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PHYTOREMEDIATION MODEL SYSTEM FOR AQUACULTURE WASTEWATER USING *GLOSSOSTIGMA ELATINOIDES* AND *HEMIANTHUS CALLITRICHOIDES*

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ABSTRACT

The aquaculture industry has made a great contribution towards economic development of Malaysia. However, the large volume of water consumption and the wastewater discharged into the water source caused a significant environmental problem that must be controlled properly. For instance, aquaculture waste may decrease dissolved oxygen level and load high nutrient and inorganic contaminants which subsequently would cause water deterioration. Thus, to ensure the effectiveness of aquaculture practices, the suitable wastewater management approach should be acquainted. Phytoremediation, which are the application of plant-based technologies, are beginning to be accepted to examine the problems and provide sustainable solutions for this issue. Therefore, this research aims to explore ecological approach by developing phytoremediation model system in order to remediate inorganic pollutants produced by aquaculture pond. In this paper, the efficiency of potential aquatic plants which are Glossostigma elatinoides and Hemianthus callitrichoides to sequester cadmium and copper were investigated. To achieve this, phytoremediation model system was developed using two selected species for three different concentrations of cadmium (Cd) and copper (Cu). This model system was run over three different periods of time, which are week 1, week 2, and week 3. The findings of this research suggested that the capability to sequester different concentration of heavy metals for certain periods of time were varied between different species. The results indicated that Glossostigma elatinoides was a good phytoremediator for Cd whereas Hemianthus callitrichoides was a good phytoremediator for Cu. The expected outcome of this research is to introduce cost- effective and eco-friendly technology to cater environmental pollution. Hence, having the thorough study on the effectiveness of this technology might contribute towards sustainable aquaculture practices in terms of ecological, economical, and social benefits.

Keywords: Aquaculture, Phytoremediation, Cd, Cu, *Glossostigma elatinoides, Hemianthus callitrichoides.*

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Contribution/ Originality

The paper's primary contribution is finding that the capability of plant to sequester various concentrations of heavy metals for certain periods of time was varied between different species. Thus, having the thorough study on the effectiveness of phytoremediation might contribute towards sustainable aquaculture practices in terms of ecological, economical, and social benefits.

1. INTRODUCTION

Nowadays, due to limited natural sources for fish production, the aquaculture production was significantly boomed and it was mainly for the world food supply (Ebel *et al*., 2007; Akinibile and Yusoff, 2012). Although this industry have given a big contribution towards economic growth of the country, however, the large volume of water consumption and the wastewater discharged into the water source caused a significant environmental problem that must be controlled properly (Read and Fernandes, 2003 ; Akinibile and Yusoff, 2012). For instance, the aquaculture waste may decrease dissolved oxygen level, accumulate bottom sediments, and load high nutrient that would cause water deterioration due to excessive phytoplankton growth (Tilley *et al*., 2002; Ghaly *et al*., 2005). Other negative impacts of the aquaculture in relation to environmental were mentioned by the Fisheries and Aquaculture Department (FAO, 2006) as below:

i. Natural habitats and the related ecological destruction as a result of ecosystem functions alteration.
ii. Freshwater demand competition.
iii. Livestock sector demand competition for aquaculture diets production.
iv. Health and environmental issues increase due to improper use of chemicals.
v. Aquatic animal diseases transmission through improper regulated translocations.

Therefore, to ensure the effectiveness of aquaculture practices, appropriate alternatives should be introduced in order to minimize the bad impact of shrimp aquaculture effluent (Shimoda *et al*., 2005). In order to remediate polluted environment, several remediation technologies have been recognized such as physicochemical and biological approaches (Riser-Roberts, 1998). This biological technology or phytoremediation has the benefits in terms of its cost effective and low environmental impact compared to conventional technology (Mohammad Iqbal *et al*., 2008; Ana *et al*., 2009; Aisien *et al*., 2012).

Phytotechnologies, which are the application of plants and associated microorganisms -based technologies, are beginning to be accepted to examine the problems and provide sustainable solutions for this issue (Mench *et al*., 2009; Prasad, 2012). In the 1980s, the concept of phytoremediation was born when the ability of plants species to accumulate high amount of toxic metals in their tissue and organs was proved (Jez, 2011; Maestri and Marmiroli, 2011). In environmental planning, plants play a vital role in ensuring the environment quality by restoring ecological balance, maintaining biological diversity and others (Shukla and Chandel, 2006).

Briefly, this research aims to explore ecological approach by developing phytoremediation model system in order to remediate inorganic pollutants produced by aquaculture pond. In this

paper, the efficiency of potential aquatic plants which are *Glossostigma elatinoides* and *Hemianthus callitrichoides* to sequester cadmium and copper were investigated. Phytoremediation model system was developed using these two selected species for three different concentrations of Cd and Cu. This model system was run over three different periods of time, which are week 1, week 2, and week 3. The findings of this research suggested that the capability to sequester different concentration of heavy metals for certain periods of time were varied between different species. The expected outcome of this research is to introduce cost- effective and eco-friendly technology to cater environmental pollution. Hence, having the thorough study on the effectiveness of this technology might contribute towards sustainable aquaculture practices in terms of ecological, economical, and social benefits.

2. MATERIAL AND METHODS

2.1. In-Vitro Culture

Aquatic plants plantlets *Glossostigma elatinoides* and *Hemianthus callitrichoides* original culture stocks were gained from Fisheries Research Institute Glami Lemi,Negeri Sembilan, Malaysia. In order to get sufficient plants for model system, these species were subcultured using Murashige and Skoog Medium and placed in incubator room at 24°C day and night temperature with a lighting system of Philips fluorescent tubes TL-D 36W/54-765.3.5.3.

2.2. Heavy Metals Solution Preparation

Stock solutions of analytical grade heavy metals salt ($CuSO_4.5H_2O$ and $CdCl_2$) were prepared in deionized sterile water with three different concentrations (1 mg/L, 2 mg/Land 3 mg/L). Then, the solutions were autoclaved before used for model system.

2.3. Model System

The heavy metals solutions were transferred into fifteen sterile tubes consisted of ten shoots of cultured aquatic plant species in plain agarose and three controls without plants with approximately of 30 mL solution for each treatment. The treatments were run over three different periods of time which were week 1, week 2, and week 3 using *Glossostigma elatinoides* and *Hemianthus callitrichoides*. The treatments were placed in the incubator room. After each 1, 2 and 3 weeks, the samples were harvested and homogenized. Approximately 0.5g of sample was weighed in vessel to which 8 mL of 65% nitric acid was added. Next, samples were digested in a microwave oven for 35 minutes at 180°C. The digested samples were then diluted with 18.2 Ωhm distilled water to a final volume of 50 mL.

Cd and Cu concentrations were determined using MERCK test kits by following the DR5000 Merck Spectroquant Procedures.

3. RESULT AND DISCUSSION

3.1. Heavy Metals Analysis

As shown in Fig. 1, the first graph revealed that at 1 mg/L concentration, the capability of *Hemianthus callitrichoides* to uptake Cd was higher than *Glossostigma elatinoides* for all 3 weeks of the treatment. Conversely, at the concentration 2 mg/L and 3 mg/L, the capability of *Hemianthus callitrichoides* to uptake Cd was lower than *Glossostigma elatinoides*. Thus, it can be suggested that *Glossostigma elatinoides* have higher potential to be phytoremediation agent for Cd but the accumulation was started efficiently in week 2. The results also showed that after 3 weeks, the concentrations of Cd in both species were decrease.

For Cu, the result suggested that the capability of *Hemianthus callitrichoides* to accumulate Cu at concentration 1 mg/L, 2 mg/L and 3 mg/L was slightly higher than *Glossostigma elatinoides* for almost all weeks of the treatments. Thus, it can be concluded that *Hemianthus callitrichoides* has a better potential to be phytoremediator for Cu.

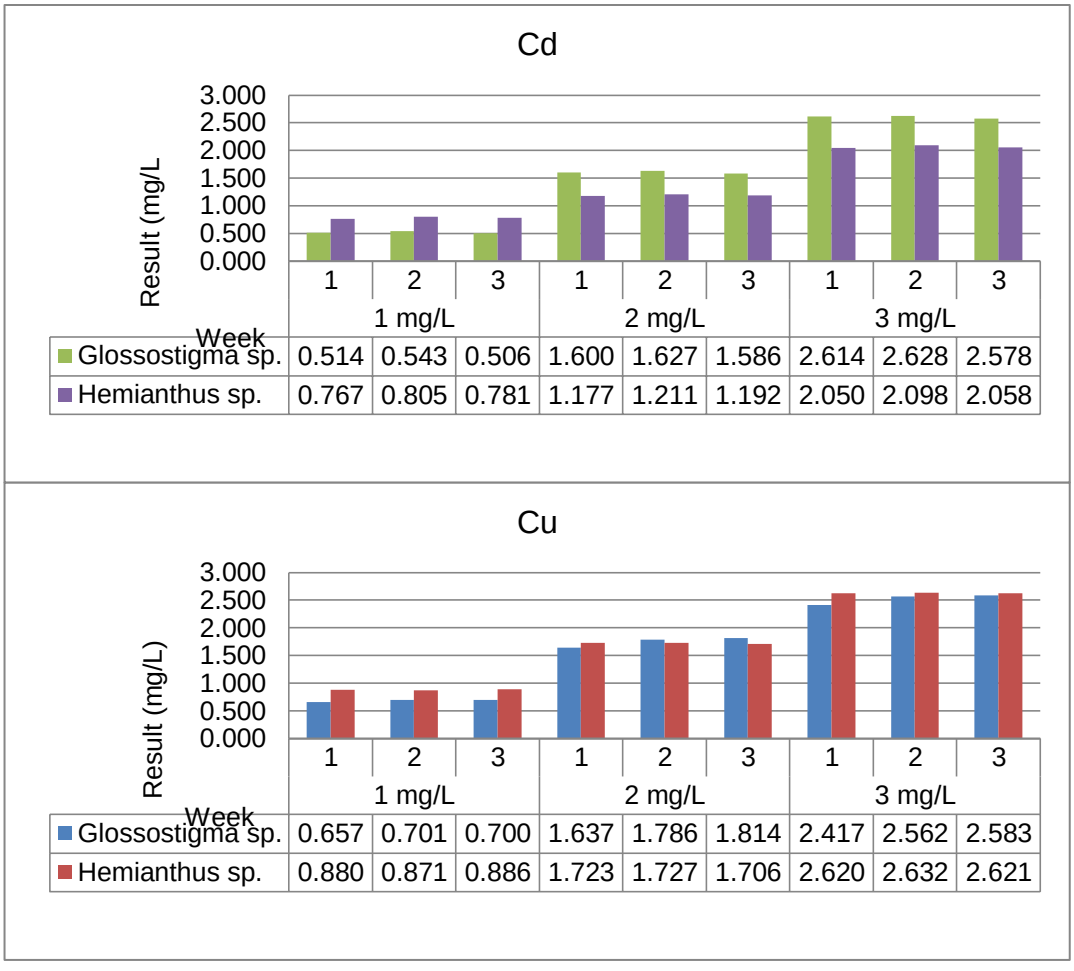

Fig-1. Concentration of Cd and Cu accumulated by *Glossostigma elatinoides* and *Hemianthus callitrichoides* after week 1, week 2, and week 3.

The results showed that different plant species have different capabilities to uptake different types and concentrations of heavy metals. This is supported by the study done by Ladislas *et al.* (2012). As mentioned by Peer *et al.* (2006) the appropriate plants species selection will determine the phytoremediation efficiency. Thus, their tolerance towards surrounding pollutants or toxic elements should become the major criteria as good phytoremediator. Based on the reviewed literature, there is no research done on the Cd and Cu phytoremediation using *Glossostigma elatinoides* and *Hemianthus callitrichoides*. Among the previous research on Cd and Cu phytoremediation were done using *Azolla pinnata* (Rai, 2008), *Eleocharis acicularis* (Sakakibara *et al.*, 2011), *Eichornia crassipes* (Agunbiade et al., 2009), *Lemna gibba* (Halaimi et al., 2014), *Lemna minor L.*, *Phragmites australis*, *Salvinia natans spp. Spirodela intermedia*, *Ipomoea aquatica*, *Vallisneria spiralis L*, *Colocasia esculent*, *Nymphaea spp.*, and *Typha spp.* (Rahman and Hasegawa, 2011).

4. CONCLUSION

The findings of this research indicated that the plant capabilities to sequester different concentration of heavy metals for certain periods of time were varied between different species. The result indicated Cd accumulation was higher in *Glossostigma elatinoides* from two to three weeks of the treatment. On the other hand, Cu accumulation was higher in *Hemianthus callitrichoides* for almost every weeks of the treatment. Therefore, it can be suggested that *Glossostigma elatinoides* was a good phytoremediator for Cd whereas *Hemianthus callitrichoides* was a good phytoremediator for Cu.

The expected outcome of this research is to introduce cost- effective and eco-friendly technology to cater environmental pollution. Hence, having the thorough study on the effectiveness of aquatic plants to remediate aquaculture wastewater might contribute towards sustainable aquaculture practices in terms of ecological, economical, and social benefits.

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