Application of Electrocoagulation Methods to Reduce BOD and COD Content in The Soft Drink Industry's Wastewater with Addition Bittern

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Abstract. Wastewater from the soft drink industry must be treated before release to reservoir. One of many treatments of wastewater is electrocoagulation method. Five litres of wastewater was agitated using a magnetic stirrer with the addition of bitterns in a tank electrochemical device. It was started by 100 rpm of agitation for 3 minutes and then the agitation was decreased to 50 rpm for the certain time. The filtrate was separated and analysed Chemical Oxygen Demand (COD) and BOD. Percent of COD removal tends to increase with the length of the electrocoagulation process and vice versa for BOD. Different things occur in percent COD and BOD removal, where the best percent removal is obtained at 0.5% bitter addition. The highest percentage of COD removal reached 98.31% at 6 hours and the highest percent of BOD removal reached 95.00% within 2 hours.

1. Introduction

Wastewater is one of the problems in the industry. Wastewater must be treated before released to water bodies, waterways, reservoir, or rivers so that this wastewater does not contaminate the environment. In this case, the methodology of wastewater treatment must be able to minimize contaminant in wastewater, even in the soft drink industry. The wastewater of the soft drink industry with all of the flavour contains organic compound about 500-3000 mg/l [1], [2]. Technologies used to treat it are plasma technology to reduce BOD, COD, TSS, and color contents [3], [4], using chitosan as a coagulant to reduce BOD, COD, and TSS contents [5] or microbiologically using the aerobic system uses activated sludge [1], using the aerobic system an oxidation ditch [2], aerobic and anaerobic systems [6].

Another method that may be able to treat wastewater of the soft drink industry is electrocoagulation. This method is a simple and efficient method for wastewater treatment [7]. The principle used is electrochemistry, mainly electrolysis, that it use electrical energy to degrade and coagulate compounds in wastewater in a present of anode-cathode. The electrocoagulation can remove or reduce organic and inorganic contaminant from wastewater. Implementation of this method were to remove fluoride from aqueous solutions [8], to reduce organics for washing wastewater reclamation [9], to reduce Chemical Oxygen Demand (COD) levels from baker's yeast wastewater [10], to remove heavy metal in industrial water [11], to remove sulphate and other anionic materials from brackish well water [12], to treat wastewater from textile industry [13]–[15], to treat domestic wastewater [16], to treat wastewater for slaughterhouses [17], and to treat wastewater for skin tanning industry [18].
Besides electrocoagulation method, there are materials as a coagulant, one of them is bittern. The bittern is a by-product of the production of salts, namely ‘air tua’. The major content of the bittern is magnesium, which is MgSO₄ and MgCl₂. Other compounds are NaCl and KCl [19]. Bittern has the ability to coagulate substances in liquid waste both inorganic and organic. Implementation of the bittern as coagulant has been applied to wastewater treatment of fish flour industry [20]. It was used to reduce TSS levels in paper industry wastewater [21], reducing levels of TSS, COD, and BOD in fish processing wastewater [22].

This research will be conducted by the combination of electrocoagulation and addition of coagulant bittern which be applied to wastewater treatment of the soft drink industry where it is not done yet. The combination of this method is expected to maximize the removal percentage of contaminants in wastewater result in the soft drink industry.

2. Materials and Methods

2.1. Materials

This research, wastewater used was obtained from the soft drink industry in East Java, Indonesia, and bittern from Garam Indonesia Company. The materials could be used without further processing. For electrode, material used is iron as anode and aluminium as a cathode.

2.2. Procedure

Implementation of this research is begun by agitation of 5 litres of wastewater using a magnetic stirrer and be added some of the bittern in the mixture according to a certain concentration in a tank electrochemical device. It was started by 100 rpm of agitation for 3 minutes and then the agitation was decreased to 50 rpm for the certain time. The filtrate was separated and analysed COD and BOD. COD and BOD removal percentage were calculated by the following equation.

\[
\text{COD Removal percentage (%) = } \frac{(\text{COD}_{\text{initial}} - \text{COD}_{\text{final}})}{\text{COD}_{\text{initial}}} \times 100\% \\
\text{BOD Removal percentage (%) = } \frac{(\text{BOD}_{\text{initial}} - \text{BOD}_{\text{final}})}{\text{BOD}_{\text{initial}}} \times 100\% 
\]

3. Result And Discussion

Wastewater used was obtained from the soft drink industry in East Java, Indonesia, which taken for five times. Each of sampling is analysed to obtain COD and BOD contents. Analysis result can be shown in Table 1.

The first step, wastewater is electro-coagulated with and without the addition of bittern. The result can be seen in Figure 2. Physically, the image shows that the electrocoagulation process with the addition of bittern gives better results compared to the electrocoagulation process without the addition
of bitterns carried out at a certain same time. This result becomes the basis to establish where the research is conducted by adding bittern to get good results.

Table 1. The Analysis result of wastewater from the soft drink industry

| Sample | COD (mg/L) | BOD (mg/L) |
|--------|------------|------------|
| Sample 1 | 4,941.15 | 2,800.00 |
| Sample 2 | 6,176.44 | 3,000.00 |
| Sample 3 | 5,173.00 | 3,000.00 |
| Sample 4 | 4,506.53 | 2,500.00 |
| Sample 5 | 4,403.59 | 2,300.00 |

Figure 2. The image of The first step of this research (a) Without Bittern (b) With Bittern

In this research, electrodes used are iron as anodes and aluminium as cathodes. The reaction occurs at the anode follows equation (3) and then oxygen oxidize Fe\(^{2+}\) to Fe\(^{3+}\) as in equation (4) [23].

\[
\text{Fe(s)} \rightarrow \text{Fe}^{2+} + 2\text{e}^- \quad (3)
\]

\[
4\text{Fe}^{2+} + 4\text{H}^+ + \text{O}_2(\text{g}) \rightarrow 4\text{Fe}^{3+} + 2\text{H}_2\text{O} \quad (4)
\]

While aluminium is used as a cathode, the reaction follows equation (5) [23].

\[
2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{H}_2(\text{g}) + 2\text{OH}^- \quad (5)
\]

Total reaction on anode-cathode become equation (6)

\[
4\text{Fe(s)} + 10\text{H}_2\text{O(1)} + \text{O}_2(\text{g}) \rightarrow 4\text{Fe(OH)}_3(\text{s}) + 4\text{H}_2(\text{g}) \quad (6)
\]

Fe(OH)\(_3\) is a negative electrically charged particle that can tend to form colloids [7], [24], which causes coagulation in the sample solution, in this case, wastewater from the soft drink industry. The contaminants contained in the wastewater are coagulated by Fe(OH)\(_3\) so that BOD and COD content in filtrate becomes smaller than wastewater. It can be seen in Figure 3 and Figure 4.

Figure 3 shows that COD removal percentage tends to increase with the increasing of electrocoagulation time. Maximum COD removal percentage achieves 98.31% at 0.50 % of bittern concentration and 6 hours electrocoagulation. Figure 4 shows that BOD removal percentage tends to decrease with the increasing of electrocoagulation time. The maximum BOD removal percentage achieves 95.00% at 0.50 % of bittern concentration and 2 hours electrocoagulation.

Both images show that the addition of 0.5% bittern shows the best COD and BOD removal percentages compared to other. This shows that COD and BOD removal percentage decrease with increasing of bittern addition. This is due to the bittern which mostly contains magnesium, which should be able to react to the base, the result of reaction on a node, cannot be deposited. Nevertheless, the solubility of magnesium is greater than iron (III) [24] so that much magnesium and other contaminants cannot be deposited so that decreasing of COD and BOD content cannot be maximized.
4. Conclusions
Percent of COD removal tends to increase with the length of the electrocoagulation process and vice versa for BOD. Different things occur in percent COD and BOD removal, where the best percent removal is obtained at 0.5% bitter addition. The highest percentage of COD removal reached 98.31% at 6 hours and the highest percent of BOD removal reached 95.00% within 2 hours.

5. References
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