Treatment of textile industry wastewater by electrocoagulation technology

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Abstract. Experiments were carried out by treating the waste samples with electrocoagulation technology. This is done to determine the effectiveness of the removal of the electrocoagulation device against textile waste. The sample used is a synthetic sample with a concentration of 1091 mg/L Pt-Co units. The research was conducted twice with the first experiment being conducted to determine the most effective electrical voltage to remove the existing COD and color pollutants while the second experiment was conducted to determine the type of anode and cathode that was most effective in removing COD, Color, and heavy metal pollutants. In the first experiment, it was found that the electric voltage that could produce the best removal was 4 amperes and in the second experiment, the anode-cathode type with the highest % removal was Fe-Fe with % COD removal of 64.09639% and % color removal of 60.00619%. It was concluded that electrocoagulation method could effectively remove color and COD in waste water.

1. Introduction

The growth development of the industry causes the needs of life to increase. Clothing is one of the most important needs for everyone. Fabric, which is the main ingredient of making clothes, must go through a long series of processes to become a ready-to-use cloth. Textile industry waste generally uses synthetic dyes on the grounds that they are cheap, durable, easy to obtain and easy to use. But the waste produced is still colored and difficult to degrade. Most of these industries are textile industries which generally do not have a good enough waste treatment. Wastewater originating from the household textile industry is an organic compound dye which, if flowed into water bodies, will reduce dissolved oxygen levels for aquatic organisms.

If this liquid waste is disposed of without prior treatment, it will be difficult to avoid pollution, especially pollution in water areas because the liquid waste still contains a lot of dyes and dyes supporting the dyeing process. These dyes can interfere with aesthetics and the process of penetration into water bodies. Based on this, more attention is needed on the waste generated from industrial activities, especially liquid waste. Liquid waste not only has an impact on environmental pollution, but also has an impact on living things such as humans. Wastewater treatment is one way to overcome environmental pollution problems and innovations can be made to become a means of meeting the need for water.

There are various technologies for wastewater treatment, both biologically, chemically, physically, or a combination of several technologies. One of the wastewater treatment technologies that can be used is the combination method between adsorption and electrochemical technology. The adsorption method
is a process when a fluid, liquid or gas is bound to an adsorbent and forms a thin layer or film on its surface. While electrochemistry is an oxidation-reduction reaction in an electrochemical cell system. Electrochemical and adsorption technology is the right combination because it does not require chemicals in the process.

This research will determine the efficiency of synthetic waste pollutant removal. To overcome the problem of pollution caused by activities in the textile industry, wastewater treatment is carried out using a combination of adsorption and electrochemical methods whose effectiveness is not yet known. In addition, the reuse of water from industrial wastewater treatment will be carried out whose quality standard value is not yet known. This study also aims to design and apply textile industry wastewater treatment with a combination of adsorption-electrochemical technology on a laboratory scale, determine the effectiveness of wastewater treatment with a combination of adsorption-electrochemical technology and determine the results of textile industry wastewater treatment that will be reused in activities. industry.

2. Methodology

2.1. Materials

Waste samples were manufactured synthetically. the color obtained from mixing textile dyes with aquadest into desired concentration. The intensity of color sought in the manufacture of this synthetic waste is 500-2000 mg/L unit of Pt-Co [1]. The solution was obtained by mixing 2 grams of blue textile dye with 1000 mL of aquadest. The concentration obtained was 1091 mg/L unit Pt-Co. Samples were then stored in a refrigerator at 4°C. The electrode used is a variation between iron and aluminum with a length of 15 cm and a width of 10 cm as anode and cathode. The variations used are Al-Al, Al-Fe, Fe-Al, Fe-Fe.

2.2. Method

Waste sample was treated using an electrocoagulation device by flowing the waste into an electrocoagulation device, the treatment is carried out for 5 minutes. Sample was then filtered and the pollutant content after the treatment were calculated. All the runs were performed at constant temperature of 25°C [2]

Waste was analyzed for the concentration of COD, color, and heavy metals $Fe^{2+}$ and Cr(VI) first, then electrocoagulation was carried out to set aside these parameters. Analysis was carried out using UV-Vis spectrophotometer and atomic absorption spectrophotometer (AAS) as per standard method [3].

2.3. EC process

The electrocoagulation process is carried out by flowing the waste into a container that has been attached to the existing anode and cathode. Anode and cathode variations based on previous paper [4][5] using Al-Al, Al-Fe, Fe-Al, Fe-Fe with a length of 15 cm and a width of 10 cm. The cathode anode is connected to a DC electric current with amperage variations based on previous paper [6] of 1 ampere, 2 ampere, 3 ampere, and 4 ampere in the preliminary experiment to determine the effect of the current on the removal.

The experiment was carried out to determine the effectiveness of removing pollutants in waste by conducting two experiments with the first experiment being carried out to find the voltage level that could give the most effective results, while the second experiment was carried out to obtain the most effective anode and cathode variations in removing waste.

Furthermore, the second stage of the test was carried out with a similar method, namely by flowing the waste into a container that had an anode and cathode installed with a predetermined variation. The anode and cathode are connected to a DC current with amperage that is able to remove the color, COD, and Cr(VI) [7] and $Fe^{2+}$[8] in the most effective manner.
2.4. Experimental design and statistical analysis

The experiment was conducted to determine the treatment efficiency of pollutants in textile waste. COD concentration and waste color were analyzed using a spectrophotometer while heavy metal analysis was obtained through analysis using AAS.

The percentage of COD removal is done by calculating
\[
\% \text{DCOD} = \frac{\text{COD}_i - \text{COD}_t}{\text{COD}_i} \times 100\% \tag{2.1}
\]

Where COD\(_i\) is the concentration of COD before treatment and COD\(_t\) is the concentration after treatment resulting from the spectrophotometer absorbance conversion in mg/L units.

Percentage of Color removal is done by calculation
\[
\% \text{DC} = \frac{\text{Abs}_i}{\text{Abs}_t} \times 100\% \tag{2.2}
\]

Where Abs\(_i\) is the absorbance of color before treatment and Abs\(_t\) is the absorbance after treatment with the absorbance of 450nm.

The percentage of Cr(VI) removal was carried out by calculating.
\[
\% \text{DCr(VI)} = \frac{\text{Cr(VI)}_i - \text{Cr(VI)}_t}{\text{Cr(VI)}_i} \times 100\% \tag{2.3}
\]

Where Cr(VI)_\(i\) is the concentration of Cr(VI) before treatment and Cr(VI)_\(t\) is the concentration after treatment resulting from the conversion of AAS absorbance in mg/L units.

The percentage of Fe\(^{2+}\) removal is done by calculating.
\[
\% \text{DFe}^{2+} = \frac{\text{Fe}^{2+}_i - \text{Fe}^{2+}_t}{\text{Fe}^{2+}_i} \times 100\% \tag{2.4}
\]

Where Fe\(_i^{2+}\) is the concentration of Fe\(^{2+}\) before treatment and Fe\(_t^{2+}\) is the concentration after treatment resulting from the conversion of AAS absorbance in mg/L units.

3. Results and discussion

3.1. Characteristic of synthetic textile wastewater

| No | Parameter | Unit | Result | Quality Standard* | Explanation |
|----|-----------|------|--------|-------------------|-------------|
| 1  | Color     | -    | 9.054878 | -                 | -           |
| 2  | COD       | mg/L | 691.6667 | 150               | not eligible |

*) Based on Perda Jawa Tengah No. 5 Tahun 2012

Based on the results, it can be seen that the results of COD exceed the quality standard. This happens because the content of organic substances in synthetic textile wastewater is high. The COD parameter is often used as a measure of the quantity of pollutants in a wastewater. This is in accordance with research conducted that rivers polluted by batik waste have a high organic material content and dark color [11].

Chemical treatment is one alternative that can be used for the main treatment of textile wastewater. The method used for textile wastewater treatment in this study is the electrocoagulation method.

3.2. Analysis of preliminary test

| Anoda | Katoda | Ampere | Absorbance | COD Result | Efficiency | Absorbance | Color Result | Efficiency |
|-------|--------|--------|------------|------------|------------|------------|-------------|------------|
| AI    | AI     | 1      | 0.081      | 175        | 74.6988    | 0.318      | 1057.667    | 3.055301   |
|       |        | 2      | 0.09       | 205        | 70.36145   | 0.299      | 994.3333    | 8.860373   |
Based on the data above, it was found that the most optimum voltage to set aside COD and color parameters was 4 amperes at all electrode variations. It was found that the decrease in polyethylene content in color and COD parameters with the highest efficiency for color was 51.33% and for COD up to 89.15% percent.

3.3. Analysis of color removal

Table 3. Color Removal for textile wastewater treatment.

| Anode | Cathode | Ampere | Absorbance | COD Result | Efficiency | Absorbance | Color Result | Efficiency |
|-------|---------|--------|------------|------------|------------|------------|-------------|------------|
| Al    | Fe      | 1      | 0.101      | 241.6667   | 65.06024   | 0.29       | 964.3333    | 11.61014   |
|       |         | 2      | 0.092      | 211.6667   | 69.39759   | 0.301      | 1001        | 8.249313   |
|       |         | 3      | 0.062      | 111.6667   | 83.85542   | 0.183      | 607.6667    | 44.30186   |
|       |         | 4      | 0.051      | 75         | 89.15663   | 0.161      | 534.3333    | 51.02353   |
| Fe    | Al      | 1      | 0.099      | 235        | 66.0241    | 0.24       | 797.6667    | 26.88665   |
|       |         | 2      | 0.093      | 215        | 68.91566   | 0.251      | 834.3333    | 23.52582   |
|       |         | 3      | 0.116      | 291.6667   | 57.83133   | 0.227      | 754.3333    | 30.85854   |
|       |         | 4      | 0.091      | 208.3333   | 69.87952   | 0.223      | 741         | 32.08066   |
| Fe    | Fe      | 1      | 0.092      | 211.6667   | 69.39759   | 0.25       | 831         | 23.83135   |
|       |         | 2      | 0.108      | 265        | 61.68675   | 0.285      | 947.6667    | 13.13779   |
|       |         | 3      | 0.085      | 188.3333   | 72.77108   | 0.253      | 841         | 22.91476   |
|       |         | 4      | 0.074      | 151.6667   | 78.07229   | 0.164      | 544.3333    | 50.10694   |
| Pure Sample | | | 0.236 | 691.6667 | | 0.328 | 1077.677 |

Based on the above results, it was obtained that the most optimum color Removal of Synthetic Textile waste was using the Fe-Fe electrode configuration which was electrified with a current of 4 A in a row. From the test results obtained the similarity of the absorbance level with the initial condition of the waste is 0.324. From the results of testing the COD parameters, the initial condition of the waste has a concentration of 1077.677 mg/L unit of Pt-Co.

3.4. Analysis of COD removal

Table 4. COD Removal for textile wastewater treatment.

| Anode | Cathode | Ampere | Absorbance | COD Result | Efficiency | Absorbance | COD Result | Efficiency |
|-------|---------|--------|------------|------------|------------|------------|-------------|------------|
| Al    | Al      | 4      | 0.175      | 488.3333   | 29.39759   | 0.18       | 465         | 32.77108   |
| Al    | Fe      | 4      | 0.106      | 258.3333   | 62.6506    | 0.13       | 248.3333   | 64.09639   |
| Fe    | Al      | 4      | 0.168      | 465        | 32.77108   | 0.13       | 248.3333   | 64.09639   |
| Fe    | Fe      | 4      | 0.103      | 248.3333   | 64.09639   | 0.13       | 248.3333   | 64.09639   |
| Pure Sample | | | 0.236 | 691.6667 | | 0.236 | 1077.677 |

Based on the above results, it was obtained that the most optimum COD Removal of Synthetic Textile waste was using the Al-Fe electrode configuration which was electrified with a current of 4 A in a row.
The test results obtained a decrease in the level of absorbance with the initial condition of the waste is 0.236. As for the COD parameter, the initial condition of the waste has a concentration of 691.667 mg/L.

3.5. Analysis of heavy metals removal

Table 5. Heavy metals removal for textile wastewater treatment.

| Anode | Cathode | Ampere | Cr  | Fe  |
|-------|---------|--------|-----|-----|
| Al    | Al      | 4      | -   | 0.001 |
| Al    | Fe      | 4      | -   | -   |
| Fe    | Al      | 4      | 0.12| 0.054 |
| Fe    | Fe      | 4      | 0.122| 0.045 |
| Pure sample | - | - |

Based on the above results, it was obtained that the most optimum heavy metal Removal of Synthetic Textile waste was using the Al-Fe electrode configuration which was electrified with a current of 4 A in a row. From the test results, the removal of heavy metals Cr 0.12 and Fe 0.54 and 0.03.

4. Conclusion

The conclusions are based on data analysis and discussion carried out. The most optimum color removal efficiency of synthetic textile waste is in the treatment by electrocoagulation method with Fe-Fe electrode configuration which is powered by an electric current with a current of 4 A in a row, with a color removal efficiency of 60.006% and a COD removal efficiency of 64.09% with a Fe-Fe electrode configuration with a strong current of 4A.

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