CHAPTER 5
CONCLUSIONS

5.1 Conclusions

The 8 types of plants that were screened were *Crinum asiaticum*, *Echinodorus cordifolius*, *Spathiphyllum clevelandii*, *Rhizophora apiculata*, *Thalia dealbata* J. Fraser, *Heliconia psittacorum*, *Sonnertia ovata*, and *Sagittaria montevidensis* for treatment of phosphorus from domestic wastewater. The result showed that *E. cordifolius* had the best efficiency for phosphorus treatment because the plant has numerous roots, was able to uptake a larger amount of water than another plants and grow rapidly. In addition, the roots of *E. cordifolius* containing acid-producing bacteria might have enhanced phosphorus removal because these bacteria produced organic acids such as acetic acid, propionic acid, butyric acid, etc. These organic acids might solubilize organic phosphate to become available phosphorus that plants can uptake easily. *E. cordifolius* was able to reduce phosphorus, nitrogen and COD from domestic wastewater. This result was due to the fact that the plant used ammonia-nitrogen and nitrate-nitrogen for their growth and because the extensive root system of plant was able to filtrate suspended solids and particulates. During the treatment, plants grew well in domestic wastewater, the flowering stage appeared, and roots, shoots, and plant leaves were extended. This result was confirmed by increasing plant biomass and photosynthesis of plants. After phosphorus treatment for 4 cycles, plant biomass was increased from 46.60±0.00 g dry weight plant^{-1} to 52.81±2.69 g dry weight plant^{-1}.The increased plant biomass was associated with the increase in photosynthesis capability. The nutrients in domestic wastewater supported plant growth and induced increase in plant photosynthesis.

For sustainable systems, the treatment of phosphorus by *E. cordifolius* was studied for 20 cycles, and the percentage of nitrogen and phosphorus accumulated in plant growing in domestic wastewater was 2.03±0.59% and 1.29±0.06%, respectively, which was significantly different from the control set which was 1.24±0.02% and 0.71±0.04, respectively. This was due to plants uptaking these nutrients for a long time, which caused nitrogen and phosphorus accumulation in plant tissues. The relationship between plant, microorganisms and soil in phosphorus treatment from domestic wastewater revealed that after soil was saturated, plants played a major role in phosphorus removal, about 81%, the least contribution was from microorganisms in soil and wastewater.

Enhancing phosphorus removal of *E. cordifolius* by using sawdust bottom ash was also studied. The result showed that adding 1% and 5% of sawdust bottom ash in the pots with plant to treat phosphorus from domestic wastewater was not significantly different from the pot without sawdust bottom ash. In addition, phosphate concentration in the pot with only soil and domestic wastewater was lower than the pot with soil, domestic wastewater and sawdust bottom ash. This was due to phosphate contaminated in sawdust bottom ash. The results suggested that enhancing phosphorus removal by material, we should be aware of material composition, which might consist of phosphorus that will be released into the system.

Bioaugmentation of phosphorus treatment by *E. cordifolius* with microorganisms (*Pseudomonas putida* and *Flavobacterium oryzihabitans*) enhanced phosphorus removal. The result of the system augmented with *P. putida* and the system augmented with mixed microorganisms (*P. putida* and *F. oryzihabitans*) was able to remove phosphorus from domestic wastewater until it passed standard criterion of the U.S.EPA within 14 hours. Moreover, after phosphorus treatment for a month, the flowering stage of plant appeared, shoots and leaves were extended; these were associated with the increase in plant biomass. This result suggested that *P. putida* and *F. oryzihabitans* supported plant growth because these microorganisms are phosphate solubilizing bacteria. The role of microorganisms might be to release protons, CO_2, and secondary organic metabolites for solubilization of organic phosphorus into available phosphorus for easy uptake by plants. In addition, acid-producing bacteria associated with *E. cordifolius* root released acid for degradation of non-available phosphorus to be available phosphorus for plants to uptake more phosphorus. This might be another reason for *E. cordifolius* in being the best plant for phosphorus removal.

This study indicated that *E. cordifolius* is a suitable plant for application in nitrogen and phosphorus treatment from domestic wastewater. In addition, the plant associated with microorganisms (*P. putida* and *F. oryzihabitans*) enhanced higher phosphorus removal because these microorganisms are plant growth promoting bacteria or phosphate solubilizing bacteria and caused increasingly higher biomass of plants.

5.2 Suggestion

The study suggested that in using plants for treatment of nitrogen and phosphorus, we should be aware of harvesting decayed plant that due to decayed plant that could release nitrogen and phosphorus back into the system. In addition, the role of microorganisms in domestic wastewater and associated plant roots are of interest for further study to enhance the efficiency of nutrient treatment from domestic wastewater by plant. Moreover, activated sludge may be applied in the system for enhancing phosphorus treatment with plant.