The capacity of water hyacinth as biofilter and bioaccumulator based on its size

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Abstract. Nowadays, aquatic environmental contamination caused by human activities is increasing. One of several types of contaminants is heavy metal. Water hyacinth, *Eichhornia crassipes* (Mart.) Solms. is an aquatic plant that has been known to have a capacity to absorb heavy metals through its roots. Previous study reported that water hyacinth can reduce the amount of the suspended solid in the water. The objective of this study is to evaluate the performance of three sizes of water hyacinth in filtering the suspended solid from turbid water. The experiment was conducted in a greenhouse over a period of seven days on August 2019. The plant material was obtained from water body in Sawangan, Depok area. We used fifteen plants which categorized into three sizes of water hyacinth, i.e. small, medium and large. Those plants were first acclimatized for a period of seven days in tap water without addition of nutrients. For the next seven days, the water hyacinths were transferred to a fiberglass rectangular fish tank filled with 50 L water from Situ (Lake) Agathis, Depok. From the results, it was found that the accumulation capacity of lead (Pb), cadmium (Cd) and copper (Cu) by water hyacinth decreased by the increase of plant size. Another result showed that compared to leaves and stems, roots accumulate more heavy metals. Under seven days of growing period, all the fifteen water hyacinth plants can reduce the total dissolved solids (TDS) from 261 ppm to 204 ppm, and total suspended solids (TSS) from 0.0449 ppm to 0.0151 ppm.

Keywords: Biofilter, bioaccumulator, heavy metal, total dissolved solids, total suspended solids, water hyacinth

1. Introduction
Aquatic environment is already contaminated by heavy metals. Some of heavy metals that can be a damage for environment are lead (Pb), cadmium (Cd), copper (Cu) and zinc (Zn). Generally, heavy metals come from industrial waste that discarded without any treatment. This act causes heavy metals go with the flow of water to any river or other water source [1].

*Eichhornia crassipes* (Mart.) Solms. known as water hyacinth is a plant that lives on water. Water hyacinth can grow fast by its vegetative pieces that brought by water flow can grow into adult water hyacinth. Water hyacinth may harm the water environment because it can grow up to 1.9 % each day [2]. Water that covered by water hyacinth is going to be lack of oxygen, and it also takes effect on carbon dioxide that contained in water. Too much water hyacinth on the surface of water also can prevent the sunlight to penetrate the water [3].
Beside all the negative effects that can be caused by water hyacinth, this plant can absorb heavy metals that contained in the water. Usually, water hyacinth is used as bioaccumulator of waste water [4]. The role of water hyacinth can purify water and retard a water spot to silting up. It depends on the composition and amount of polluter substance in water [5]. If water hyacinth died, the waste will become an underwater deposit. By a good superintendence, water hyacinth can be a good bioaccumulator in the water [6].

Situ Agathis might be already contaminated by heavy metals. It might come from water that sourced from the residents of citizens around Universitas Indonesia. The existence of water hyacinth in Universitas Indonesia is so many. Usually, it can be found at inlet and outlet of the water near Universitas Indonesia, especially Situ Agathis [7]. But, lately we found that water hyacinth population was destroyed by the university guards because its existence can ruin water environment. However, people do not know that water hyacinth can accumulate sedimentation of water so that the water can be clearer than before. This research aims to know the capacity of water hyacinth as a bioaccumulator and biofilter in the water based on its size.

2. Materials and method

2.1. Collecting water hyacinth
The plant material was obtained from a water body in Sawangan, Depok area on June 25, 2019. Before that, we measured the environment parameter, such as pH (using pH meter), environment temperature and water temperature (using thermometer), light intensity (using lux meter), also wind acceleration of the field (using anemometer). We used fifteen plants which categorized into three sizes of water hyacinth, i.e. small, medium and large.

2.2. Acclimatization and treatment
The plants were first acclimatized for a period of seven days in tap water without addition of nutrients using water pump with capacity of 40W. Gross weight of water hyacinths was measured using a scale. For the next seven days, the water hyacinths were transferred into a fiberglass rectangular fish tank filled with 50 L water from Situ (Lake) Agathis, Depok (figure 1). During the acclimatization and treatment, the environment parameter was also measured, such as pH, environment, and water temperature, light intensity, also wind acceleration. After seven days of treatment, the gross weight of water hyacinth using scale was measured to see the difference between before and after treatment.

2.3. Heavy metals amount, TDS and TSS measurement
July 16th, 2019 we started to measure the total suspended solids (TSS) of 1 L of Situ Agathis water before and after treatment by filtering the water using Whatman filter paper number 1. Also, we measured the weight of filter paper before and after filtering the water. After that, we calculated the result into the TSS formula.
The Total dissolved solids (TDS) was measured by heat up 1 L of Situ Agathis water before and after treatment. After its getting warm, we measured the TDS using TDS meter. Then, we brought all water hyacinths to PT. Mutuagung Lestari Laboratory to measure the heavy metals (Pb, Cd and Cu) contained in the water hyacinths. We chose lead (Pb), cadmium (Cd) and copper (Cu) because they are easier to be found in water [8].

3. Results and discussion

The classification of plant size was measured by the length of water hyacinth from the edge of roots to the edge of the tallest leaf of the plant. Small water hyacinth has the length of 15–20 cm, medium water hyacinth has the length of 25–30 cm, and the large water hyacinth has the length of 35–40 cm. In table 1 we can see that mostly, the bigger size is the water hyacinth, the heavier the gross weight. But, some of small water hyacinth has the same weight as medium sizes because of small plant has more roots than the medium sizes. Water hyacinths’ gross weight average before treatment is mostly heavier than the gross weight before treatment. It caused by the growth of water hyacinths day by day.

Table 2 and table 3 show that water temperature, environment temperature, and humidity are mostly stable, but the light intensity increases drastically on day 2 of the treatment. Also, pH of water on the treatment day is higher than acclimatization day.

Water hyacinth’s organ has different capability to absorb heavy metals. Water hyacinth also can localize the amount of heavy metals at certain organ [9]. Based on the result, roots of water hyacinth can absorb heavy metals better than the stem and leaf (table 4, figure 2). Heavy metals can be absorbed by water hyacinth because there is rhizospherous microbes on the surface of water hyacinth roots. This microbe is able to change a non-organic Cu to be an organic Cu so that can be used by the water hyacinth as metalloenzim from plastocyanin enzyme, which can be used on photosynthesis to stimulate cell division of water hyacinth. That is why water hyacinth can still grow richly in the contaminated water and the most absorbed heavy metal is copper (Cu) [10]. The ability of root to absorb the substances is called Rhizofiltration. Rhizofiltration can be used to rejuvenate water that contaminated by harmful substances [11]. A larger water hyacinth has a shorter root (figure 2). While, a smaller water hyacinth has a longer root (figure 3). Based on table 4, heavy metals mostly can be absorbed by the small water hyacinth better than the large water hyacinth. The longer root of small water hyacinth may be because of small plant can absorb more nutrition and heavy metals than the large water hyacinth.

| Plant size | t0 | Small (gr) | Medium (gr) | Large (gr) | Average (gr) | t7 | Small (gr) | Medium (gr) | Large (gr) | Average (gr) |
|------------|----|------------|-------------|------------|--------------|----|------------|-------------|------------|--------------|
| 1          | 40 | 35         | 220         | 40         | 40           | 245|
| 2          | 30 | 40         | 190         | 40         | 40           | 200|
| 3          | 30 | 30         | 205         | 25         | 35           | 240|
| 4          | 25 | 25         | 245         | 25         | 25           | 230|
| 5          | 25 | 35         | 125         | 25         | 40           | 145|
| Average    | 30 | 33         | 197         | 31         | 39           | 212|
| SD         | 6.12 | 5.70     | 45.08       | 8.22       | 10.84        | 41.32|
Table 2. The comparable data of environment parameter on the acclimatization day.

| Acclimatization day | 1   | 2   | 3 | 4   | 5   | 7   |
|---------------------|-----|-----|---|-----|-----|-----|
| Water temperature (°C) | 30  | 28  | 28| 29  | 28  | 29  |
| Environment temperature (°C) | 34  | 34  | 34| 33  | 33  | 38  |
| Humidity (%)        | 45  | 44  | 49| 51  | 55  | 44  |
| pH                  | 5   | 5   | 5 | 5   | 5   | 5   |
| Light intensity (cd) | 645 | 545 | 539| 534 | 507 | 540 |

Table 3. The comparable data of environment parameter on the treatment day.

| Treatment day | 1   | 2   | 3 | 4 | 5 | 7 |
|---------------|-----|-----|---|---|---|---|
| Water temperature (°C) | 29  | 28  | 28| 28 | 27 | 27 |
| Environment temperature (°C) | 36  | 33  | 36| 35 | 34 | 34 |
| Humidity (%) | 47  | 51  | 45| 46 | 51 | 45 |
| pH           | 6   | 6   | 7 | 7  | 7  | 7  |
| Light intensity (cd) | 426 | 780 | 948| 886 | 878 | 838 |

Table 4. The comparable data of heavy metals and water amount that contained in water hyacinth.

| Parameter     | Small | Medium | Large |
|---------------|-------|--------|-------|
|               | Root  | Stem   | Leaf  | Root  | Stem | Leaf  | Root  | Stem | Leaf  | Root  | Stem | Leaf  |
| Pb (ppm)      | 1.34  | 0.15   | 0.06  | 2.17  | 0.08 | 0.01  | 0.00938 |       |       | < 0.00448 |       |       |
| Cd (ppm)      | 0.047 | 0.05   | 0.05  | 0.89  | 0.02 | 0.03  | 0.805   | 0.0181 | 0.00071 |       |       |
| Cu (ppm)      | 53.5  | 16.7   | 17    | 83.8  | 15.1 | 19.5  | 84.4    | 11.2  | 17.6  |       |       |
| Water content (%) | 7.69 | 7.66   | 6.56  | 7.69  | 6.58 | 7.67  | 7.69    | 6.58  | 5.02  |       |       |

Figure 2. Large water hyacinth has short roots.

Figure 3. Small water hyacinth has long roots.

From table 4 and figure 2 we can see that mostly heavy metals that can be absorbed well by water hyacinth is copper (Cu). Heavy metals that contained in the root are mostly in higher amount than stem and leaf (figure 4).
Figure 4. The comparable data of heavy metals amount that contained in water hyacinth.

Table 5. The comparable data of Total Dissolve Solid (TDS) and Total Suspended Solid (TSS) before and after treatment.

|                     | Total Dissolve Solid (TDS) | Total Suspended Solid (TSS) |
|---------------------|---------------------------|----------------------------|
| Before treatment    | 261 ppm                   | 0.0449 mg/l                |
| After treatment     | 204 ppm                   | 0.0151 mg/l                |

Table 5 shows that both Total Dissolve Solid (TDS) and Total Suspended Solid (TSS) before treatment are higher than the after treatment.

Water that contaminated by heavy metals usually has a higher acidity than the uncontaminated one. From table 2 and table 3, we can see that pH on the acclimatization day is lower that pH on the treatment day. It means that the acidity of water is decreasing during the water treatment by water hyacinth. The higher amount of heavy metals is in the water, the lower pH of the water. If water has a lower pH (higher acidity), the solubility of heavy metal is bigger. Also, if water has a higher pH (lower acidity), the solubility of heavy metal is getting smaller. Usually, the process is followed by the deposition on the base of water [12]. The other environment parameters are mostly stable at both situations, before and during the treatment.

The Total suspended solid (TSS) shows the amount of residue that contained in water. The higher is the number of TSS, the higher amount of residue that contained in water. Total dissolve solid (TDS) shows the turbidity of water. The higher is the number of TDS, the bigger particle contained in the water and becomes more turbid [13]. Table 5 shows that the presence of water hyacinth can reduce TDS from 261 ppm to 204 ppm and TSS from 0.0449 ppm to 0.0151 ppm. It is all because the capability of water hyacinth that can absorb substance in the water and makes the water becomes clearer.

4. Conclusion
The results of this study show that heavy metals which can be well-absorbed by water hyacinth is copper (Cu). Water hyacinth’s root can accumulate heavy metal in larger amount than its stem and leaf.
The size of water hyacinth does not determine the capability to absorb heavy metals. Water hyacinth is effective to be applied as a bioaccumulator and biofilter, as shown by the number of TSS and TDS that reduced after the placement of water hyacinth on the water. Water hyacinth can make the water to be clearer and reduced the substance or heavy metals that can damage the water environment.

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