Modified tea bag biosorbent as Cr(VI) removal in batik wastewater

by Sri Lestari

Modified tea bag biosorbent as Cr(VI) removal in batik wastewater

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ABSTRACT

Batik wastewater contains heavy metals which are harmful to the environment. One of these metals is Cr (VI). Cr(VI) contents on batik wastewater has been removed by biosorption. Biosorption capacity depends on biosorbent type and surface area. Abundant, cheap, and easily available biosorbent are Straw and baglog waste. Modified tea bag can increase biosorben surface area. This research aims to obtain the optimum of biosorbent ratio and pH in Cr(VI) adsorption capacity. This experimental research was conducted using Spilt Plot Design. The obtained data were analyzed using F-test with the significane level of 5%. The result showed that the highest of Cr adsorbed was 0,0047 mg/g with efficiency decrease was 84,23% in the biosorbent ratio of 3:1 and pH 5. Modified tea bag biosorbent was effective to removal Cr in batik wastewater.

Keyword: batik wastewater, biosorbent, Cr(VI), modified tea bag

INTRODUCTION

Sokaraja Batik Center is one of small scale batik industries in Banyumas Regency. It is a common knowledge that small scale batik industries doesn't have Waste Water Treatment Plant (WWTP). So is the case with Sokaraja Batik Center. Sokaraja Batik Center disposes of wastewater directly into the Wangan River. Pollutant compounds in batik wastewater can pollute the Wangan River. One of heavy metal contains in batik wastewater is Cr(VI). Chromium concentration in the Wangan River has exceended the treshold concentration by goverment regulation no. 82 of 2001 i.e., 0,231 mgL^{-1}[1].

Chromium in batik wastewater is very dangerous for organisms in the Wangan River. Chromium can damage organs such as gills, liver, lungs and kidneys, causing death. Chromium in batik wastewater can remove by biosorption. Biosorption is the reduction of heavy metals through the adsorption process using dead or inactivated organisms[2]. Biosorption is greatly effective to heavy metals adsorption in wastewater due to the high adsorption rate, relatively simple, selective and cheap[3 - 5].-Biosorption can also degradate the dyes contained in batik wastewater.

As an alternative technology for wastewater treatment, biosorption must use biosorbent which is relatively cheap and has abundant availability. Straw and baglog waste fulfill these requirements. Straw and baglog waste contains lignin and cellulose which has an active group to bind chromium through ion exchange. Lignin and cellulose contain hydroxyl and carboxyl which can an efficient chromium ion exchanger[6]. Straw powder can reduce Pb in batik wastewater up to 50,35%[7]. *P. ostreatus* baglog waste can adsorp heavy metal and remove odor[8]

Biosorption capacity is highly dependent on surface area, contact time and biomass[9]. The high biosorbent surfaces area and biomass can increase the number of active sites available to bind chromium. So that it can increase the adsorption capacity. Adsorption capacity can be increased by by reducing biosorbent surface area. biosorbent form have been widely applied to adsorb heavy metals and in wastewater, such as immobilized silica gel [10], biomass size 1 cm[11], ash[12], pellet[13], powder[14]. All of biosorbent forms are effective but difficult to separate and causing sedimentation. Biosorbent in tea bag package easily separated from the wastewater but clotted [15]. Modified tea bag with press can reduce clumping when dipped in batik wastewater. Another factor that affects the adsorption capacity is pH. pH has an effect on ion shape changes available to bind chrome. For that reason, the objective of this study is to get the optimum ratio straw and baglog waste in modified tea bag and optimum pH to adsorb Cr(VI) batik waste water.

RESEARCH METHOD

Material and Method

This experimental research was conducted using Spilt Plot Design. The main plot was the mixture ratio of straw and baglog wastes and a subplot was pH. The proportion of straw and baglog wastes was made up of five levels (1:0; 3:1; 1:1; 1:3 and 0:1) while pH of five levels (5;6;7;8 and 9)

Biosorbent Production in Tea Bag

The weight of biosorbent was around 300 mg with the composition directly proportional to treatment. Biosorbent was wrapped in a tea bag paper with a size of 6 x 6 and made into small columns by pressing. After this, the biosorbent is packed in the tea bags and ready to use.

Batik Wastewater Preparation

The wastewater was obtained from the batik industrial center in Sokaraja Kulon Village, Sokaraja Subdistrict, Banyumas Regency, Central Java. The wastewater is considered as the final waste of staining and dyeing residual. The initial pH of waste set to 5; 6; 7; 8 and **9.**

Adsorption Experiments at Laboratory Scale

Erlenmeyer 250 mL provided about 45 pieces; each erlenmeyer filled 100 mL of batik wastewater. Each of the erlenmeyer was added to one packed biosorbent in the tea bag with the composition to the treatment. Erlenmeyer was covered with paraffin. It homogenized in the shaker incubator at a speed of 175 rpm at a temperature of 25^0C for 1 hour.

Adsorption Capacity of Chromium

Adsorption capacity is calculated using the formula below:

$$q=\frac{V\,(C_o-C_{eq})}{m}$$

q = Adsorption capacity (mgg^{-1})
V = volume of solution (L)
M = biosorbent weigth (g)
C_o = initial concentration (mgL^{-1})
C_{eq}= final concentration (mgL^{-1})

The Percentage of Decolorization

The percentage of decolorization was measured at each interval treatment with the aid of the spectrophotometric method. Five mL of batik wastewater was obtained before and after treatment and centrifuged at a speed of 5,000 rpm for 10 minutes. The obtained supernatant is then measured by its absorbance using a spectrophotometer at a wavelength of 645 nm. Decolorization ability is calculated with the formula below:

$$\% \, decolorization = \frac{\text{the initial absorbance} - \text{the final absorbance}}{\text{the initial absorbance}} x100\%$$

Analysis Method

The result obtained is in the chromium adsorption and decolorization as well as its capacity. The data is evaluated using an ANOVA test on 5% significant level to determine the effective treatment.

RESULT AND DISCUSSION

The data reveals that the Cr(VI) concentration of batik wastewater before and after biosorption are not the same. Cr(VI) adsorption capacity is influenced by the ratio of biosorbent mixer and pH. The highest Cr(VI) adsorption capacity was in straw and baglog waste ratio of 3:1 and pH 5 that is 0.0047 ± 0.003 mgg^{-1} (Fig. 1) with adsorption efficiency of 84..23%. The lowest Cr adsorption capacity in ratio 0f 3:1 with pH 9 is 0.0026± 0.001 mgg-1 (Fig 1.) with adsorption efficiency of 66.04%

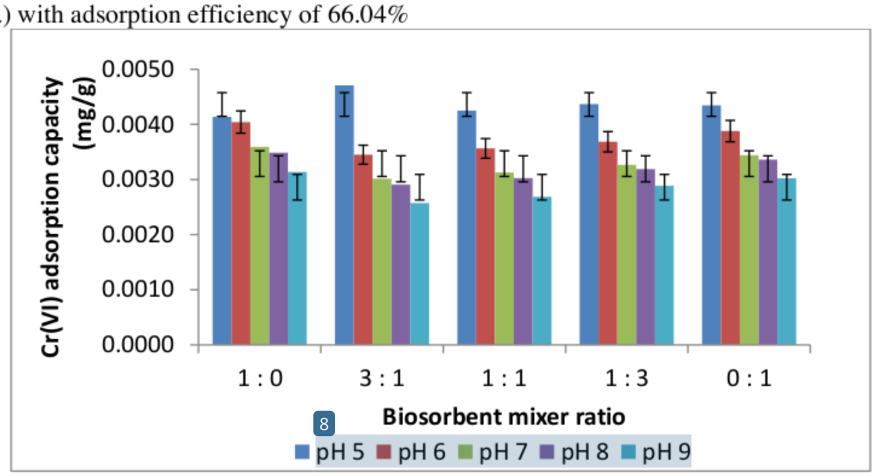

Fig1. Adsorption capacity of chromium by straw and waste *baglog* mixer in the modified tea bag

According to Fig. 1, Cr(VI) adsorption capacity in all composition ratios of the biosorbent is reduced from pH of 5 to 9. It demonstrates that the optimal conditions of adsorption are at acidic pH. Metal adsorption has increased along with the reducing pH value but has decreased after passing the optimum at pH 6.53[15]. Straw and baglog waste have some lignin with hydroxyl and carboxyl. These functional groups affect adsorption capacity. The adsorption capacity *S. cinereum* and *P. ostreatus* baglog waste in the tea bag with the ratio of 3:1 is 0.0042±0,0005 mgg^{-1}[16]. It shows that the packaging of tea bag modified by pressing is higher in adsorping Cr since it provides more active sites.

Biosorption process is one of the mechanisms for the removal of heavy metal ions passively[17]. The process successfully occurs when heavy metal ions bind to the cell wall in two different ways. They are (1) complex formation between heavy metal ion with functional formations such as carbonyl, amino, hydroxyl, phosphate, and hydroxyl-carboxyl located on the cell wall and (2) ion exchange in which monovalent and divalent ions such as Na, Mg and Ca in the cell wall replaced by heavy metal ion The active process coincides in line with the metal ion consumption and intracellular accumulation of metal ion. The presence of Cr(VI) reductase is the key in enzymatic pathway. It reduce Cr(VI) to Cr(III) as soluble and membrane-bound enzyme. There are at least two steps in enzymatic Cr(VI) reduction. Firstly Cr(VI) accepted one NADH molecule forming Cr(V) as intermediate and will receive two more electrons from the same coenzyme forming Cr(III).

According to analysis variance, the ratio of the biosorbent mixer and the interaction of the biosorbent and pH showed is not significant to adsorb chromium. However, pH significantly affects absorb chromium. It shows that the adsorption process of chromium is not affected by the mixer ratio but by the pH. The ratio of biosorbent mixer and pH based on LSD test (Table 1), pH 5 and pH 9 have a different effect on Cr(VI) adsorption capacity than on other treatment.

Table 1. LSD value of pH to Cr adsorption capacity

pH	Cr adsorptin capacity (mgg^{-1})
5	0,0687a
6	0,0521b
7	0,0502b
8	0,0500b
9	0,0463c

Note: numbers followed by the same letter doesn't different based on LSD at 95% confidence level

The adsorption difference is under the influence of compound concentration in biosorbent. Straw and baglog waste have known potential as adsorption material. This is because they have some lignin content. Lignin has –OH and –COOH as its active binding site. Baglog waste also has cellulose as well as hemicellulose [18 - 19] which provide a more binding site.

CONCLUSION

The optimum ratio straw and baglog waste in the modified tea bag to adsorp Cr(VI) in batik wastewater was 3: 1 and pH 5. The respective biosorbent modified tea bag was proven to be more effective than tea bag package to removal Cr(VI) in batik wastewater.

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