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The Assessment and Potential Usage of Aquatic Macrophytes in Constructed Wetland for Removing Water Polluted with High Nutrients

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Several experiments were conducted to investigate the capacity of aquatic plants for removing nutrients (nitrogen, phosphorus and potassium) in phytoremediation process using water containing high nutrients concentration where various kinds of aquatic plants (emergent and floating plants) were used. Phyto-reactors and control reactor (no planting in the reactor) have been carried out in Laboratory scale under certain condition (light and temperature). Results had shown that nutrients assimilation rates and fate of nutrients transformation by aquatic plants in constructed wetland were directly depended on the types of aquatic plants. In addition, aquatic plant geometry such as weight and area occupied by aquatic plants in the phyto-reactor would be considered.

Key words: constructed wetland; aquatic macrophytes; phytoremediation; nutrients removals

1. Introduction

The development of plant-based remediation technology where the green or vascular plants have been used for removal of contaminants in the soils is attracting and widely appreciating as the green innovative technology.[4)] Wetlands are a major feature of the landscape in almost all parts of the world. The extent of the worlds wetlands is generally thought to be from 7 to 9 million km^2, or about 4 to 6 percent of the land surface of the Earth.[1,2,5)] In addition, a more recent estimate of the worlds wetlands developed by the U.S. Department of Agriculture (USDA) reported that 13.7 percent (18.8 million km^2) of the Earths surface is wetland.[7)]

Now a day, the study of Phytoremediation in wetland have become a topic of increasing interest around the country, both to governmental regulators and to scientists, and the nature of wetlands processes has only recently begun to be understood. The use of phytoremediation process by wetlands are increasingly being recognized because of some favorable results in apparently positive greenhouse results, relatively low-cost, energy-efficient, natural means of treating sewage, agricultural and industrial wastes, and stromwater runoff while at the same time offering the potential for multiple benefits such as source of recreational systems provided aesthetic qualities, wildlife habitat and the superior quality effluent that can be recycled for landscape irrigation.[3)]

The objective of this study was to explore the types of aquatic plants affecting on removal of nutrients (nitrogen, phosphorus and potassium) under enriched nutrients condition including its performance for removing nutrients considered mass of aquatic macrophytes and its area occupied with soil surface area, and to produce the knowledge necessary to make a selection and management of aquatic plants in phytoremediation process.

2. Methodology

2.1. Wastewater Characteristics

Wastewater used in the experiment was synthesized by laboratory grade chemicals. The wastewater characteristics are summarized in Table 1.

The phyto-batch reactor (PBR) was made of plastic containers with dimensions of 230 mm × 230 mm × 250

Table 1. Wastewater Characteristics

Parameters	Units	Quantity
pH	–	7.0–8.0
Dissolved Oxygen	mg O_2/L	4.0–5.0
Temperature	°C	25.0–30.0
Nitrate Nitrogen (NO_3–N)	mg/L	60.0–110.0
Phosphate (PO_4)	mg/L	50.0–70.0
Potassium (K)	mg/L	50.0–60.0

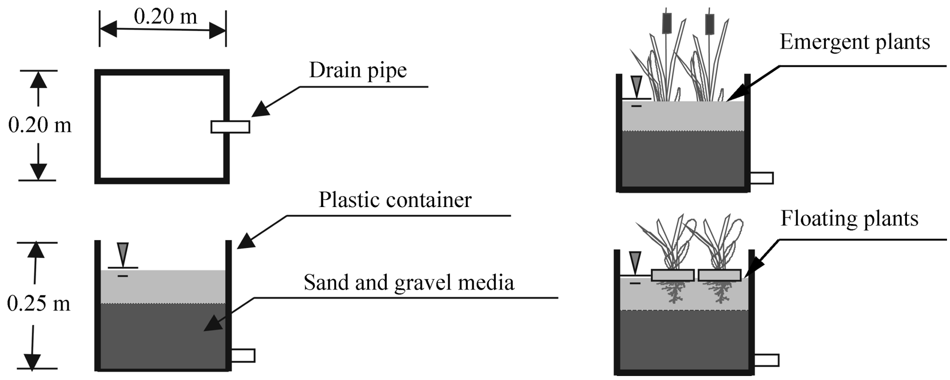

Fig. 1. Experimental Setup.

mm (width × length × height), accommodating a volume of 5-9 L. Figure 1 illustrated the setup of PBR in Laboratory. The reactors were replaced of Ø10–15 mm of gravel and Ø0.6–2.4 mm of sand with approximate depth of 2 cm and 8 cm. During April to September 2003, various kinds of aquatic plants were planted into each reactor and filled up with 3.5 L of synthetic water. Figure 2 showed the control reactor and PBR used in this experiment. The water was daily sampling to analyze for pH, dissolved oxygen (DO), temperature, nitrate (NO_3-N), phosphorus (PO_4-P) and potassium (K) for two weeks of each PBR. Table 2 shown the types of aquatic plants used.

3. Results and Discussion

During experiment, ambient temperature was found in the range of 20–30 °C. Figure 3 showed the variation of Laboratory ambient temperature (monthly average temperature). Recordation of pH (Figure 4) showed that no significant in changing of pH during experiments. Compare with control reactor, pH in PBRs contained aquatic plants were lower than in control reactor and trending of pH will gradually increased with time. The approximation of pH was of 7.0–7.8 in PBR and 7.4–8.1 in control reactor.

Figure 5 shows the DO in each PBR fluctuated from 5.5–6.0 to 0.2–4.5 mg/L. Results shown that rapidly reducing of DO in the most of PBR was at 1–2 days of the experiment. The reason is that the remaining of organic carbon matters in media beds coupling with the decaying of some death leaves from plants in PBR resulted in high oxygen demand during first and second

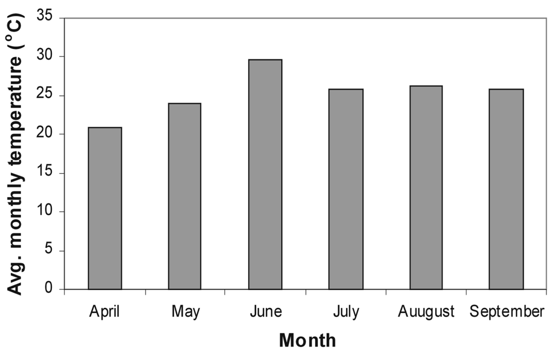

Fig. 3. Average Monthly Ambient Temperatures in Laboratory.

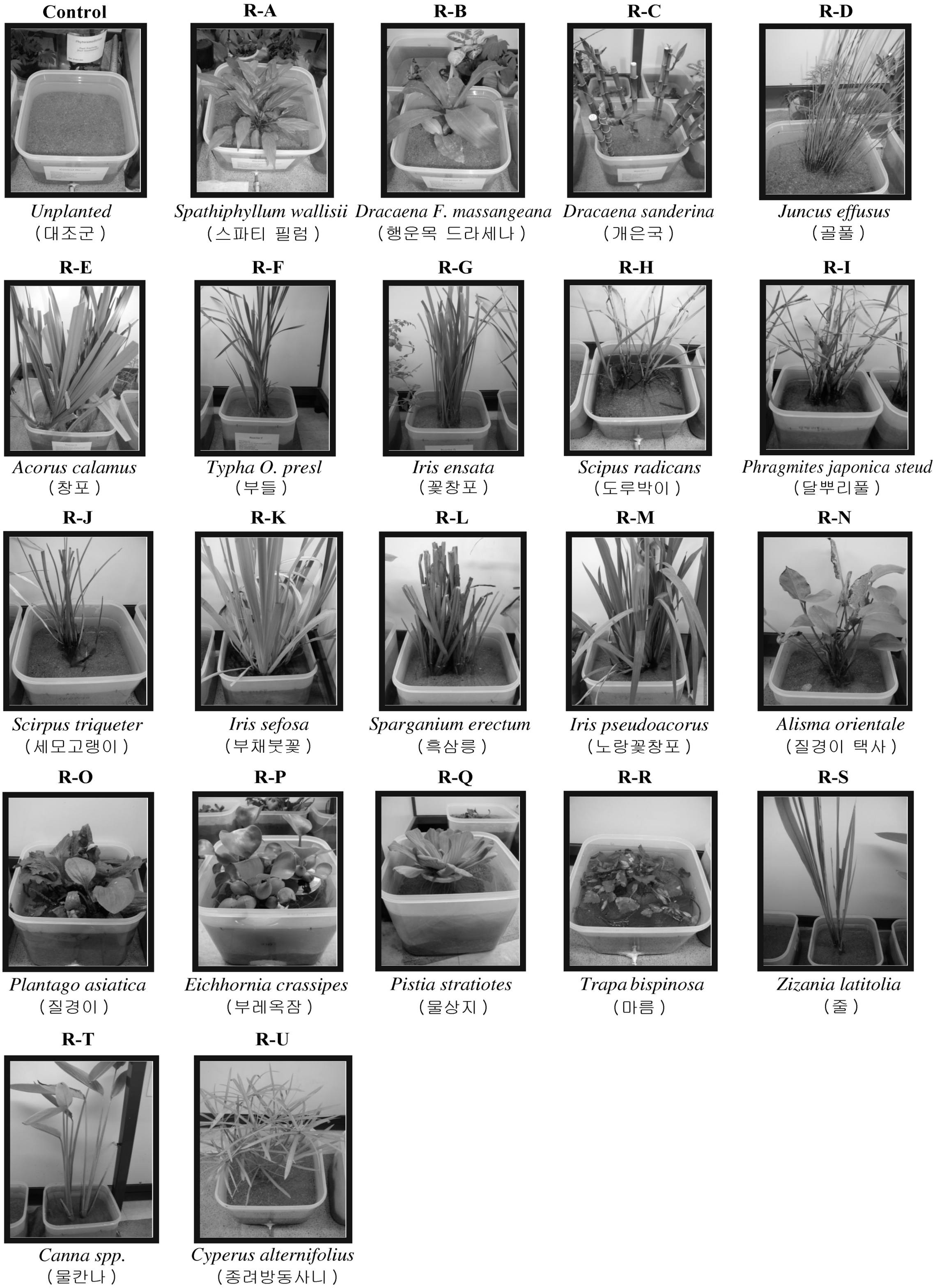

Fig. 2. Control and Phyto-batch Reactors in Laboratory 4. Conclusion.

Table 2. List of Aquatic Plants

Phytoremediation reactor	Plant's name
Control[a]	None
R-A	*Spathiphyllum wallisii* (스파티 필럼)
R-B	*Dracaena F. massangeana* (행운목 드라세나)
R-C	*Dracaena sanderina* (개운국)
R-D	*Juncus effusus* (골풀)
R-E	*Acorus calamus* (창포)
R-F	*Typha O. presl* (부들)
R-G	*Iris ensata* (꽃창포)
R-H	*Scipus radicans* (도로박이)
R-I	*Phragmites japonica steud* (달뿌리풀)
R-J	*Scirpus triqueter* (세모고랭이)
R-K	*Iris sefosa* (부채붓꽃)
R-L	*Sparganium erectum* (흑삼릉)
R-M	*Iris pseudoacorus* (노랑꽃 창포)
R-N	*Alisma orientale* (질경이 택사)
R-O	*Plantago asiatica* (질경이)
R-P	*Elchhornia crassipes* (부레옥잠)
R-Q	*Pistia stratiotes* (물상추)
R-R	*Trapa hispinosa* (마름)
R-S	*Zizania latitolia* (줄)
R-T	*Canna spp.* (물칼나)
R-U	*Cyperus alternifolius* (종려방동사니)

[a] Control is PBR without plant.

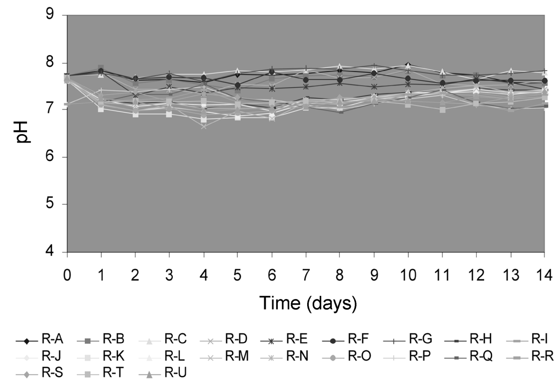

Fig. 4. Variation of pH in PBR.

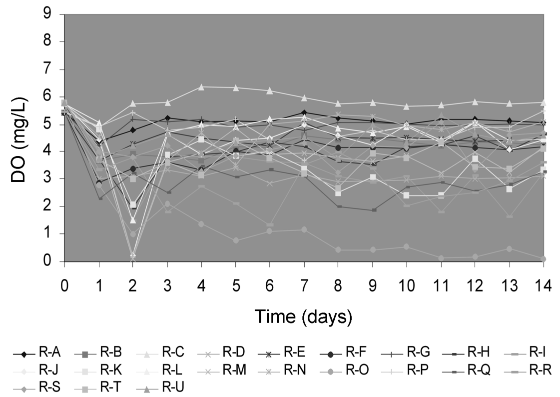

Fig. 5. Variation of DO in PBR.

Figure 6 and 7 show the nutrients used (nitrogen, phosphorus and potassium) in each PBR. Figure 6 represents the nutrients removals in term of one unit weight of aquatic plants in one unit area of reactor while Figure 7 represent the nutrients removals in term of one unit area occupied by aquatic plant in one unit area of reactor.

Comparison between floating plants (R–P, R–Q and

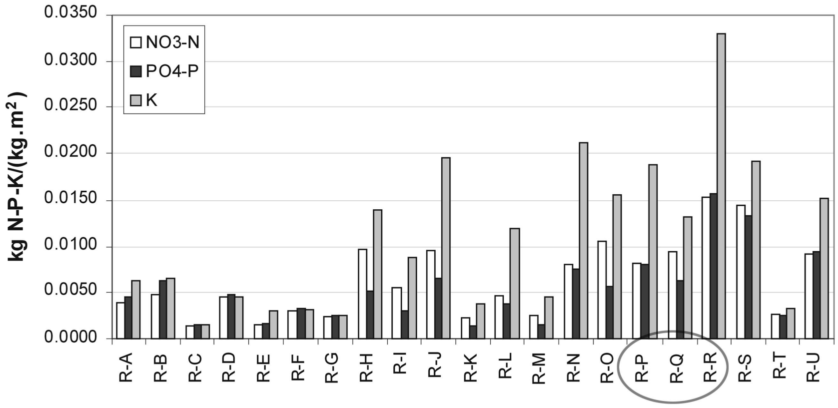

Fig. 6. Nutrients Used by Aquatic Macrophytes (kg-nutrients per kg-plant).

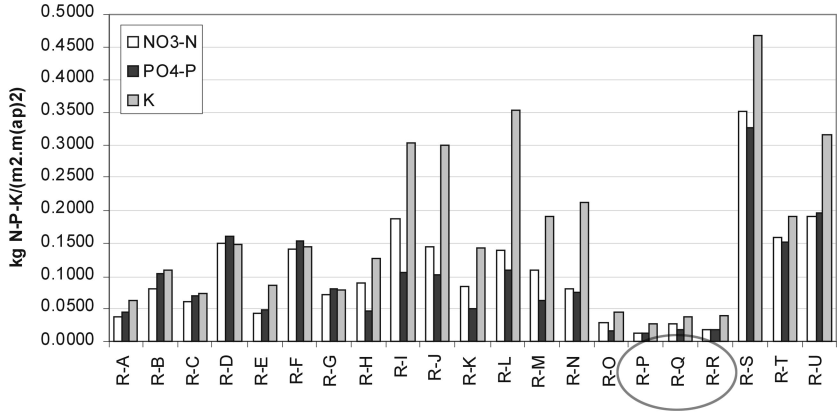

Fig. 7. Nutrients Used by Aquatic Macrophytes (kg-nutrients per area plant occupied in reactor).

R–R) and emergent plants, the result shown that all of floating plants used in this experiment gave higher nutrients removal per weight of plant than other emergent plants while they gave lower nutrients removal when area occupied by aquatic plant on reactor was considered. Reactor contained *Zizania latitolia* (줄) dominantly gave the highest nutrient removals both in term of unit plants weight and area occupied by aquatic plant. However the data shown in Figure 6 and 7 are not only nutrients removal by aquatic plants but also bacteria activities (nitrification, denitrification, etc.) and physical properties of media beds (i.e. precipitation and adsorption of phosphorus and potassium) must be accounted.[6)]

4. Conclusion

The removal of excess nutrients in polluted water by wetlands was found to attractive in considering of green technology for environments and ecological method. Aquatic plants in wetland played important roles on the nutrients removal in phytoremediation process of water polluted with high nutrients. Type of plants was directly shown to affect the removal of nutrients in PBR. Physiology of aquatic plants such as height of plant and shape of leaves also affected to the overall nutrients removal in constructed wetland. No significant changing of pH was recorded during the experiment. Additionally, plants weight and area occupied by aquatic plants should be considered for selecting and managing the proper aquatic macrophytes in constructed wetland.

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