Analysis of Chromium (VI) Concentration in the Area Around the Wastewater Treatment Plant at the Batik Factory

Rahayu Fuji Astuti[a*], Erif Ahdhianto[b], Ryzal Perdana[c], [a]Universitas Potensi Utama, Indonesia, [b,]Department of Primary School Teacher Education, Universitas Nusantara PGRI Kediri, Indonesia, [c]Universitas Nahdlatul Ulama Lampung, Indonesia.

Wastewater from batik fabric production is one of the potential sources of water pollution. This is because the waste water from the rest of batik production contains high organic compounds, dangerous chemical compounds, and pathogenic microorganisms that can cause health problems. Chrome (Cr(VI)) is a heavy metal waste which is included in one type of hazardous waste, usually originating from the batik industry. Chrome concentration analysis was carried out on batik waste before and after undergoing treatment at the Waste Water Treatment Plant. Analysis is also carried out on the waste after passing the river flow around the factory. Determination of chromium concentration was carried out using a UV-Vis spectrophotometer at a wavelength of 541 nm. Based on the standard curve produced at the standard solution concentration of 2 – 6 mg/L, the regression equation Y = 0.112x - 0.009 with R^2 = 0.9949 is obtained. This equation is used to calculate the concentration of chromium in wastewater. In the preliminary test, the concentration of chromium in wastewater before being treated was 16.6747 mg/L and the pH was 14. After the waste was treated, the pH of wastewater became 5 and the concentration of chromium was 10.1181 mg/L. And the concentration of chromium after passing through 2 km of river flow is also still high at 7.6277 mg/L.

Key words: *Chrome, Batik Waste, Diphenylcarbazide, Waste Treatment Installation*

Introduction

Waste is waste generated from a production process both industrial and domestic household (Sugiharto, 1987; Baehaki, Rudibyani, Aeni, Perdana, and Aqmarina, 2020). Waste as a result of community activities or as a result of a natural process is a waste material that is no longer needed for human life (Mahida, 1992; Baehaki, Rudibyani, Aeni, Perdana, and Aqmarina, 2020). The types of waste include liquid waste, solid waste, waste gas and particles. Liquid waste causes environmental pollution and the compounds contained therein are harmful to the environment. In addition, changes in water become dirty, changes in water coated with oily materials or other solids that cause surface water closure. The compounds contained when exceeding the specified level causes water can not be used for the purposes as it should (Ginting, 2007).

Apart from its role as a reliable export commodity, the batik industry can have a serious impact on the environment, especially problems caused by liquid waste produced (Baehaki, Rudibyani, Aeni, Perdana, and Aqmarina, 2020). Waste water from batik production is a potential source of water pollution. This is due to the fact that batik production wastewater contains organic compounds which are quite high, contain dangerous chemical compounds and contain pathogenic microorganisms that can cause disease (Siregar, 2005).

Batik industry activities produce liquid waste containing color, suspended solids, BOD, COD, ammonia, phenol, chromium, fatty oil and pH which need to be processed before being discharged into water bodies (Mahida, 1992). Ammonia is corrosive and can interfere with disinfection with chlorine. If wastewater entering public waters has high ammonia levels, it can increase the growth of microorganisms in the waters. Cr(VI) heavy metal waste, a type of hazardous waste, can come from the batik industry, electroplating, and leather tanning (Acar and Malkoc, 2004; Loukidou *et al*, 2004; Abdi and Kazemi, 2015; Lichtfouse and Schwarzbauer, 2012; Olukanni, Agunwamba, and Ugwu, 2014). The level of chromium toxicity is so high that it is toxic to all organisms for concentrations> 0.05 ppm (Abdi and Kazemi, 2015; Olukanni, Agunwamba, and Ugwu, 2014; Nagaraj, Aradhana, Svivakumar, Shrestha, and Gowda, 2009; Hua, Chan , Wu, and Wu, 2009). Chrome is carcinogenic and can cause irritation to human skin (Metcalf & Eddy, 1991; Sharov, Plotnikova, Evseev, Rykova, 2019; Klatt and Kunze, 2009). If the batik waste water is channeled directly into the environment without any prior treatment, it will reduce the quality of the environment and endanger the communities around the effluent. A wastewater treatment plant is needed so that wastewater discharged into lakes or rivers meets the requirements for wastewater quality standards.

The main purpose of wastewater treatment is to break down the content of pollutants in water, especially organic compounds, suspended solids, pathogenic microbes, and organic compounds that cannot be broken down by microorganisms found in nature. However, there are still a number of batik industries in Indonesia whose sewage treatment systems have not been maximized. Residents around the factory still complained about the presence of wastewater that interferes with daily activities because it is dark, itchy, and smells bad. Based on this background it is necessary to analyze the concentration of chromium in batik waste before it is processed, after being processed and in river water that flows around the batik industry waste disposal.

Research Method

Tools and Materials

The instruments used in this research are Shimadzu-branded Uv-Vis spectrophotometer, Cuvette, Sample Bottles, Pumpkin and Volume Pipettes. While the materials used are Potassium dichromate, Diphenylcarbazide, Sodium hydrogen sulfite, Sodium hydroxide, all these materials are provided with pro analysis grade

Sampling

Samples were taken from batik industry wastewater in the city of Solo before being processed, after being treated and after flowing in the river about 2 km from the factory. Each taken 3 times, to check the chromium content in the wastewater.

Sample Preparation

Pipette as much as 100 ml of liquid waste containing Cr(VI). The waste is then put into a 250 ml erlenmeyer and $NaHSO_3$ solution is added dropwise until the solution is green. To the green solution is added 4 N NaOH solution until the pH of the solution becomes 8-9. Then lime water is added to form a precipitate. The solution is allowed to stand for about 10 minutes so that the sediment drops, then tested with a drop of lime water. If no precipitate has formed, the deposition process with lime water is stopped and filtered.

Determination of Maximum Wavelength

At this stage, a potassium dichromate solution of 2.0 mg/L is made. Next is the addition of a solution of diphenylcarbazide as much as 2.5 ml. Dilute the solution to the mark by adding distilled water. Beat until homogeneous and wait for 10 minutes to form a perfect brownish yellow color. Absorption is measured at wavelength 530 - 550 nm.

Making the Calibration Curve

At this stage, we measured 0.153 grams of $K_2Cr_2O_7$ crystal and dissolved it with distilled water in a 1000 ml volumetric flask. Then the addition of distilled water is done until the boundary markers are homogenized (Standard Solution 1). Next make a standard solution with a concentration of 2 ppm, 3 ppm, 4 ppm, 5 ppm, and 6 ppm. Of the Standard Solution 1, pipette as much as 2.0 ml, 3.0 ml, 4.0 ml, 5.0 ml and 6.0 ml. Each of the five solutions was put into six 100 ml volumetric flasks and 2.5 ml diphenylcarbazide solution was added. Dilute the solution by adding distilled water to the mark. Beat until homogeneous, wait a few minutes for the formation of a stable color. And then make absorbance measurements with a spectrophotometer at maximum wavelength.

Measurement of Chrome Concentration in Batik Waste

Measurement of sample concentrations carried out refers to research by Nagaraj, Aradhana, Svivakumar, Shrestha, and Gowda, (2009) and Minarsih (2009). The waste filtrate was acidified to pH 2 by adding a solution of H_2SO_4 4 N. The solution was pipetted as much as 25.0 ml and put into a 100.0 ml measuring flask. Subsequently added as much as 2.5 ml diphenylcarbazide and diluted to the mark by adding distilled water. Beat until homogeneous, wait for 5-10 minutes until the formation of a stable color. Measure the absorbance with a spectrophotometer at the maximum wavelength.

Results and Discussion

Preliminary results of the wastewater sample before being treated, after being treated and in the river water flow about 2 km from the factory, can be seen in Table 1.

Table 1. Preliminary Results of Wastewater Before And After Treatment

Condition	Color	Smell	pH
Before treatment	Deep blue	Typical batik	14
After treatment	Purple	No	5
River water around the factory	Turbid yellow	No	4

The preliminary test was immediately carried out shortly after sampling. This is to avoid changes that might occur during storage. For wastewater, the time interval between sampling and inspection is 12 hours. From Table 1 it can be seen that there are clear differences in the preliminary test results between treated and treated untreated wastewater, both in color, odor and pH of the wastewater. The pH of wastewater before being treated is 14. After being treated in a sewage treatment system, the value approaches the pH parameter set in the wastewater quality standard that is 5. While the pH requirements for wastewater are 6.0 - 9.0. And in river water the pH becomes more acidic, 4.0. Next to calculate the chromium content in batik waste, the chrome standard curve is determined, and the regression equation between concentration and absorbance is determined. Chrome standard solution measured by spectrophotometer at the maximum wavelength of the scanning result is 541 nm. Addition of diphenylcarbazide is needed as a reactant to form molecules that can absorb visible light. The reagents used must meet several requirements, namely selective, sensitive, fast, quantitative and reproducible reactions, and the results of stable reactions over a long period of time (Adhyatma, 1990). From the resulting standard curve equation can be used to determine the chromium content. The results of making chrome standard curves can be seen in Table 2.

Table 2. Results of Measurement of Chromium Standard Solution Absorbance

Concentration (mg/L)	Absorbance
2	0.212
3	0.326
4	0.457
5	0.534
6	0.668

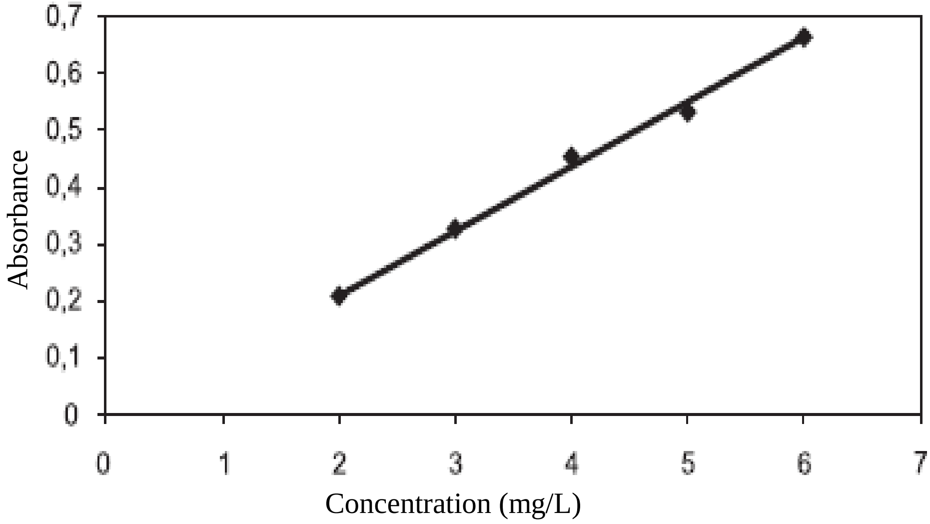

Figure 1. Chromium Standard Solution Calibration Curve

Based on the results of absorbance measurements of the standard chromium solution, the regression equation y = 0.112x0.009 with the correlation coefficient (R^2) = 0.9949 is obtained. The results of the regression equation have a good correlation coefficient between chromium concentration and absorbance (Musiam and Alfian, 2017). This shows that the regression equation can be used to calculate the concentration of chromium in batik waste water samples. The chromium standard solution curve can be seen in Figure 1.

Furthermore, the determination of the concentration of chromium in wastewater before treatment, after treatment, and after passing the river flow. Test results for determining the concentration of chromium in wastewater can be seen in Table 3.

Table 3. Test Results of Chrome Concentration Determination in Wastewater

Condition of Wastewater	**Concentration of Chromium (mg/L)**	**Average Concentration (mg/L)**
Before Treatment	17.3606 ±0.7654 15.9653 ±0.6789 16.6984 ±0.7021	16.6747 ±0.6980
After Treatment	10.3839 ±0.2458 9.9188 ±0.2217 10.0513 ±0.2295	10.1181 ±0.2396
In river water	8.5234 ±0.9023 6.7763 ±0.8547 7.5833 ±0.8689	7.6277 ±0.8744

The results of the determination of the concentration of chromium in wastewater before treatment have an average level of chromium is 16.6747 mg/L. Whereas after being processed the concentration becomes 10.1181 mg/L. And the river water flow has a concentration of 7.6277 mg/L. From these results it can be seen that after being processed, the chromium content has decreased, which is equal to 6.5566 mg/L. Likewise in river water flowing 2 km near the factory. The concentration of chromium in treated wastewater and flowing in river water still greatly exceeds the required threshold value of 1.0 mg / L (Adhyatma, 1990). This shows that the Waste Treatment Plant owned by the factory has not been maximized and needs to be adjusted again. So the chromium content produced can meet the quality standards of wastewater in the textile and batik industries. A good treatment of waste is removal of heavy metals and phosphorus compounds by applying an alkaline solution (for example lime water) to form hydroxide deposits of these metals or hydroxyapatite deposits. Especially for wastewater treatment containing hexavalent chromium, before it was precipitated as chrome hydroxide [$Cr(OH)_3$], it was first reduced to trivalent chrome by applying a reductant ($FeSO_4$, SO_2 or $Na_2S_2O_5$) (Klatt and Kunze, 2009; Mahida, 1992; Nagaraj, Aradhana, Svivakumar, Shrestha, and Gowda, 2009).

Conclusion

The results of the study give different characteristics between wastewater before it is treated, after being treated and after passing the river flow. The pH of treated wastewater that has passed through the river flow does not meet the standard requirements for wastewater, which is 6.0 - 9.0. The results of the determination of the concentration of chromium in wastewater after treatment have decreased, but the concentration still exceeds the threshold value required for the textile and batik industry wastewater quality standards, which is 1.0 mg/L.

Acknowledgements

The researcher would like to thank Lembaga Pengelola Dana Pendidikan (LPDP) Indonesian endowment fund for education, Finance ministry of Indonesia for supporting this research.

References

Abdi, O. and Kazemi, M. (2015). A Review Study Of Biosorption Of Heavy Metals And Comparison Between Different Biosorbents. *J. Mater. Environ. Sci.*, 6(*5*): 1386-1399.

Acar, F. N. and Malkoc, E. (2004). The Removal Of Cr(VI) From Aqueous Solutions By Fagus Orientalis L. *Bioresource Technology*, 94: 13 – 15.

Adhyatma (1990). *Syarat-Syarat dan Pengawasan Kualitas Air*. Peraturan Menteri Kesehatan Republik Indonesia No. 416/MENKES/PER/IX/1990

Baehaki, F., Rudibyani, R. B., Aeni, S. R. N., Perdana, R., and Aqmarina, S. N. (2020). Utilization of *Salacca zalacca* Seeds As Chromium(VI) Adsorbents. *Tche Quimica*, 17(34).

Ginting, P. (2007). *Pengolahan dan Limbah Industri*. Bandung: Yrama Widya.

Hua, L., Chan, Y. C., Wu, Y. P., and Wu, B. Y. (2009). The Determination Of Hexavalent Chromium (Cr^{6+}) In Electronic And Electrical Components And Products To Comply With Rohs Regulations *Journal of Hazardous Materials*, 163: 1360 – 1368.

Klatt, V. and Kunze, J. (2009). The Determination of Chromium VI in Wastewater Using GFAAS After Extraction as Diphenylcarbazide Complex. *Atomic Spectroscopy*, *30*(6), 185 – 190.

Lichtfouse, E. and Schwarzbauer, J. (2012) *Environmental Chemistry For A Sustainable World Volume 1: Nanotechnology And Health Risk*. New York: Springer.

Loukidou, M. X., Zouboulis, A.I., Karapantsios, T.D., and Matis, K.A. (2004). Equilibrium And Kinetic Modeling Of Cr(VI) Biosorption By Aeromonas Caviae *Colloids And Surfaces A: Physicochem. Eng. Aspects*, 242: 93-104.

Mahida, U.N. (1992). *Pencemaran Air dan Pemanfaatan Limbah Industri*. Jakarta: Rajawali Press.

Metcalf & Eddy, Inc. (1991). Wastewater Engineering: *Treatment, Disposal, Reuse, 3rd Ed*. (Revised By: G. Tchobanoglous And F.L Burton). New York: McGraw Hill, Inc.

Minarsih, T. (2009). Analisa Pengaruh Adanya Instalasi Pengolahan Air Limbah Terhadap Kadar Krom Pada Limbah Pabrik Batik di Kabupaten Pekalongan. *Jurnal Farmasi Indonesia*, 6(*3*), 1–5.

Musiam, S. dan Alfian, R. (2017). Validasi Metode Spektrofotometri UV Pada Analisis Penetapan Kadar Asam Mefenamat Dalam Sediaan Tablet Generik. Jurnal Ilmiah Ibnu Sina, 2(1).

Nagaraj, P., Aradhana, N., Svivakumar, A., Shrestha, A. K., and Gowda, A.K. (2009) Spectrophotometric Method For The Determination Of Cr(VI) In Water Samples. *Environmental Monitoring and Assessment*, 157: 575 – 582.

Olukanni, D. O., Agunwamba, J. C., and Ugwu, E. C. (2014). Biosorption of Heavy Metals In Industrial Wastewater Using Microorganisms (*Pseudomonas Aeruginosa*) *American Journal Of Scientific And Industrial Research*, 5(*2*): 81 – 87.
Sharov, A. V., Plotnikova, O. M., Evseev, V. V., Rykova, A. I. (2019). *Periodico Tche Quimica*, 16(*32*), 516–528.
Siregar, A. S. (2005). *Instalasi Pengolahan Air Limbah.* Jakarta: Kanisius.
Sugiharto (1987). *Dasar-Dasar Pengolahan Air Limbah.* Jakarta: Universitas Indonesia Press.