Utilization of yellow velvetleaf and water spinach to reduce copper ion in surface water of the estuary of babon river Semarang

B Syahputra\textsuperscript{1,}\textsuperscript{*}, Nafiah\textsuperscript{1}

\textsuperscript{1}Department of Civil Engineering, Faculty of Engineering, Sultan Agung Islamic University, (UNISSULA) Semarang, Indonesia

benny@unissula.ac.id

Abstract. The Babon River in East Semarang has been polluted by heavy metals sourced from industrial waste. So that water pollution at the Babon River estuary does not spread, it is necessary to carry out water treatment. This research uses a glass aquarium reactor and utilizes yellow velvetleaf (limmoncharis Flava) and water spinach (Ipomoea aquatic fork) plants as a medium to reduce the concentration of copper ions (Cu\textsuperscript{2+}) by using variations in detention time. The results and analysis showed that yellow velvetleaf and water spinach could reduce the concentration of copper ions (Cu\textsuperscript{2+}) in estuary surface water within 1 hour, 2 hours, 3 hours, and 5 hours. After going through several stages of a simple drinking water pre-treatment process, the results showed that yellow velvetleaf plants could reduce the concentration of copper ions (Cu\textsuperscript{2+}) in Babon river water samples, from an initial concentration of 0.055 mg/L to 0.020 mg/L, with the highest efficiency percentage reduction up to 61.5%. As for water spinach, the concentration of copper ions that can be reduced only reaches the lowest level of 0.047 mg/L, with the highest percentage reduction efficiency of only 9.6% after the same pre-treatment process.

1. Introduction

Heavy metal is a potential element that pollutes the environment [1]. Periodic monitoring is needed to reduce the impact of decreasing environmental quality. One of the impacts of a decrease in environmental quality is the decrease in the quality and quantity of water as a source of human life, which can affect health [2].

Semarang City has nine river streams, one of which is the stream of the Babon River. The Babon River is one of the rivers in Semarang that is susceptible to pollution because from upstream to downstream, many activities can reduce water quality, for example, dense settlements and industrial activities [3]. The Semarang chapter is classified poor [4] because the value of river water quality from the analysis results has exceeded the class II of standard quality threshold based on Government Regulation No.82 of the year 2001 to pollute the environment.

According to the Semarang City Environmental Agency data, the main problem that always occurs in the Babon River is river water pollution caused by domestic waste, agricultural waste, industrial waste, and factory-scale home industry waste. Industrial waste mainly disposed of in the Babon River estuary comes from the tanning or leather processing industry, textile, pulp or paper industry, and shrimp canning [5].
Waste that enters the river can be either organic or inorganic. Most organic wastes can rot and can be degraded by microorganisms, but not so with inorganic waste. Inorganic waste material originating from the remaining production of the printing industry, chemical plants, textiles, and electronics has the potential to damage the environment because it contains hazardous and toxic materials (B3), including heavy metals such as lead (Pb), cadmium (Cd), mercury (Hg), chrome (Cr), nickel (Ni), cobalt (Co), manganese (Mn), copper (Cu) and tin (Sn). The entry of heavy metals that exceed the concentration should have resulted in the death of this aquatic biota [6].

There are also many uses of plant media to reduce heavy metals in water using plant media. Yellow velvetleaf and water spinach plants are two types of plants from several plants that can absorb and reduce heavy metals in wastewater. So it is not uncommon for yellow velvetleaf and water spinach to be used in research. Research on copper (Cu) heavy metals with plant media also exist and is still ongoing, including research on decreasing heavy metal content and growth of Saigon plants (Paraserianthes falcatoriaL (Nielsen)) bermicroriza in extracted sludge waste medium [7]. To develop previous research, different studies were carried out on the ability of other plants such as yellow velvetleaf and water spinach to reduce copper ion concentration (Cu$^{2+}$) in river water.

This study aims to determine the magnitude of the ability of yellow velvetleaf and water spinach plants in reducing copper ion concentration (Cu$^{2+}$) in surface samples of the Babon River Semarang.

2. Methodology
Phytoremediation using yellow velvet and water spinach plants is a pre-treatment and not the primary treatment because removing copper ions requires wastewater treatment technology. However, the pre-treatment of these two plants contributed to the removal of the copper ion concentration.

2.1. Location of the research
The location for sampling surface water is in Babon River Semarang. Direct sampling of the river water surface, including the Babon River estuary, namely in the Karang Asem area, Trimulyo. The selection of the collection location is based on the closest observation of several industries, including the paint, the textile, and the electronics manufacturing industry, as well as a large amount of industrial waste thrown into the Babon River estuary so that the most likely high levels of Cu are at the river mouth.

2.2. Research parameter
A parameter of this research is copper ion concentration (Cu$^{2+}$). This study analyzed the measurement and testing of Copper (Cu$^{2+}$) parameters in water samples taken in the Laboratory, both before treatment (influent), after the filtration treatment (sand, palm fiber, and media sand, fibers, and charcoal media), and after further treatment (with yellow velvetleaf and water spinach plant). After the sample is taken from the raw water source, namely the surface water of the Babon River estuary with a 4 hour Td (detention time), the water sample is put into the aquarium filtration first with Td (live time) 10 hours. From the filtration process, then the water sample flows into the reactor aquarium with variations in the research time taken every 2 hours.

2.3. Stage of the research
In the study of the surface water treatment of the Semarang River Babon estuary using plant media in the aquarium reactor, which was carried out continuously with a variation of each hour, 2 hours, 3 hours, 4 hours, and 5 hours. The media of the plants used are yellow velvetleaf (limnocharis Flava) and water spinach (ipomoea aquatic forks) to reduce the levels of copper ions (Cu$^{2+}$). The next step is the preparation of acclimatization of yellow velvetleaf and water spinach plants. Acclimatization aims to neutralize the yellow velvetleaf and water spinach plants against the original planting media. The acclimatization method is as follows: preparing the media for yellow velvetleaf and water spinach plants using refill water, choosing healthy and fresh yellow velvetleaf and water spinach plants and not mixed with other species or varieties, planting yellow velvetleaf and water spinach plants in growing
media (Water) and every 2 days once water changes are made, acclimatization is carried out for 10 days with a natural lighting system (sunlight) [8]. After 10 days, yellow velvetleaf and water spinach plants are washed with refill water until clean; choose fresh and healthy yellow velvetleaf and water spinach plants, then plant yellow velvetleaf and water spinach are ready to be applied [9].

Next is the manufacture of filter reactor media in the form of a rectangular glass aquarium. For the second step, the sampling process, an initial examination (blank) for the parameters of copper (Cu\(^{2+}\)) ions. Then during the examination of the sample after the filtration process, the sample is then examined at the reactor while maintaining the condition of the sample water that is flowed into the reactor aquarium in a constant state to determine the decrease in copper ion levels (Cu\(^{2+}\)), each time 1 hour, 2 hours, 3 hours, 4 hours and 5 hours at the Laboratory. After the data from the test results of copper ion (Cu\(^{2+}\)) parameters are obtained, the next step is data processing and analysis. Parameters of copper ions (Cu\(^{2+}\)) must be adjusted to Government Regulation Number 82 the year 2001 for drinking water quality standards concerning Management of Water Quality and Water Pollution Control [9].

![Figure 1. Yellow velvet and water spinach in the reactor.](image)

3. Results and discussion

3.1. Testing of copper ion (Cu\(^{2+}\)) in water samples in the reactor which planted with yellow velvetleaf

The initial (influent) examination of copper ions was 0.055 mg /liter after passing filtration to 0.052 mg /liter. After the filtration process, this study conducted testing on the water collected in the reactor aquarium planted with yellow velvetleaf. Table of examination results of copper ion concentration (Cu\(^{2+}\)) with yellow velvetleaf plant media, namely as follows:

**Table 1. Results of examination of copper ion concentration (Cu\(^{2+}\)) with yellow velvetleaf plant media.**

| No. | Parameter | Result (mg/L) | Time (hour) | Standard Quality (mg/L)* |
|-----|-----------|---------------|-------------|--------------------------|
| 1   | Copper (G1) | 0.048         | 1           | 0.02                     |
| 2   | Copper (G1) | 0.048         | 2           | 0.02                     |
| 3   | Copper (G1) | 0.047         | 3           | 0.02                     |
| 4   | Copper (G1) | 0.037         | 4           | 0.02                     |
| 5   | Copper (G1) | 0.020         | 5           | 0.02                     |

*Based on Government Regulation No. 82, the year 2001
3.2. Testing of copper ion (Cu\(^{2+}\)) levels in water samples in a reactor planted with water spinach

In this study, after the filtration process, tests were also carried out on the water collected in the reactor aquarium, planted with water spinach. Results of examination of copper ion concentration (Cu\(^{2+}\)) with yellow velvetleaf plant media, namely as follows:

| No. | Parameter      | Result (mg/L) | Time (hour) | Standard Quality (mg/L) |
|-----|----------------|---------------|-------------|-------------------------|
| 1   | Copper (K1)    | 0.051         | 1           | 0.02                    |
| 2   | Copper (K1)    | 0.051         | 2           | 0.02                    |
| 3   | Copper (K1)    | 0.049         | 3           | 0.02                    |
| 4   | Copper (K1)    | 0.049         | 4           | 0.02                    |
| 5   | Copper (K1)    | 0.047         | 5           | 0.02                    |

*Based on Government Regulation No. 82, the year 2001

Table 1 is the result of examining copper ion concentration (Cu\(^{2+}\)) using yellow velvetleaf plant media. The sample taken as the sample of the study is the water from the filtration process, which is flowed into the aquarium reactor with a duration time of 1 hour, 2 hours, 3 hours, 4 hours, and 5 hours. Duration time 1 hour, 3 hours, and 4 hours is when the water flows from inlet to outlet. At a duration time 1 hour and 2 hours, the examination results were 0.048 mg/L, the decrease in copper ion concentration (Cu\(^{2+}\)) was 0.004 mg/L from the filtration sample. At a duration time, 3 hours and 4 hours, the results of the examination of the levels of copper (Cu\(^{2+}\)) were 0.037 mg/L, and there was a more significant decrease of 0.015 mg/L from the results of the filtration sample. The lowest decrease was at duration time 5 hours with the number of examination results of 0.020 mg/L, meaning that the decrease in the more significant the filtration sample was 0.032 mg/L. In this case, the Yellow velvetleaf plant is proven to have the ability to reduce the levels of copper ions (Cu\(^{2+}\)) with the most outstanding percentage reduction efficiency up to 61.5%.

Table 2 is the result of examining copper ion concentration (Cu\(^{2+}\)) using water spinach plant (Ipomoea aquatic Forsk) media. The sample taken as the research sample is the same as the test sample with the yellow velvetleaf plant and at the same time variation, that is duration time 1 hour, 2 hours, 3 hours, 4 hours, and 5 hours. At 1 hour and 2 hours, the examination results are 0.051 mg/L, a decrease in the levels of copper ions (Cu\(^{2+}\)) from filtration samples is only 0.001 mg/L. At a duration time 3 hours and 4 hours, the examination results of copper ions (Cu\(^{2+}\)) amounted to 0.049 mg/L, and a more significant decrease was 0.003 mg/L. The lowest decrease was at Td 5 hours with the number of examination results 0.047 mg/L, meaning only experienced a decrease of up to 0.005 mg/L. In this case, water spinach plants are also proven to reduce the levels of copper ions (Cu\(^{2+}\)), although the results of the tests obtained do not reach a minimum level of 0.02 mg/L of clean water with the highest percentage reduction efficiency of only 9.6%.

The results showed that yellow velvetleaf plants were better than water spinach plants. The yellow velvetleaf plant can accumulate copper (Cu\(^{2+}\)) ions through the roots and spread them to its organs. Accumulation of copper ions (Cu\(^{2+}\)) by the yellow velvetleaf plant occurs through the roots and spreads to all of its organs to the leaves [10]. This is evidenced by the reduction of copper ions (Cu\(^{2+}\)) in the growing media, but in the roots and leaves of the yellow velvetleaf plant, copper (Cu\(^{2+}\)) accumulation occurs. The yellow velvetleaf plant has fiber roots, making it possible to absorb more and more effective copper (Cu\(^{2+}\)) ions. Fiber roots have many root hairs that are roughly the same size and come out from the base of the roots to spread sideways and in all directions. Fiber roots form branches with branch sizes that are not too different [7].

The loss of copper (Cu\(^{2+}\)) in the planting media is not entirely absorbed by yellow velvetleaf and water spinach plants, but due to copper ions (Cu\(^{2+}\)) that have entered the plant's body, they are excreted by dropping old leaves so that they can reduce copper (Cu\(^{2+}\)) ions. In addition, copper ions
(Cu\(^{2+}\)) do not entirely enter the plant due to the precipitation of copper ions (Cu\(^{2+}\)) in the form of salt molecules in water.

Based on the Decision of the Minister of the Health Republic of Indonesia Number. 907 the year 2002 concerning the Requirements for Drinking Water, the maximum level of parameters permitted is 2 mg/L, the results are said to be below the prescribed threshold because the results of examination using yellow velvetleaf media are equal to the minimum level of water quality standard, which is 0.02 mg/L according to the provisions of Government Regulation Number 82 of 2001 concerning Drinking Water Quality Standards. While the examination results using water spinach plant media are still below the maximum level requirements for drinking water, although it exceeds the minimum level of drinking water quality standards.

4. Conclusion
Yellow velvetleaf plants can reduce the levels of copper ion concentration (Cu\(^{2+}\)) with the initial results of the standard sample 0.055 mg/L to reach the lowest level of 0.020 mg/L, with the highest percentage reduction efficiency up to 61.5% in surface samples of the Babon River Semarang estuary after passing several stages of a simple drinking water pre-treatment process. Whereas for water, spinach plants can only reduce the levels of copper ion concentration in the samples of the Babon River estuary surface, reaching the lowest levels up to 0.047 mg/L, with the most significant efficiency percentage reduction of only 9.6% after going through the same pre-treatment process.

Acknowledgments
The author would like to thank you for the financial support from the research and community service institutions of Sultan Agung Islamic University so that this research can run smoothly. Moreover, I do not forget to thank my fellow lecturers and staff at the Sultan Agung Islamic University.

References
[1] Adimalla N 2019 Environ. Geochem. Health
[2] Hua Y, Zhoua J, Dud B, Liua H, Zhanga W, Liang J, Zhang W, Youa L and Zhoua J 2019 Ecotoxicol Environ Saf 171 329–336
[3] Wahyudi RS, Wahyudi SI, and Subagya PH 2020 IOP Conf. Ser.: Earth Environ. Sci. 612
[4] Raymond M, Yanuar MJP, Hartoyo S, Sapei A, and I Wayan A 2011 Jrl. 7 193–204
[5] Supriyantini E, Nuraini RAT, and Fadmawati AP 2017 Bul. Osean. Marina 6 29-38
[6] Al Naggar Y, Khalil MS and Ghorab MA 2018 Open Access J.Toxicol. 3
[7] Testi EH and Soenardjo N 2019 J. Mar. Res. 8 211–217
[8] Oktoviana I, Hanifah TA and Kartika GF 2015 JOM FMIFA 2 1-7
[9] Tiro LL, Ishak I, Iyabu H 2017 J. Entropi. 12 81–86
[10] Rachmadiarti F, Soehono LA, Utomo WA, Yanuwiyadi B and Fallowfield H 2012 J. Appl. Environ. Biol. Sci. 2 210–215
[11] Tjitrosoepomo G 2007 Anatomi Tumbuhan (Yogyakarta: UGM Press)