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The Effectiveness of *Pistia stratiotes* as Phytoremediation Agents in Reducing Lead (Pb) Levels in Batik Household Industrial Wastewater in Bakaran Village, Central Java-Indonesia

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Authors' contributions

This work was carried out in collaboration between both authors. This research was conducted at the Laboratory for health and testing of medical devices, Central Java and the health laboratory, Dian Nusantara University in collaboration between authors KDKR and IS. Author KDKR conducted the research design, analyzed the results of the study and wrote the initial draft script. Author IS administered the research analysis and administered the literature search and administered corrections to the draft final research report. Both authors read and approved the final draft of this article.

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ABSTRACT

Background and Objectives: The Bakaran Batik industry is engaged in domestic textiles in Juwana district, Indonesia. The wastewater produced by the burnt batik is discharged into the environment without going through any prior treatment. Therefore, an effective and easy-to-implement processing technology is needed by the community. Phytoremediation technology is an effort to treat waste that is proven to be effective and easy to implement. This study aims to determine the effectiveness of the *Pistia stratiotes* in reducing Lead (Pb) levels in batik wastewater.
Methodology: The method used in this research is the type of experimental research. The

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research method is True Experimental with Post-test Only Control Group Design. The statistical test used is One Way Anova and linear regression test to determine the rate of degradation.
Results: showed that the *Pistia stratiotes* was effective in reducing lead levels of Lead (Pb) from an initial concentration of 0.042 ppm to 0.022 on a day for 48 hours, the speed of degradation was based on the linear equation - 0.0108x + 0.048, R^2 = 0.8526 in the treatment with *Pistia stratiotes* 50 grams, whereas in the 75 grams and 90 grams the Lead (Pb) concentration was not detected.
Conclusions: Phytoremediation with the biological agent *Pistia stratiotes* is quite effective in degrading Lead (Pb) -containing batik waste.

Keywords: Phytoremediation; Pistia stratiotes; lead (Pb); degradation; batik liquid waste.

1. INTRODUCTION

Batik cloth is a legacy of the Indonesian nation and the wealth of the Indonesian nation. Batik is used as an identity and national identity which is the embodiment of cultural diversity which has unique symbolic values and has high aesthetic value for all Indonesian people [1].

The batik industry in Bakaran Juwana village has become the largest center for written batik craftsmen in Pati Regency so that it is a special attraction for the economy of the people of Pati Regency, especially the Juwana community, but the increasing demand for batik production can also have a negative impact on environmental issues [2]. The batik industry is also an industry that uses a lot of water in its production, which results in looking for waste at the end of the production process. Batik industrial waste is a series of waste products that are no longer used, especially in the washing process. Liquid waste in the batik production process contains heavy metals such as Pb, Cr, Cu and others. The use of water in the household batik-making process is estimated at an average of 25 - 50 m^3 per meter of batik cloth [3].

Lead or Plumbum (Pb) is a heavy blackish metal that is used as a constituent in industry, paint, batteries, and is currently widely used in the manufacture of gasoline. Heavy metal Lead (Pb) can also cause acute poisoning of the human nervous system through the intake of Lead (Pb) which is contaminated in food [4]. Contamination by heavy metal Lead (Pb) cannot be broken down through natural processes and very difficult to decompose (presistent). therefore an effective way to reduce the heavy metal content of Lead (Pb) is by means of phytoremediation technology [5]. Phytoremediation is an effort to restore polluted environmental conditions by utilizing biological agents (plants). Utilization of plants that have hypercumulator properties in specific heavy metals which can be used for the phytoremediation of wastewater [6]. *Pistia stratiotes* is a hyperaccumulator plant to absorb heavy metal Pb. Pollutants that are remediated include heavy metals, in this case Lead (Pb). The *Pistia stratiotes* is a plant that belongs to water weeds, and can be used as a phytoremediation plant to absorb and stabilize toxins, such as heavy metals found in batik liquid waste [7].

This research is a case study of phytoremediation by utilizing *Pistia stratiotes* as a biological agent in reducing the concentration of Lead (Pb) in household batik waste in Bakaran Village, Central Java.

2. RESEARCH METHODS

This research was conducted from September to October 2020. The instrument used for the phytoremediation study of Lead (Pb) levels was *Atomic absorption spectrometer* (AAS) AMT 3800 series [8]. The examination was carried out at the Laboratory for Health and Medical Device Testing, Semarang. The material used in this study is the household batik industrial waste water in the Bakaran Kulon Juwana village. The *Pistia stratiotes* samples were obtained from a pond owned by the residents of Sidoarum village. Then the acclimatization process is carried out, which is a process of adjusting or adapting the plants to be used in the new planting medium, and the surrounding conditions, the acclimatization process for three days. Before the acclimatization stage, the Pistia stratiot was first cleaned of dirt and then the acclimatization stage was carried out. After the acclimatization process was carried out for 3 days, the Pistia stratiot was weighed with a weight of 50 gr, 70 gr, and 90 g for the variety of research needs. The Pistia stratiote is weighed then transferred to a container that already contains batik liquid waste. The Pb level test in the batik waste

sample was carried out on the second, fourth, and sixth day and then tested in the laboratory.

This study used a completely randomized design with a true experimental method with post-test only control group design [9].

3. RESULTS AND DISCUSSION

Most of the batik industry in Bakaran Kulon Village does not have sewage treatment plants due to limited space and costs, so the batik wastewater is discharged into open waterways. This causes ecological isturbances to the surrounding environment, especially pollutant lead (Pb) pollution which is quite dangerous because it is bioaccumulated and biomagnified. Therefore it is necessary to reduce the lead pollutant (Pb) contained in the batik industry wastewater through phytoremediation technology.

Phytoremediation research on Lead (Pb) levels was carried out on batik liquid waste as a control (before processing) and after processing it by giving weight variations on the *Pistia stratiot*. Table 1 shows the results of the lead content analysis lead (Pb) , as follows:

Fig. 1 shows a graph of the degradation of Lead (Pb) concentrations and a linear equation model based on the rate of reduction in Lead (Pb) concentration by *Pistia stratiotes* based on each treatment

Table 1. Average lead (Pb) concentration test results per day (mg / l)

Treatment	Day1	Day 2	Day 4	Day 6
Treatment control	0.042	0.042	0.042	0.042
Treatment 50 g	0.042	0.022	<0.010	<0.010
Treatment 70 g	0.042	<0.010	<0.010	<0.010
Treatment 90 g	0.042	<0.010	<0.010	<0.010

Note: limit of detection Atomic absorption spectrometer (AAS methods) = < 0.010

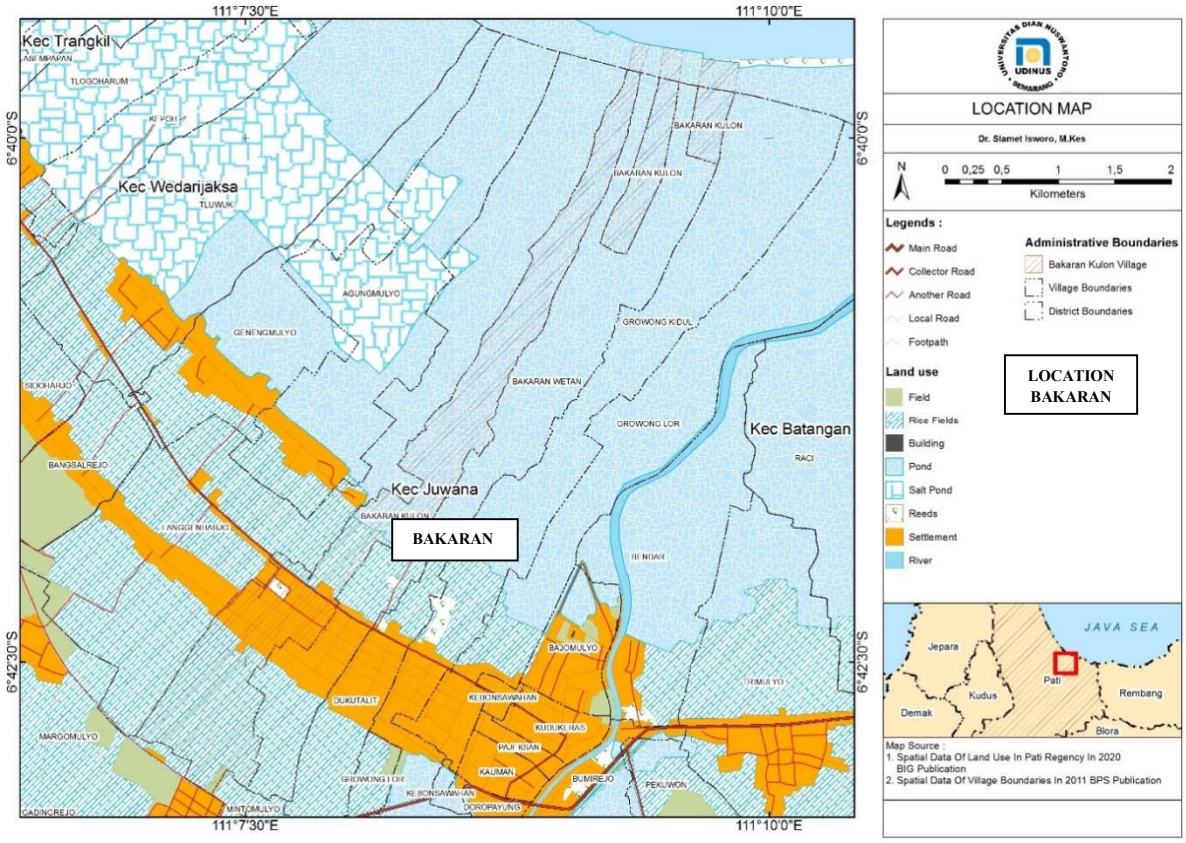

Fig. 1. Location of Bakaran village

The picture 2 is Pistia stratiotes used in phytoremediation research, as follows: (research documentation)

Based on Table 1. In all treatments, namely treatment 50 g, treatment 70 g and treatment 90 g showed a decrease in the concentration of Lead (Pb), it was shown that all equations had a negative value. (y= -0.02 x + 0,062/ 50 gr, -0,032 x + 0,074 / 70 gram and -0,032 x + 0,074 / 90 gram). However, only treatment with a sample weight of 50 grams can be detected by the atomic absorption spectrometer, namely a decrease in the concentration of Lead (Pb) on the 2nd day from a concentration of 0.042 mg/l t o 0.022 mg/l, while on the 4th day and the concentration of Lead (Pb) not detected. (exceed detection limit). In the 70 gram and 90 gram treatments, the lead concentration (Pb) was not detected. The possibility of concentration resulting from phytoremediation is so small that the detection limit of the atomic absorption spectrometer cannot be reached.

This shows that the Lead (Pb) concentration has been completely degraded, with the linear equation model y = 0.02 x + 0.62. In the 3rd and 4th treatments with sample weights of 70 and 90 grams, it was shown that on day 2 the Lead (Pb) concentration was not detected (exceeding the detection limit), this shows that the Lead (Pb) concentration has been degraded by the linear equation model y = - 0.32 x + 0.074. The linear equation shows that the rate of Lead (Pb) degradation is better at 70 gram and 90 gram treatments. The more or the weight of the Pistia stratiot as a remediator agent, the faster the lead pollutant (Pb) degradation process will be [10].

The result of the effectiveness test shows that the weight (number) of Pistia stratiot as a remediator agent affects the phytoremediation process. Table 2, as follow:

Table 2. Degradation efficiency of *Pistia stratiotes*

No	Treatment	Lead (Pb) (%)
1.	50 gram	95.40%
2.	70 gram	100 %
3.	90 gram	100 %

Analysis of Table 2 shows that the greater the number or weight of *Pistia stratiotes* plants, the faster the phytoremediation process. More and more metabolic processes in plants will cause the speed of degradation of pollutants by plants to be faster [11].

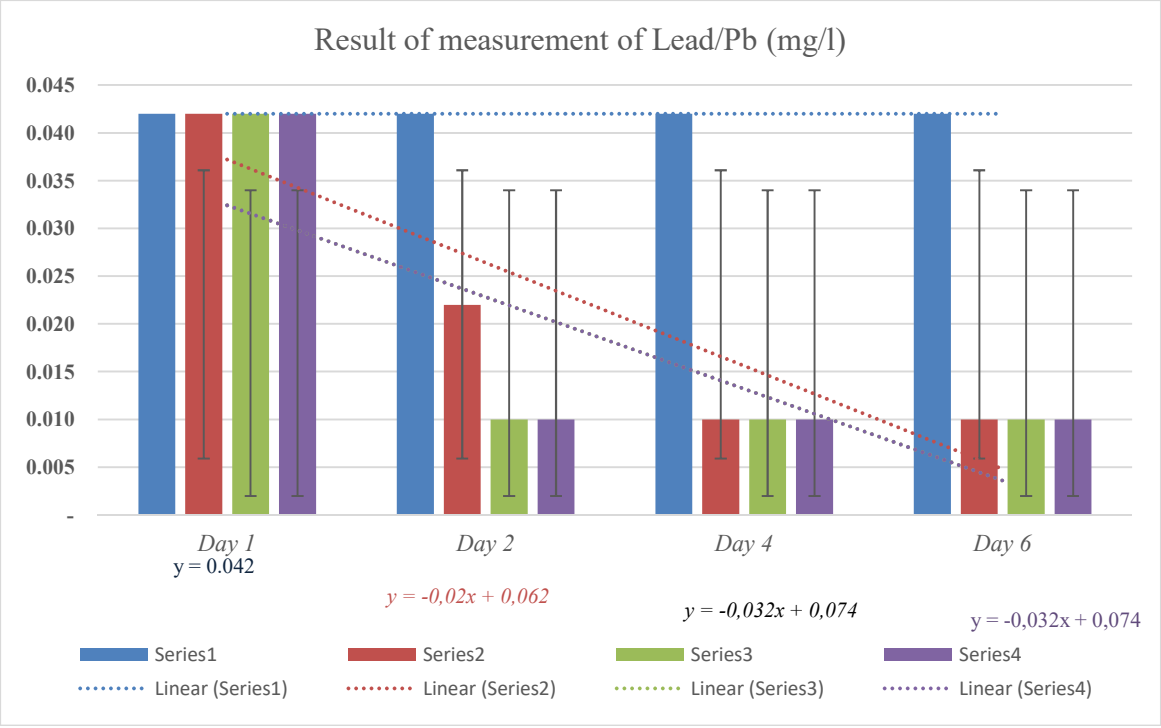

Fig. 2. Result of measurement of lead (Pb) (mg/lt)

Fig. 3. *Pistia stratiotes*

Fig. 4. Chlorosis in *Pistia stratiotes*

The absorption mechanism of Lead (Pb) in batik liquid waste is carried out by the root tips of the *Pistia stratiotes.* Substances that are absorbed by the roots will enter the stem through the xylem vessels, which are then passed to the stems and then the leaves through the photosynthetic mechanism [12].

Metabolism in the test plant will be disrupted if the pollutant (Lead (Pb)) is absorbed excessively and will cause chlorosis [13]. *Pistia stratiotes* that have absorbed Lead (Pb) will try to prevent poisoning by accumulating these toxins in certain organs, such as roots, which will be translocated into the tissues and enter the xylem, but if the load of Lead (Pb) is very high it disrupts metabolism and can cause plant death. The leaves will change color gradually, the color change on the leaves turns yellowish and brownish, this is called a symptom of chlorosis [14]. Symptoms of chlorosis in plants are caused by exposure to high Lead (Pb) for a long time, thus inhibiting the action of enzymes that catalyze chlorophyll synthesis [15]. his can be seen from the leaves in the test sample which are yellow and brownish.

4. CONCLUSION

The *Pistia stratiotes* is effective in reducing the Lead (Pb) content in the wastewater of batik. And the weight difference in the *Pistia stratiotes* affects the reduction of the lead (Pb) content in the batik wastewater.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

AVAILABILITY OF DATA

All datasets generated or analyzed during this study are included in the manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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