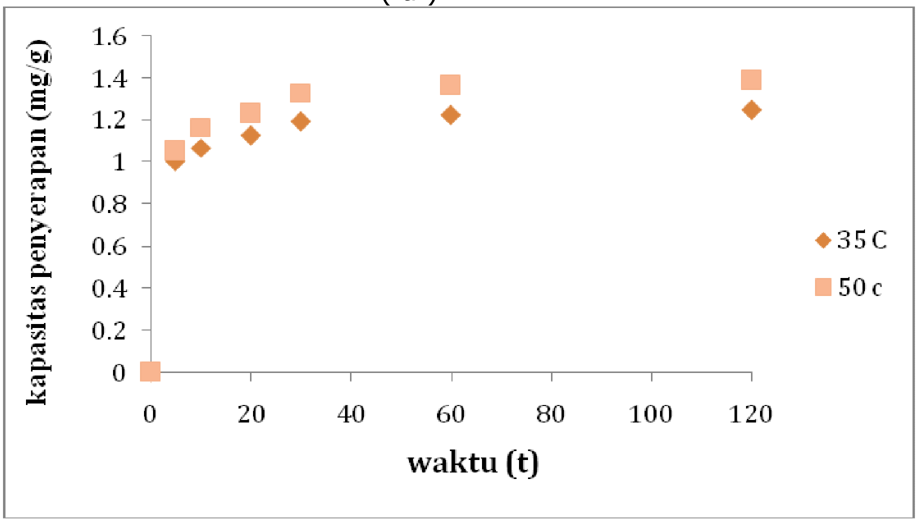


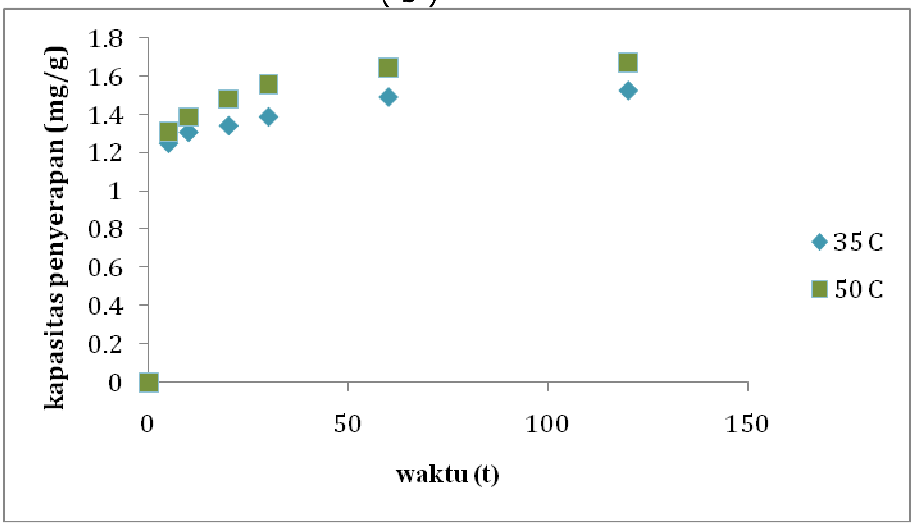
Figure 2 The effect of time and temperature on absorption efficiency of guava leaves at a concentration of (a) 10 mg/L, (b) 20 mg/L, (c) 50 mg/L.



(a)



(b)



(c)

Figure 3 The effect of time and temperature on absorption capacity of guava leaves at concentration of (a) 10 mg/L, (b) 20 mg/L, (c) 50 mg/L.

Conclusions

The optimum absorption process of Cr^{6+} metal with adsorbent dose of 1 g and contact time of 60 minutes was obtained at concentration of 50 mg/L and temperature of 50º C. The best absorption process of Cr (VI) metal ions using guava leaves was obtained on contact time for 30 minutes.

Acknowledgements

We would like to thank to the members of Chemical Engineering Lab Operations, Unsyiah. Special thanks to the Ministry of Education and Culture, in accordance with the Assignment Agreement in the Framework of Implementation of Fundamental Research Program for Fiscal Year of 2013 Number: 383UN11/A.01/APBN-P2T/2013 dated 29 April 2013.

References

Mariana, Sanada C., Hasegawa M., Maezawa A. and Uchida S. 2006. Cr(III) Removal from Aqueous Solution by Alkaline Solution. J. Chem. Eng. Japan., 39, 7:724-730.

Sudiarta, I.W. 2009. Biosorpsi Cr(III) Pada Rumput Laut Eucheuma Spinosum Teraktivasi Asam Sulfat. Jurusan Kimia FMIPA. Udayana University. Bukit Jimbaran. Bali. Indonesia

Ajeng T., Apsari and Dina F. Studi Kinetika Penyerapan Ion Khromium Dan Iom Tembaga Menggunakan Kitosan Produk Dari Cangkang Kepiting. Chemical Engineering Department, Diponegoro University. Semarang. Indonesia.

Aprilia and Susanti. 2009. Potensi Kulit Kacang Tanah sebagai Adsorben Zat Warna Reaktif Cibacron Red. Chemistry Department (FMIPA), Institute Agriculture Bogor. Indoensia

Sutrasno and Kartohardjono. 2008. Pemanfaatan Kulit Batang Jambu Biji (Psidium Guajava) Untuk Adsorpsi Cr(VI) Dari Larutan. Chemical Engineering Department. Indonesia University. Jakarta. Indonesia.

Nurhayati M. 2009. Adsorpsi Ion Logam Pb2+Dengan Menggunakan Kulit Batang Sukun (Artocarpus altilis). Chemical Engineering Deparment. Syiah Kuala University, Banda Aceh. Indoensia.

Muktamar Z. 2004. Adsorbsi dan Desorpsi Herbisida Paraquat oleh Bahan Organik Tanah. Juournal Akta Agrasia.7.1:11-17.

Soemargono. 2008. Kajian Penyerapan Logam Khrom dari Limbah Industri Elektroplating Menggunakan Resin Dowex SBR-P. Chemical Engineering Department. UPN. Jawa Timur. Indonesia