The effect of *Phragmites australis* and *Eichhornia crassipes* in the removal of high total phosphorus concentrations from water

L N Salamah¹, I Y Perwira² and Andi Kurniawan¹³*

¹Coastal and Marine Research Center, Brawijaya University
²Faculty of Marine Science and Fisheries, Udayana University
³Faculty of Fisheries and Marine Science, Brawijaya University

*Corresponding author: Andi_k@ub.ac.id

Abstract. In order to evaluate the accumulation of high phosphorus and the distribution on macrophytes part, the experiment was conducted by arranged vegetated and unvegetated treatment in a greenhouse experiment. Reactor containing 5L of phosphorus solution (50 or 500 mg/L), 4 kg of sediment and plants (*Phragmites australis* or *Eichhornia crassipes*) were prepared. The studied concentrations tried to stimulate an accumulation of Total Phosphorus (TP) in plants. Water were sampled every 5 days during 30 days of experiments while sediment and plant samples (roots, submerged leaves and aerial leaves) were collected at the beginning and at end of this study. Relative growth rate (RGR) of plants was determined considering initial and final plant height. As results, more than 60% of TP was removed by *P. australis* and *E. crassipes* from the water. Both *P. australis* and *E. crassipes* has great capability to accumulated TP in their tissues, submerged part of leaves accumulated highest TP than other part, due to directly contact with water. RGR was positive suggested both plant able to tolerance TP in high concentration. *P. australis* was accumulated higher TP than *E. crassipes*. Therefore *P. australis* is suitable for phytoremediation practice, being capable to tolerate high TP concentration.

Keywords: Phosphorus, Macrophyte, *Phragmites australis*, *Eichhornia crassipes*.

1. Introduction

Human activity is one of the main sources of phosphate pollution in aquatic ecosystem. In huge amount phosphorus is used in many human activities such as agriculture (fertilizers, chemical pesticides, and animal feed), food production industry, etc. Eutrophication is one of problem in aquatic ecosystem caused by high of phosphorus and nitrogen concentration. Therefore, effluent containing high concentration of phosphorus need preliminary and extract treatment before released it to environment.

In order to remove phosphorus (P) in aquatic ecosystem constructed wetlands are generally used in agriculture runoff, industrial effluent treatment, and sewage [1]–[3]. Nevertheless, the study of phosphorus often in low concentration.

Numerous techniques have been developed to reduce the concentrations of phosphorus in the aquatic ecosystem (e.g., chemical precipitation, membrane filtration), but most of them, even if effective, proved expensive and non-ecofriendly [3]–[5]. As a result, increasing demands for purification of aquatic ecosystem led to develop cost-effective and eco-friendly biotechnologies like phytoremediation, which relies on naturally occurring plant species to uptake phosphorus.
As a primary producer in ecosystem, macrophytes have important role to produce oxygen through photosynthesis, besides macrophytes play a role in the provision substrates for algae and refuge for fish. Therefore, macrophytes help in nutrient cycle in sediments and also help in stabilizing river and stream banks. Consequently, macrophytes are potential to be used to uptake nutrient in the aquatic ecosystem through their own metabolic system.

In last two decades, the potentiality of macrophytes to use in nutrient removal from aquatic ecosystem take the researchers attention. *Spirodea oligorrhiza* was successfully removed more than 80% of phosphorus in two months experiment. TP removal was investigated by [6] in pots for 132 days. The percent removal of Total Phosphorus (TP) was found significantly greater in pot with macrophytes (42%) than in pots without macrophyte (20%). This study aimed to evaluate the accumulation of phosphorus and the distribution on macrophytes part.

2. Materials and methods

2.1. Experimental design

Sediment and water were collected from Kitanoshin pond (Kusatsu city, Shiga, Japan). *P. australis* and *E. crassipes* were bought from the home center, only healthy plants of uniform size and weight were selected and transferred to the greenhouse. Twelve plastic reactors of 10L contained (*P. australis* or *E. crassipes*) and 4kg of sediment. Three reactors without plants were prepared and called as unvegetated treatments. Phosphorus solution (H₂KPO₄) was added to the reactors: 50 mg/L P (P50), 500 mg/L P (P500), and Control (reactors with water, without P solution). The experiment was conducted for 30 days with 3 replications. Water level in the reactors was maintained by adding pond water constantly during the experiment.

2.2. Chemical analysis

Water was sampled every 5 days during 30 days of experiment. TP in water was measured as soluble reactive phosphorus (SRP). SRP was analysed by using colorimetric molybdenum blue method after acid digestion method. TP in plants and sediment was analysed at the beginning and the end of the experiment. TP concentration in sediment was determined using the molybdenum blue method after Kjeldahl extraction.

Plants were sampled and separated into 3 types; leaves, submerged leaves and roots. They were washed with tap and distilled water, and subsequently oven dried at 60°C for 48 h. Dried plant samples were ground and analysed in the same way as sediment samples.

2.3. Plant study

Plant height was measured and the external appearance of plants was observed daily, to detect possible senescence. Relative growth rate (RGR) was calculated in each treatment considering initial and final plant height, according to

\[
RGR = \frac{\ln H2 - \ln H1}{T2 - T1}
\]

where, H1: initial height (cm), H2: final height (cm), T2-T1: experimental period (days).

3. Results and Discussion

TP removal during the experiment was shown in Fig. 1. The results show TP was successfully removed in all reactor. TP removal in *P. australis* reactor was higher than *E. crassipes* and unvegetated reactor of both P treatments (65%, 60%, and 31%, respectively, for P50 and 75%, 70%, and 43%, respectively for P500). In the TP removal in reactor *P. australis* is higher than *E. crassipes*. 
Phosphorus is an essential nutrient for plant growth, but in high concentration it caused environmental contamination and lead to eutrophication. Eutrophication may trigger habitat degradation, loss of biodiversity, duration of harmful algal blooms and alteration of food-web structure [4], [8]. The high TP in this study are representative of raw effluent from industries.

These results are consistent with those reported by [6], [7] who reported that P. australis vegetated treatment removed TP in high concentration than unvegetated treatment. TP was effectively removed using two kind of macrophytes; P. australis and E. crassipes. P. australis reactor presented higher removal than E. crassipes, indicating P. australis is suitable for TP removal. These results are consistent with those reported by [6], [7] who reported that P. australis vegetated treatment removed TP in high concentration than unvegetated treatment.

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Figure 1. TP removal percentage in (a) P50 and (b) P500 reactors during the experiment

Figure 2. TP concentration (mg/g) in (a) P. australis and (b) E. crassipes reactors during the experiment
Among types of macrophytes, emergent type has a huge potential to accumulate P. Emergent types has root inside the sediment which can directly accumulated P not only from water but also from sediment. Vegetated rooted in sediment often considered phosphorus requirement obtained from sediment porewater then translocated it to every part tissues of macrophytes to supply nutrient need for their growth [9].

The results of this experiment revealed that high level of TP concentration in macrophytes followed by high accumulation of TP concentration in the submerged part of leaves, means that TP in translocated from roots to leaves and absorbed through direct contact with water, similar results was reported by[10], using *Paspalum repens* in natural wetland. The lower TP concentration in sediment of *P. australis* reactor and higher concentration in plants tissues suggested higher accumulation of TP by this macrophytes compared with *E. crassipes*.

4. Conclusion
The important contribution of macrophytes to remove phosphorus showed by the highest TP removal from water and the lowest TP content in the sediment in vegetated treatment. The greatest accumulation
was shown in reactor of *P. australis* with high accumulation of TP in plants tissues, highest TP removal in water and lowest TP content in the sediment, suggested that *P. australis* is suitable for phytoremediation practice, and being capable to tolerate high TP concentration. TP removal from aquatic ecosystem could be enhanced by using macrophytes wetland system planted with *P. australis*.

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