Reduction of Color and Heavy Metals (Pb, Cu) in Hand-drawn Batik Liquid Waste Using Electrolysis

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Abstract: The liquid waste of hand made batik in Pekalongan City that is disposed of directly into the river will be harmful to aquatic biota and the surrounding environment. To overcome these problems, processing is required first. One of the faster processing to remove color and heavy metals is to use the electrolysis method. This study aims to determine the efficiency level of reducing dyestuffs, and heavy metals (Pb, and Cu). This research method is a laboratory experiment using electrocoagulation with variations in current voltage of 12 volts, 18 volts and 32 volts and contact times of 60, 120, and 180 minutes. This electrolysis process uses two aluminum plates as electrodes. The results of the analysis showed that the highest percentage of dye removal reached 95.43% with a contact time of 180 minutes with an electric voltage of 32 volts with a current of 5 Ampere. The percentage of heavy metal content of Pb ions showed a reduction of up to 84.41% with a contact time of 180 minutes with a voltage of 32 volts and a current of 5 amperes. For Cu metal ions at mains voltage, 18 and 32 volts with contact times of 120 and 180 minutes achieved a 100% reduction.
The results of processing using the electrolysis method are able to reduce batik liquid waste below the quality standard according to the Minister of Environment Regulation No. 5 of 2004 and Central Java Regional Regulation No. 5 of 2012 Processing electrolysis systems with variations in high voltage and longer contact times can reduce color and metal ions weight in the processed batik liquid waste, but in its application it is better to pay attention to the use of electric voltage and current.

Keywords: Electrolysis, batik waste, dyestuffs, heavy metals

Introduction

The process of making batik that causes the most pollution is the wet process, namely the process of batik in a chemical solution with water as the medium and as an auxiliary material consisting of starch, oil, wax, soda (NaOH), and others. Based on the preliminary survey, the water storage tanks are discharged directly into water bodies (16;7;4;5). Liquid waste is also referred to as a water pollutant, because the components of water pollutants generally consist of solid materials, organic waste materials, and inorganic waste materials. Inorganic materials that are considered toxic are arsenic (As), barium (Ba), cadmium (Cd), chromium (Cr), lead (Pb), mercury (Hg), selenium (Se), and silver (Ag) (2;6).

In general, the content contained in the home industry of written batik is in the form of organic materials, heavy metals, suspended solids as well as oils and fats, so it needs to be processed first so that when discharged into water bodies it does not harm the environment. Various treatments commonly used in batik industrial wastewater are ordinary deposition, adsorption, filtration and flotation (11:4)

One of the home industries of batik in the city of Pekalongan produces 50-250 liters of liquid waste per day. The hand-drawn batik industry disposes of batik liquid waste directly into the drainage because it considers that the waste disposed of is not as large as large-scale industrial waste. According to Moertinah (2010), stating that batik industry wastewater, if discharged into the environment without proper management, will certainly be able to disrupt receiving water bodies.

In the production process, the batik industry uses a lot of chemicals and water. This batik wastewater is alkaline which is characterized by a thick color and a high pH (9-12.5) and has a high salt content (15:3). The liquid waste of written batik has a very thick color, it causes aquatic environmental problems if it is directly disposed of without any prior treatment because it contains non-biodegradable organic compounds (18). The most widely used dyes in the batik industry include benzonaphthalene-derived dyes, azonaphthalene-derived dyes, direct (natural) dyes and reactive dyes (17).

The main waste content in the batik industry can be seen from several parameters, namely the high pH value, concentration of Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solid (TDS) and color intensity (1;14;). Batik waste can also be said to be liquid waste as a water pollutant, because the components of water pollutants generally consist of solid materials, organic waste materials, and inorganic waste materials. Inorganic materials that are considered toxic are arsenic (As), barium (Ba), cadmium (Cd), chromium (Cr), iron (Pb), mercury (Hg), selenium (Se), and silver (Ag) (2). The combination of Zn, Al and Fe electrodes has high efficiency. The combination of Al-Zn electrodes can reduce the levels of heavy metals Cr at the outlet of batik industry waste up to 99% and Pb up to 92.1%. (9).

The purpose of this study was to determine the ability of electrolysis to reduce the parameters of color content, Pb, and Cu metals to determine the efficiency of parameter reduction using the electrolysis method. Observing the impact caused by the batik liquid waste, it is necessary to have an alternative processing of written batik liquid waste so as not to pollute river water and surface water. The removal of dyes and heavy metals was based on a preliminary study of the characteristics of batik wastewater at Banyu Urip Ageng, Pekalongan City. The color, Pb, and Cu parameters have exceeded the threshold determined by the government in the Regulation of the Minister of the Environment No. 5 of 2014, Permenkes 416 of 1990, and Central Java Regional Regulation No. 5 of 2012.

Methods

Material

The material used is batik wastewater with characteristics such as Table 1, filter paper with specifications such as Table 1.

Table 1. Characteristics of Batik Wastewater

No	Parameter	Unit	Concentration	Quality standards
1.	pH	-	10,1	6,0-9,0*
2.	Warna	Skala Pt-Co (TCU)	23410	50*
3.	Kekeruhan	NTU	7560	25*
4.	Pb	Mg/L	3,015	-
5.	Cu	Mg/L	0,085	-

Source : *) Minister of Environment Regulation No. 05 of 2014
**) Central Java Provincial Regulation No. 5 Year 2012Alat

The tools used include a spectrophotometer (Thermo Scientific with an accuracy of 0.001), a turbidimeter, a separating funnel, an analytical balance, and 1 unit of electrolysis equipment. This research was conducted in the laboratory in batches. The electrolysis device made consists of two components, namely an electrolysis bath and an electrode plate. The electrolysis bath is made with a length of 15 cm, a width of 10 cm and a height of 15 cm. The electrode consists of 3 cathodes and 3 anodes made of aluminum.

In the study of processing batik waste using electrolysis, voltage variations were carried out, namely 12 volts, 18 volts, and 32 volts and 5 Ampere and variations in contact time of 60, 120 and 180 minutes and the distance between the electrodes was 1 cm. The batik liquid waste used in this study is the original written batik waste that comes from the reservoir from the home process of the written batik industry in Banyu Urip Ageng Village, Pekalongan City. The parameters analyzed were in the form of dyes, and heavy metals (Pb and Cu).The process of the electrolysis performance mechanism is as follows;

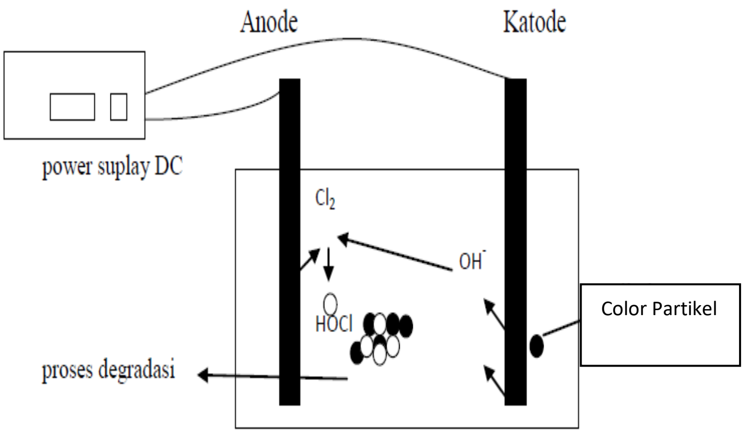


Figure 1. Mechanism of the electrolysis process

Result

Results of Reducing Color Wastewater for the Batik Industry

In this study, the sample used was written batik liquid waste in Banyu Urip Ageng, Pekalongan City. Samples were taken in the batik industry waste container which was accommodated in a water reservoir before being disposed of. Furthermore, the results of the written batik waste are taken and put into an electrolysis bath as much as 1 liter. After that, the batik waste treatment equipment was turned on with a current of 5 amperes and a varying voltage of 12 volts, 18 volts and 32 volts. The contact time also varies from 60 minutes, 120 minutes and 180 minutes. Each treatment 60 minutes, 120 minutes and 180 minutes was flowed into a filter bath to filter the precipitate from the electrolysis process. The results of the processing of written batik liquid waste by the electrolysis method are as follows;

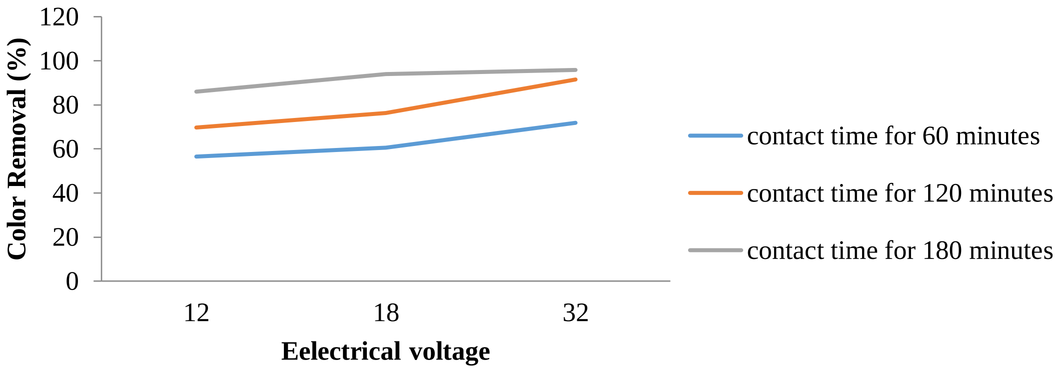
Figure 3. Results of batik waste treatment (a). The original batik waste before being processed, (b) 12 volts, (c) 18 volts, (d) 32 volts.

Pengaruh Kuat Arus dan Waktu Kontak Terhadap Penurunan Warna

Table 1. Effect of voltage and contact time on color loss

Time (Minutes)	Color parameters						
	Initial (ppm)	12 volt		18 volt		32 volt	
		ppm	%R	ppm	%R	ppm	%R
60	23410	10178,30	56,52	9216,54	60,63	6594,37	71,83
120	23410	7093,9	69,70	5573,81	76,19	1986,66	91,51
180	23410	3281	85,98	1401	94,02	974,3	95,84

Table 1. shows that the electrolysis process with various voltage variations (12, 18, 32 volts) and contact time in decreasing color shows a strong current of 5 A and a contact time of 60 minutes can set aside 56.52%;60.63;%;71 ,83%, with a strong current of 5 A and a contact time of 120 minutes can set aside 69.70%; 76.19%; 91.51%. Meanwhile, at a current of 5 Ampere, the contact time of 180 minutes can set aside 85.98%; 94.02%; 95.84%.



Effect of Current Voltage and Contact Time on Color Degradation

Figure 3. The relationship between the current voltage and the percentage of color loss at various contact times.

Based on the picture above, it can be seen that the longer the contact time and the greater the voltage, the greater the color loss. This is because the particles contained in organic wastewater are generally negatively charged, because of the same charge there is a repulsion between the particles that causes the particles to be in a stable state. During the electrolysis process, positive and negative ions produced by electrodes made of metals such as aluminum will destabilize the particles present in the wastewater (19).

The anode electrode will undergo an oxidation reaction to anion (negative ion) to form Al_3+ and bind OH- to form $Al(OH)_3$ compound which can bind pollutants, while at the cathode it will produce hydrogen gas (H_2) which serves to lift the formed floc to the surface. , the floc formed over time will increase in size and eventually settle to the bottom of the electrolysis bath.

Figure 3 shows that the effluent before processing was dark black in color and after the electrolysis process the color became clear due to the destruction of the dye structure. The clearest color is obtained when the voltage is 32 Volts for 180 minutes. Increasing the voltage can increase the current flowing in the solution, so that the reaction for the formation of hydroxide coagulant increases. The increase in coagulant is directly proportional to the increase in the decolorization reaction (10)

Effect of Strong Current and Contact Time on Pb Decrease

Table 4. Effect of voltage and contact time on the decrease in Pb

Time (Minutes)	Lead (Pb) Parameter						
	Initial (ppm)	12 voltase		18 voltase		32 voltase	
		ppm	%R	ppm	%R	ppm	%R
60	3,015	1,30	56,88	1,26	58,21	1,12	62,85
120	3,015	1,37	54,56	1,23	59,20	1,11	63,18
180	3,015	0,92	69,48	0,75	75,12	0,47	84,41

Table 4 shows that the electrolysis and biosand processes with a current of 5 Ampere and a contact time of 60 minutes with voltage variations (12, 18, 32 volts) in Pb decrease showed an allowance of 56.88%; 58.21%; 62.85%. At a current of 5 Ampere and a contact time of 120 minutes with variations in voltage (12, 18, 32 volts) in decreasing Pb, the allowance for Pb is 54.56%; 59.20%; 63.18%. Meanwhile, at 5 Ampere current and contact time of 180 minutes with voltage variation (12, 18, 32 volts) in decreasing Pb, the allowance for Pb is 69.48%; 75.12%; 84.41%.

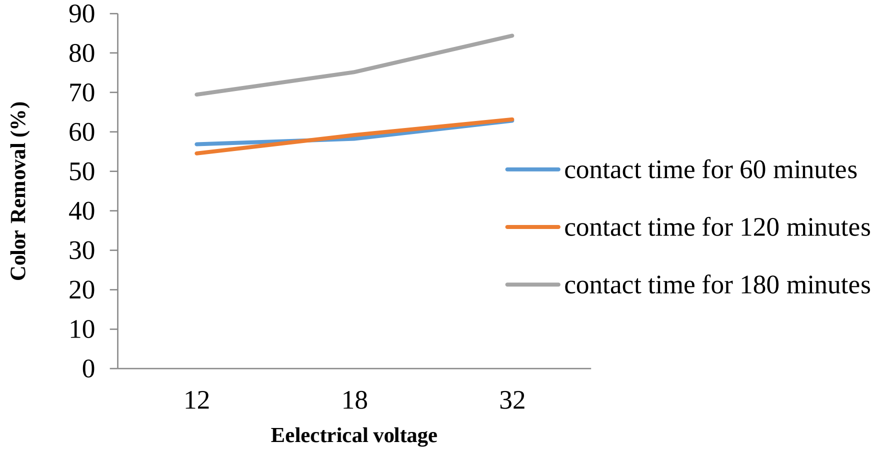


Figure 5 The relationship between the current strength and the percentage decrease in Pb at various contact times.

Lead (Pb) is a black metal. It is widely used as a constituent in paints, seals and is now widely used in gasoline. Pb poisoning will cause symptoms: metallic taste in the mouth, black lines on the gums, GI disturbances, anorexia, vomiting, encephalitis, wrist drop, irritability, personality changes, paralysis, and blindness (11). Lead metal (Pb) is commonly found in the wastewater of the printed circuit board manufacturing industry, the battery industry, the paint industry, the electronic equipment assembly industry, leachate from waste disposal and also in batik wastewater.

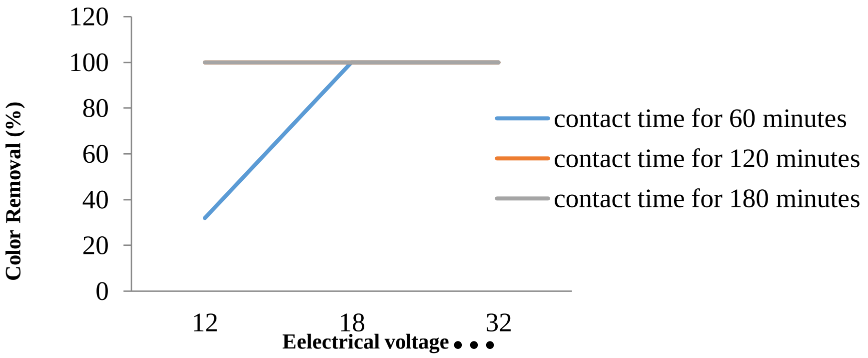
To treat wastewater in which lead (Pb) is present, it needs to be deposited or with an ion exchange resin process. In this study the Pb value before processing was 3.015 mg/L. After processing the Pb value of written batik liquid waste decreased to 0.47 mg/L. The best results were at a voltage of 32 V with an electrolysis time of 180 minutes with a Pb value of 0.47 mg/L. Pb reduction and removal could be carried out by ion exchange using either anion resin or cation resin (11). One of them is the electrolysis method.

4.2.8 Effect of Voltage and Contact Time on Cu Drop

Table 4.9 Effect of voltage and contact time on Cu . reduction

Time (Minutes)	Cu Parameter						
	Initial (mg/l)	12 voltase		18 voltase		32 voltase	
		mg/l	%R	mg/l	%R	mg/l	%R
60	0,0851	0,06	31,96	0	100,00	0	100,00
120	0,0851	0	100,00	0	100,00	0	100,00
180	0,0851	0	100,00	0	100,00	0	100,00

Table 4.9 shows that the electrolysis process with a current of 5 Ampere and a contact time of 60 minutes with voltage variations (12, 18, 32 volts) in decreasing Cu shows an allowance of 41.96%; 100%; 100%. At a current of 5 Ampere and a contact time of 120 and 180 minutes with variations in voltage (12, 18, 32 volts) in the reduction of Cu, it shows an allowance of 100%; 100%; 100%.



From Figure 4.9, it can be seen that the efficiency of decreasing copper (Cu) content very quickly with electrolysis and biosand processes decreased at 12 volts, 18 volts, and 180 volts at contact times of 60, 120, and 180 minutes. From these data, electrolysis occurs and the biosand works very well on the electrodes and the magnetic field that occurs has a very large decrease reaching 100%, then the electrolysis process works at maximum conditions. Copper metal (Cu) in wastewater can be removed by deposition into a salt form which insoluble in water, precipitates as metallic copper and can also be removed by an ion exchange process (11).

Conclusion

The electrolysis method was proven to be able to remove dyes and heavy metals Pb and Cu in the wastewater of the batik industry. At a voltage of 32 Volts with a contact time of 180 minutes it reaches 95.5%; 84.41%; 100%. Processing of written batik waste by electrolysis can reduce the content of color and heavy metals in the liquid waste of the written batik industry. The higher the voltage and the contact time, the faster the process of reducing the color and heavy metals in the written batik wastewater.

References

Agustina, T., dan Badewasta, H. (2009). Pengolahan Limbah Cair Industri Batik Cap Khas Palembang dengan Proses Filtrasi dan Adsorpsi. *Prosiding Seminar Nasional Teknik Kimia Indonesia*. Bandung: 19-20 Oktober 2009.

Amril, A., Refilda., Arifin, B., 2013, Analisis pH, BOD, COD, Logam (Pb, Cu, Cd, Fe, dan Zn) pada Drainase Fakultas MIPA dan Fakultas Farmasi UNAND, Jurnal Kimia Unand

Aouni A., Fersi C., Cuartas-Uribe B., Bes-Pia A., Alcaina-Miranda M.I., Dhahbi M. 2012. Reactive dyes rejection and textile effluent treatment study using ultrafiltration and nanofiltration processes. Journal of Desalination 297, 87-96.

Kiswanto, Wintah, Jaya Maulana. 2019. Penurunan Warna, Tss, Cod, Dan Cr Pada Limbah Batik Tulis Secara Elektrolisis Dan Biosand Di Desa Kalipucang Wetan Kabupaten Batang. Jurnal Riset Teknologi dan Inovasi Kabupaten Batang hal 5-17.

Kiswanto, Laila Nur Rahayu, Wintah., 2019. Pengolahan Limbah Cair Batik Menggunakan Teknologi Membran Nanofiltrasi Di Kota Pekalongan. Jurnal Litbang Kota Pekalongan Vol. 17 Tahun 2019 |, 17, Pp.72–82.

Kiswanto, Hamada NA, Sudarno, Purnaweni H. 2020. Removing Content of Color and Heavy Metals (Pb) in The Waste Liquid Using Batik Industries Membrane Technology NF 270. *The 2nd International Conference on Public Health 2020 Teuku Umar University, 31 October 2020*

Kurniawan, W.M., Purwanto, P., dan Sudarno, S. 2013. Strategi Pengelolaan Air Limbah Sentra UMKM Batik yang Berkelanjutan di Kabupaten Sukoharjo. Jurnal Ilmu Lingkunga, 11 (2): 62 -72

Moertinah, S. (2010). Kajian Proses Anaerobik Sebagai Alternatif Teknologi Pengolahan Air Limbah Industri Organik Tinggi. *Jurnal Riset Teknologi Pencegahan dan Pencemaran Industri*, 1(2): 104–114.

Murniati, T., Inayati dan Budiastuti, S. (2015). Pengelolaan Limbah Cair Industri Batik dengan Metode Elektrolisis Sebagai Upaya Penurunan Tingkat Konsentrasi Logam Berat di Sungai Jenes, Laweyan, Surakarta. *Jurnal Ekosains*, 7(1): 77–83.

Ni'am, M.F., Huber, W., Dubin, P., dan Field, J.A. (2007). Removal COD and Turbidity to Improve Watewater Quality using Electrocoagulation Technique. *The malaysian Journal of Analytical Science*, 11(1): 198-205.

Nusa Idaman Said, 2010. Metoda Penghilangan Logam Berat (As, Cd, Cr, Ag, Cu, Pb, Ni, dan Zn) Di Dalam Air Limbah Industri . JAI Vol 6. No. 2 2010

Peraturan Daerah Provinsi Jawa Tengah Nomor 5 Tahun 2012. Baku Mutu Air Limbah.

Peraturan Menteri Lingkungan Republik Indonesia Hidup No 5 Tahun 2014. Baku Mutu Air Limbah.

Riyanto. (2013). *Elektrokimia Dan Aplikasinya* 1st Ed., Yogyakarta: Graha Ilmu.

Shu, L., Waite, T. D., Bliss, P. J., Fane, A., Jegatheesan, V. 2005. Nanofiltration fot The Possible Reuse of Water and Recovery of Sodium Chloride Salt from Textile Effluent. Journal of Desalination 172, 235-243.

Subki, N.S. and Rohasliney, H. 2011. A Preliminary Study on Batik Effluent in Kelantan State: A Water Quality Perspective. International Conference on Chemical, Biological and Environment Sciences (ICCEBS'2011). Bangkok Dec., 2011.

Sumantri, I., Sumarno, A.. Nugroho, Istadi, dan L. Buchori. 2006. Pengolahan Limbah Cair Industri Kecil Batik dengan Bak Anaerobik Bersekat (Anaerobic Baffled Reaktor). Undip Semarang.

Suprihatin, Hasti. 2012. Kandungan Organik Limbah Cair Idustri Batik Jetis Sidoarjo dan Alternatif Pengolahannya. Riau: PPLH Universitas Riau.

Yulianto, A. 2009. Pengolahan Limbah Cair Industri Batik Pada Skala Laboratorium Dengan Menggunakan Metode Elektrokoagulasi. Jurusan Teknik Lingkungan. Universitas Islam Indonesia, Yogyakarta