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The Effectiveness of Plant *Pistia Stratiotes* Weight to Reduction of Heavy Metal Content Chromium (Cr) Waste at Batik Home Industry in Regency of Pekalongan

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Abstract

Batik industry is one industry that generates wastewater with high levels of heavy metals, especially chromium in quite high level because of the use of dyes. Chromium (Cr) was carcinogenic metal and toxic to organism and the environment. The accumulation of heavy metals in the environment would cause pollution and damage to ecosystems. One way that can be used to reduce levels of Cr in the wastewater was a method of phytoremediation using plant of Pistia stratiotes. The purpose of this research was to determine the effect of variation in plant of Pistia stratiotes to reduction at the level of chromium in the wastewater generated from the home industry. This type of research is experimental design with pretest-posttest control group designs. The treatment was done two stages, the first stage to seek the effective time of exposure plant of Pistia stratiotes by using a batch system and the second stage combines wood weight variation plant of Pistia stratiotes by the method of the constructed wetland with the type of Subsurface Flow Systems. Samples of water were used in this research is the liquid waste of batik home industry in regency of Pekalongan. The method of Cr content analysis in the waste water by using Specthrofotometer Atomic Absorption (AAS). The results of one research showed that phytoremediation stage with a variety of contact time 2, 4 and 6 days showed differences significant decreased levels of Cr in wastewater (p-value = 0.012), with the effective contact time was 6 days with 31.318% .

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While the results of two phase research shows that there are also significant differences in decreased levels of Cr in wastewater at all weight variation (p-value = 0.000), and weight effective to reduce levels of Cr in the liquid waste was 600 gram of Pistia stratiotes plant with effectiveness reach 30.177% with combined method of constructed wetland. This research shows that there are differences in decreased levels of Cr in wastewater at various contact time and weight variation, or in other words the contact time variation and variation weight of Pistia stratiotes effect on decreased levels of Cr.

Keywords: Phytoremediation, Pistia stratiotes, contact time, constructed wetland

1. Introduction

Some batik entrepreneurs had experienced a heyday. Especially in the 1980s batik was a formal dress to be worn on any occasion state or other official events. So as to introduce and improve the image of batik in the international community at that time [1]. Batik industry in Indonesia spread over several areas in Java which later became the name of types such as batik Batik of Pekalongan, batik of Solo, Batik of Yogya, batik of Lasem, Batik of Cirebon, batik of Sragen. Each batik from the area has a specific characteristic motif. Type batik produced three namely hand-drawn batik, stamped batik and batik printing. Batik as cultural heritage become familiar in the world after the recognition of UNESCO on October 2, 2009. One area was known with batik is Pekalongan. Pekalongan is central largest producer of batik in Indonesia so dubbed by the city of Batik [1,2].

Pekalongan is the most dominan of batik producer in the supply of batik to the wholesale markets and in the all over Indonesia with many kinds of batik products are produced, such as stamped batik, drawn-hand batik and batik printing. Batik has been a source of income for the people of Pekalongan. But behind the beauty of batik, there is the problem that the liquid waste of batik. Liquid waste is one of the contaminants of water that is a byproduct of industrial development. In fact, batik waste is a problem that is difficult to overcome, because each manufacturer batik home, every day throwing tens of cubic water mixed drug batik (batik waste). In general, waste originating from batik industry discharged directly without going through the treatment process beforehand. Contaminants contained in the waste of batik vary, such as phenol, ammonia (NH3) in total, sulphide, pH, BOD, COD, oil, fat color, heavy metals Cadmium (Cd), Chromium (Cr), lead (Pb) and organic material which can cause odor.

Pollution from heavy metals from industrial wastewater needs to be minimized existence.Liquid waste is discharged can cause a decrease in the quality of the environment where disposal that may threaten the availability of clean water and the preservation of the environmental ecosystem. Heavy metals discharged into the environment will accumulate and can damage both directly and indirectly to living creatures, especially humans. Direct accumulation can occur through contact with contaminated irrigation systems, whereas indirect accumulation can occur through the food chain such as fish, vegetables contaminated with heavy metals. Heavy metal pollution occurs in several river in the town of Pekalongan. This has become one of the serious problems. According to data from the Environmental Office of Pekalongan city on river water quality monitoring in 2013 the results of the test parameter contains chromium (Chromium) in river water showed that almost all the rivers

were monitored its Chromium levels already exceed the quality standards established in accordance PP 82 of 2001 was 0.05 mg / l [2].

The ability of plants to absorb heavy metals in the water in variable amounts, and only certain plants that are known to accumulate certain metals in high enough concentrations. Some types of aquatic plants capable of working as an agent phytoremediation (plant absorbing heavy metals) such as Azolla, water clover, water hyacinth, plant of Pistia [3].

The utilization of plant of Pistia stratiotes in water treatment has been carried out of that was conducted by [4] in 2008 was using plant of Pistia stratiotes as pretreatment for surface water with color and TDS parameters, the results of these research at a concentration of 100% with a decline TDS from 308 mg / l to 128 mg / l. The research of Tuti Suryanti and Budi Priyanto in 2003 [5] studied the elimination of heavy metal cadmium in wastewater using plant of Pistia stratiotes, showed the percentage reduction in Cd levels in wastewater at 93.5%. This research will use a method of phytoremediation using plant of Pistia stratiotes in lowering levels of chromium metal in the waste of batik with a variety of heavy media plants with constructed wetlands technology combines with the type of Subsurface Flow Systems where the effective time has been determined previously

2. Materials and Methods

2.1 Study Materials

The independent variable in this research is a phytoremediation medium weight that is Pistia stratiotes as the media, in this research there are three variations of weight of 200 g, 400 g and 600 g. While the dependent variable in this research is the level of chromium metal in batik waste. Controlled variable in this research is the effective time for phytoremediation, waste temperature, pH and light intensity waste when given treatment.

2.2 The research hypothesis

The hypothesis in this research that there was a difference penurunaan Cr levels in wastewater with heavy media with a method of phytoremediation using plant of Pistia stratiotes.

2.3 The type design research

This type of research was a quasi-experimental model with repeated non-random experimental design called pretest-posttest control group design was a research model by using a treatment (intervention) on the subject of research in the field to know the results of the changes (changes to the variable or research object after treated (intervention) [6].

3. Results and Discussion

The observation results of batik wastewater characteristics found that the color of the waste water was murky and smelled with sewage water colors vary (according to the type of dye when it is used). It was also found in

the ditch around the industry up to the river. The river water was black-colored and smelling. From the results of the initial examination of the levels of Cr on home industry wastewater obtained results of 1.89 mg / l, while the examination of Cr metal content in river water of 0.2 mg / l.

3.1 The checking result of Cr level with a difference contact time

This research was done to reduce levels of Cr in wastewater of batik home industry using plant of Pistia stratiotes. Phytoremediation processes carried out by the variation contacts 2 days, 4 days, and 6 days. This is because of the results of existing research that plant of Pistia stratiotes can grow well in wastewater until the sixth day. On the seventh day, the physical characteristics of plants show the color of the leaves begin to turn yellow and root hairs begin to fall out. Changes in the physical characteristics of this plant occurs because the plant began entering saturation point of the absorption of contaminants in wastewater.

Table 1: The results of examination Cr levels after phytoremediation with the difference contact time

Level of Cr *Pre test* (mg/l)	Level of Cr *Post test* (mg/l)					
	P1	k-P1	P2	K-P2	P3	k-P3
	(Days 2)		(Days 4)		(Days 5)	
0,645	0,639	0,006	0,635	0,01	0,59	0,055
0,645	0,611	0,034	0,622	0,023	0,565	0,08
0,645	0,598	0,047	0,608	0,037	0,523	0,122
0,645	0,572	0,073	0,579	0,066	0,497	0,148
0,645	0,56	0,085	0,525	0,12	0,458	0,187
0,645	0,532	0,113	0,502	0,143	0,416	0,229
0,645	0,513	0,132	0,478	0,167	0,385	0,26
0,645	0,488	0,157	0,445	0,2	0,36	0,285
0,645	0,465	0,18	0,418	0,227	0,33	0,315
0,645	0,449	0,196	0,397	0,248	0,306	0,339
Average 0,645	0,5427	0,1023	0,5209	0,1241	0,443	0,202

Table 1 show that the average Cr levels pre group was 0,645 mg / l, while the average Cr content group post was 0.5427 mg / l. On treatment with contact 2-day, the average differences Cr levels pre and post group was 0.1023 mg / l. While the Cr content of the group average post was 0.5209 mg / l. On treatment with contact 4 days, the average differences Cr levels pre and post group was 0.1241 mg / l. And for the treatment of 6 days the average Cr levels post group was 0.443 mg / l. On treatment with contact 6 days, the average differences Cr levels pre and post group was 0.202 mg / l.

Table 2: The effectiveness decrease varying levels of Cr with day of contact of pistia stratiotes plant

Number of treatment-	The affectivities of varying day of contact (%)		
	Days 2	Days 4	Days 6
1	0,930	1,550	8,527
2	5,271	3,566	12,403
3	7,287	5,736	18,915
4	11,318	10,233	22,946
5	13,178	18,605	28,992
6	17,519	22,171	35,504
7	20,465	25,891	40,310
8	24,341	31,008	44,186
9	27,907	35,194	48,837
10	30,388	38,450	52,558
Average	15,860	19,240	31,318

Table 2 is based on the calculation of the effectiveness of Cr decreased levels using plant of Pistia stratiotes with a variety of contacts 2, 4 and 6 days showed an average effectiveness largest decrease in contact time of 6 days in the amount of 31.318%.

3.2 The result of data analysis

The statistical analysis to determine the effect of variations in contact day with plant of Pistia stratiotes to decrease the levels of Cr in the liquid waste of batik. Statistical tests used are:

a. The Data normality test with Shapiro-Wilk

Based on the data normality test by Shapiro-Wilk ie data obtained Cr levels post test p-value = 0.393 (> 0.05) and decrease of Cr levels obtained p-value = 0.260 (> 0.05), then Ha is rejected, Ho accepted , So the data post test levels of Cr and Cr decreased levels of data are normally distributed.

b. Homogeneity test

Based on the data normality test with Levene Statistic ie data obtained Cr levels post test p-value = 0.239 (> 0.05) and decrease of Cr levels obtained p-value = 0.119 (> 0.05), then Ha is rejected, Ho is accepted. So the data post test levels of Cr and Cr decreased levels of data are homogeneous.

c. One Way Anova

Based on the test of One Way Anova, the values obtained as the table below:

Table 3: The test result of One Way Anova Phase I

		Sum of Squares	df	Mean Square	F	Sig.
Level of decrease	Between Groups	0,063	2	0,031	5,195	0,012
	Within Groups	0,162	27	0,006		
Total		0,225	29			

From Table 3 known p-value = 0.012 (<0.05), then Ha accepted, Ho rejected. So there is a difference decreased levels of Cr on batik waste water before and after treatment with long variation contact with plant of Pistia stratiotes.

d. Post Hoc Test

Post Hoc test used was the Least Significant Different (LSD) due to the same variant. The test results were obtained as the table below:

Table 4: The test Results LSD Post Hoc Test Phase I

(I) Treatment	(J) Treatment	Mean Difference (I-J)	Sig.	95% Confidence Interval	
				Lower Bound	Upper Bound
plant of Pistia stratiotes in 2days	plant of Pistia stratiotes in 4 days	-0,006000	0,864	-0,07718	0,06518
	plant of Pistia stratiotes in 6 days	-0,099700*	0,008	-0,17088	-0,02852
plant of Pistia stratiotes in 4 days	plant of Pistia stratiotes in 2 days	0,006000	0,864	-0,06518	0,07718
	plant of Pistia stratiotes in 6 days	-0,093700*	0,012	-0,16488	-0,02252
plant of Pistia stratiotes in 6 days	plant of Pistia stratiotes in 2 days	0,099700*	0,008	0,02852	0,17088
	plant of Pistia stratiotes in 4 days	0,093700*	0,012	0,02252	0,16488

From Table 4 it can be seen that:

a. There is a significant difference in the average decreased levels of Cr waste by processing using plant of Pistia stratiotes between variations within 2 days to 6 days (p-value = 0.008).

b. There is a significant difference in the average decreased levels of Cr waste by processing using plant of Pistia stratiotes between variations in a time of 4 days to 6 days (p-value = 0.012).

The results obtained from the mean difference indicates that the most effective treatment that could reduce levels of Cr metal when treated with a contact time of 6 days because the group has the greatest mean difference.

4. Discussion

4.1 Levels of Cr before treatment

Dye which can affect levels of Cr was chrome yellow, reactive and modrant. Another compound which was used as a dye with a content of chromium is iron chromium oxide (FeCr2O4) and CrF6 which gives a yellow color. The use of dyes containing chromium during many industrial processes that will lead to increased levels of Cr in waste water. The content of Cr mainly in the dye mordant. Chemicals needed in the process of coloring mordant were sodium sulphate, acetic, formic acid, naphthalenedisulfic acid, disodium salt, Na or K dichromate [7]. Modrant dye contains heavy metals commonly used as chromium, aluminum, copper and iron. The use of these dyes for dyeing wool usually, leather, fur, and coatings alumunium. In reactive dye also contained heavy metals, but the numbers are below the limit requirement of ET AD [8].

4.2 Levels of Cr after treatment

The decrease in the mean levels of Cr in each treatment amounted to 0.102 MGL / l with a contact time of 2 days, 0.124 mg / l with a contact time of 4 days, and 0.202 mg / l with a contact time of 6 days. Smallest decline occurred in treatment with 2 days old contacts ie 0.102 mg / l. This research was in line with research of [9] which states long effective contact of water hyacinth plant to the decline of heavy metals Cd was 6 days. As for Pistia stratiotes plants, in the range of 4-8 days contacts show effectively decreased levels of Cd [10].

Treatment with phytoremediation method aims to reduce levels of Cr in wastewater with contacting with Pistia stratiotes plants. Another research finding by [11] using Pistia stratiotes plants was able to reduce levels of up to 92.01% Cr with plant regeneration method every day for 4 days contacts, while for the method without regeneration plant, the levels of Cr were able to be lowered to 89, 95% for 4 days contacts. , The process of absorption of heavy metal contaminants by plants as a result of the diffusion law, namely the movement of metal ions of Cr dense media concentration to a more dilute concentration, into the cell membrane [11].

4.3 *The effect of Long Contacts Pistia stratiotes plants to decrease of Cr level*

Long contact time was in the process of phytoremediation plants to absorb contaminants in the water. The longer the contact will increase the absorption of contaminants in the waste water to the saturation point the plant to absorb. Another research conducted by [12] concern the absorption of Cu and Zn using plants of water hyacinth. The research results show the contact time of 14 days there are optimum absorption of Cu, but the contact time of 21 days absorption of Cu began to decline. While the absorption of Zn show equilibrium after

long contact 14 days. This is because the concentration of Cu and Zn in the media on the wane due to plant uptake [12].

5. Conclusion and Suggestion

5.1 Conclusion

1. Levels of Cr total home industry batik wastewater before treatment with variation of contact time was 0.645 mg / l, whereas before treatment of combination of phytoremediation plant of Pistia stratiotes with a constructed wetland was 0.679 mg / l.
2. Calculating the difference in the levels of metals Chromium (Cr) on wastewater of batik home industry before and after treated with phytoremediation plant of Pistia stratiotes and the effectiveness of treatment with variations in time:

a. Phytoremediation plant of Pistia stratiotes with contacts of 2 days to reduce levels of Cr with an average 1023 mg / l and the average effectiveness 15.860%
b. Phytoremediation plant of Pistia stratiotes with contacts of 4 days to reduce levels of Cr with an average 0,1241 mg/l and the average effectiveness 19,240%
c. Phytoremediation plant of Pistia stratiotes with contacts of 6 days to reduce levels of Cr with an average 0,202 mg/l and the average effectiveness 31,318%

3. There is a significant difference between the amount of Cr decreased levels in all treatment groups or variations prolonged contact to give effect to decreased levels of Cr in the liquid waste of batik industry with phytoremediation plant of Pistia stratiotes with a p-value = 0.012 (<0.05)
4. Levels of Cr total wastewater of batik home industry before treatment combination of phytoremediation plant of Pistia stratiotes weight variation with the constructed wetland was 0.679 mg / l.
5. Calculating the difference in the levels of metals Chromium (Cr) on wastewater of batik home industry before and after treated with phytoremediation plant of Pistia stratiotes and the effectiveness of treatment with severe variations and combinations of the wetland:

    a. Phytoremediation plant of Pistia stratiotes by weight variation plant of Pistia stratiotes in combination with methods of *constructed wetland* lowering Cr with an average of 1.227 mg / l and an average effectiveness 18.071%
    b. Phytoremediation plant of Pistia stratiotes by weight variation plant of Pistia stratiotes in combination with methods of *constructed wetland* lowering Cr with an average of 0,133 mg/l and an average effectiveness 19,588%
    c. Phytoremediation plant of Pistia stratiotes by weight variation plant of Pistia stratiotes in combination with methods of *constructed wetland* lowering Cr with an average of 0,2049 mg/l and an average effectiveness 30,177%

6. There is a significant difference between the amount of Cr decreased levels in all groups treated with wood phytoremediation plant of Pistia stratiotes by weight variation of plant of Pistia stratiotes in combination

with the method constructed wetland with p-value = 0.000 (<0.005)

5.2 Suggestions

For the batik industry entrepreneurs are advised to do the processing of waste water before discharge into water so it didn`t cause pollution. One way was to utilize Pistia stratiotes which are easy to find in the environment around the rice fields. The further research needs to be conducted with the density and duration of contact of Pistia stratiotes with a combination of constructed wetland used to obtain better results.

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