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Removal of chromium from batik wastewater by using kenaf (*Hibiscus cannabinus L.*) with bed evapotranspiration

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Removal of chromium from batik wastewater by using kenaf (*Hibiscus cannabinus L.*) with bed evapotranspiration

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Abstract. Wastewater treatment using plants is being applied by researchers to its capability in metal removal. Technologies are using plants for treatment as a green technology. Phytotreatment is a technology using plants that can reduce organic and inorganic pollutants in the environment. Kenaf (*Hibiscus cannabinus* L.) is terrestrial plants that can be used in the phytotreatment process because they can reduce pollutants. The aim of this study was to remove chromium from batik wastewater. This experiment used bacth system in bed evapotranspiration. Variables used were kenaf plant varieties (KR 11 and KR 15), kenaf plant age (30 days and 45 days), and batik wastewater concentration. This research was conducted for 28 days. The specific response of kenaf plants is indicated by the growth of kenaf, the increase in plant height and the number of leaves in the batik wastewater treatment. The most removal of chromium was found 66,49 %. The results showed that Kenaf can be used for phytotreatment agent to removal of chromium.

1. Introduction

Batik is one of Indonesian cultural heritage of high value. The batik industry is an industry that is currently growing rapidly. Batik wastewater is produced from the batik industry. Activities batik industries produce wastewater that contains a dye. Some types of dyes derived from the washing process of batik cloth contain heavy metals such as chromium (Cr). Concentrations of metals Cr in batik wastewater is the highest than other heavy metals wich is 3.263 ppm [1]. According to East Java Governor Regulation Number 82 of the year 2014 about wastewater quality standards for industrial wastewater and / or other business activities in East Java Indonesia, the quality standard Cr in wastewater is 0.5 ppm. Wastewater and sediments contain heavy metals Cr produced from the manufacture or coloring. Wastewater of household scale batik industry usually directly discharged into water bodies without any treatment. Laboratory analysis of batik home industry wastewater showed groundwater samples containing Cr exceeding quality standards. The regulations of the Government of the Republic of Indonesia Number 82 of the year 2001, the quality standard Cr in water or river is 0.05 ppm. Wastewater contain Cr which is directly thrown into the environment results in increasing the amount of heavy metal ions in environmental water. Environmental water containing excessive amounts of heavy metal ions generally cannot be consumed as drinking water. The content of Cr in the water that exceed the quality standards can cause health effects for humans. Heavy metals are potentially toxic if the concentration is too high in the body. Cr is a heavy metal which is categorized as very toxic, can cause death or health problems that do not recover in a short period of time. Therefore, batik wastewater treatment is needed.

Phytotreatment is a technology using plants that can reduce organic and inorganic pollutants in the environment. This is the most cost effective treatment methods [2]. Some plants have the ability to remediate heavy metal contamination in the soil. Processing soil contaminated with heavy metals using plants is an effective, inexpensive and environmentally friendly technology Plants can absorb, reduce, degrade, move and immobilize pollutants such as heavy metals [3]. Plants have the ability to accumulate heavy metals and reduce heavy metals. Heavy metals that can accumulate in the roots and shoots [4].

Kenaf plants (*Hibiscus cannabinus* L.) are commercial plants that have important economic potential, including paper production, building materials, and textiles. Kenaf plants have the ability to adapt to climate and soil, are tolerant of salt, but sensitive to water loss. In the previous study it was

found that kenaf plants were tolerant of pollutants. Kenaf plants can reduce heavy metals [5]. The aim of this study was determining removal concentration Cr from batik wastewater treatment.

2. Method

Reactor uses an evapotranspiration bed system. The research reactor is a batch. The research use composite sampling and constructed wetlands with Horizontal Subsurface Flow. The kenaf plants tested were varieties of KR 11 and KR 15 with age 30 and 45 days. The tools and materials used in this study was follows: Observation and parameter analysis equipment, plastic tubs, plastic pots, thermometers, rulers, parameter analysis equipment. The materials used in this study are Kenaf plants, PDAM water, batik wastewater, sand, gravel, Cr content analysis.

2.1 Plant acclimatization

Acclimatization stage of plants is carried out in a greenhouse. The seeds had been taken in BALITTAS (Balai Tanaman Serat dan Pemanis) in Malang city. The seeds was planted in polybags that containing media in the garden soil and fertilizer in a ratio of 1: 1. The plants had been watered every day using PDAM water for 1-2 weeks during germination and shoots. Then the Kenaf plant was transferred to a polybag.

2.2 Preliminary analysis test

The initial testing phase was to test Cr concentration in batik wastewater. The batik wastewater was taken from the home industry batik cloth in Sumberjambe, Jember Regency.

2.3 Range Finding Test (RFT)

Range finding tests was conducted to argue the ability of plants to absorb pollutants contained in batik wastewater. The RFT on the test this time is done: 25%, 50%, 75%, and 100%. In this test the kenaf plants specific response to batik wastewater were observed. Planting parameters were observed after 7 days of exposure.

2.4 Phytotreatment test

The reactor was operated according to a predetermined research variation. Phytotreatment test reactor were 27 reactors. The kenaf plants used were 5 plants each reactor. The phytoremediation test reactor had been given batik wastewater according to the results of the RFT concentration at the specified reactor. Parameter testing was carried out 7 days for 28 days.

2.5 Phytotreatment analysis

The analysis of Cr contained in batik wastewater used atomic absorption spectrophotometer. Plant analysis were a physical analysis of kenaf plants, plant height and number of leaves. Temperature analysis used thermometer to analyze each reactor.

2.6 Data analysis

The data obtained from observations were analyzed with a complete randomized design using ANOVA (Analysis of Variance). ANOVA is a statistical test to facilitate analysis of several different sample groups with the smallest risk of error. This test can find out the significance of the average difference between one sample group to another that can be used in laboratory experiments.

3. Results and Discussion

The plants used in this experiments used Kenaf that were varieties KR11 and KR15. The two varieties are including superior varieties owned by BALITTAS Kenaf seeds measuring 0.5 cm. Preliminary research was carried out first before the main research was carried out. This aims to obtain data on the characteristics and content of heavy metals in the wastewater. Analysis of heavy metal content Cr was 1.54 ppm in batik wastewater. This batik wastewater exceeds the wastewater quality standard. The characteristics of batik wastewater are characterized by very thick colors.

RFT is an important stage to determine the level of maximum batik wastewater that can be absorbed by the kenaf plant. The observation phase of the 7th day of RFT kenaf KR 11 and KR 15 at concentrations of 25%, 50%, 75% showed that most of the leaf color was green and the stem of the plant was brown. At the observation of 100% concentration most of the kenaf leaves are yellow and the stems are yellowish green. This shows that growth and development is not optimal at 100% concentration. In the concentration of 75%, kenaf plants can grow well and are still tolerant of pollutants of batik wastewater. The maximum level of batik wastewater that can be tolerated by kenaf plants is a concentration of 75%. So, the phytotreatment test used was 75%.

The observations show that Kenaf plants have the ability to adapt on land exposed to batik wastewater. The consentration Cr has decreased in the phytotreatment test (Figure 1).

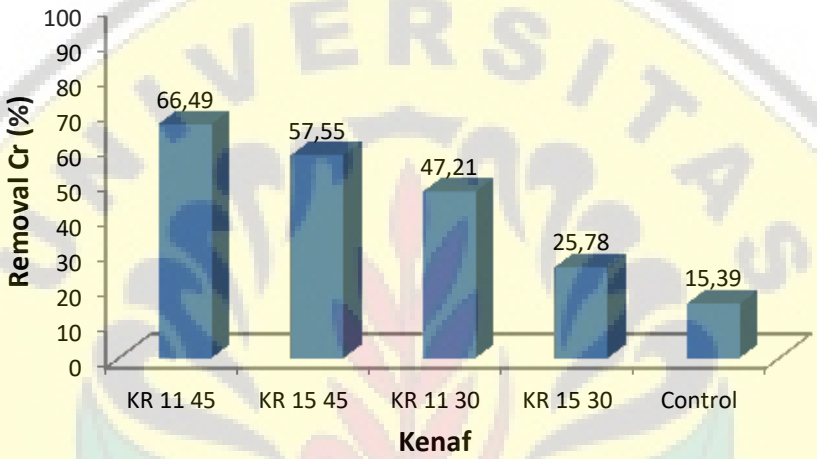

Figure 1. Phytotreatment test

The results of the observation of the highest decrease in Cr levels for KR11 plants aged 45 days were 66.49%. The results of ANOVA on the deconcentration of heavy metal Cr in the reactor of batik wastewater showed a significant difference with the control. Based on physiological mechanisms, Kenaf plants actively reduce the metal concentration found in batik wastewater. Kenaf plants can reduce organic pollutants and heavy metals [6]. Heavy metal removal can occur because the physiological and biochemical responses were plants and metal specific [7]. Kenaf can uptake and accumulation Cr in the leaves, stems and roots [8]. This study showed that concentration of Cr reduced in phytotreatment test that can be accumulated Cr in the leaves, stems and roots.

The observation of kenaf plant physical used plant height and number of leaves. This aims to determine the specific response of kenaf plants to exposure to batik wastewater. The study was carried out during the vegetative period of the Kenaf plant. The vegetative period of the kenaf plant is up to 90 days. At this time the plants experience growth such as the addition of size and number of cells in a plant. On observation of plant height and number of leaves can be seen optimal growth or slowing down. Plant height was observed as a growth parameter to measure environmental influences or treatments. The most visible growth size was plant height (Figure 2).

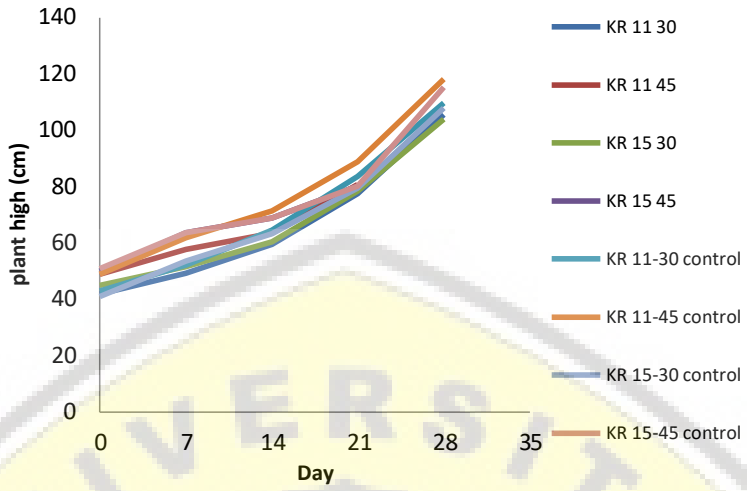

Figure 2. Plant High Growth

The results of physical analysis of plants was able to survive in the phytotreatment test. This was because the kenaf plants could tolerate the pollutants of batik wastewater containing Cr. The observation results showed that the longest kenaf plant height was KR 11 age 45 days which was 116 cm.

The second parameter of vegetative growth observed was the number of leaves. Observation of the number of leaves is needed as an indicator. Additional number of leaves was also needed as supporting data to explain the growth process in the phytotreatment test (Figure 3).

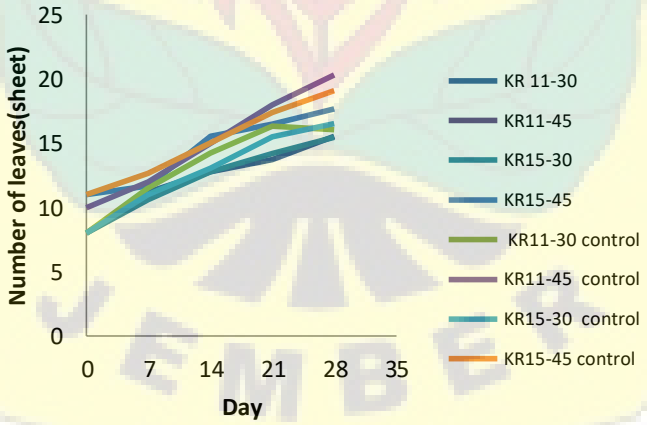

Figure 3. Number of Leaves in phytotreatment test

The observation number of leaves appear in Figure 3 that were not so much different. The phytotreatment test showed that the most number of leaves was Kenaf KR 11 age 45 days. This number of leaves were 19 leaves. Based on observations of plants physical showed that were a plant-specific responses in each treatment. Kenaf KR 11 and Kenaf KR 15 growth in phytotreatment test has been shown in plant height and number of leaves. This study indicated that Kenaf KR 11 and Kenaf KR 15 tolerant of Cr in batik wastewater treatment. Concentration of Cr and other heavy metals were found on the stems and leaves of kenaf [9].

Temperature affects metabolic rate, ionization balance, gas transfer rate and substrate solubility. The temperature also affects microorganisms with the optimum temperature of the organism is 30 ° C. In this study, the results of fluctuating temperature measurements were not much different (Figure 4).

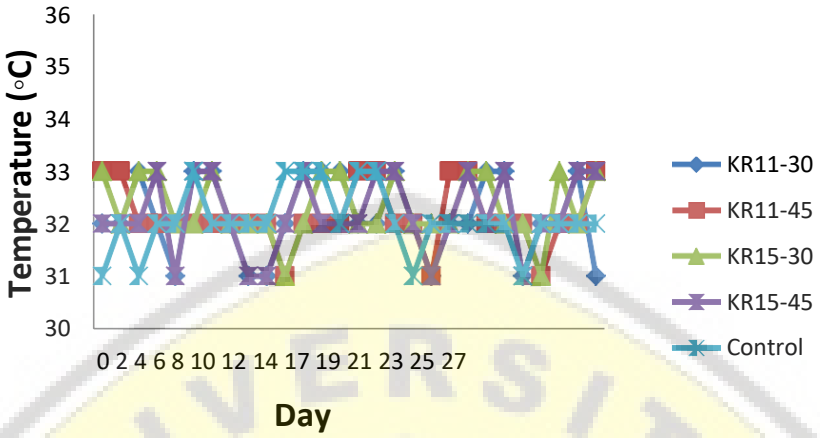

Figure 4. Temperature Analysis

The observations of the temperature of the phytotretment test was ranging from 31-33˚C. This temperature is the condition of plants that are able to perform growth and development.

4. Conclusion

The results presented here was based on data analysis and discussion of phytotreatment test. The most reduction efficiency of chromium in the batik wastewater treatment was kenaf KR 11 age 45 days that was 66.49%. The specific response of the kenaf plant were characterized by the growth of kenaf in increasing plant height and number of leaves in the treatment of batik wastewater. The observation results showed that the longest kenaf plant height and the most number of leaves was KR 11 age 45 days.

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