A STUDY ON DESIGN AND MAINTENANCE OF CONSTRUCTED WETLAND IN CAMPUS

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ABSTRACT
A constructed wetland is applied to treat the wastewater from campus. We study the maintenance on three aspects: decontamination capability, ecological environment and public hygiene. In addition, we experiment on the tolerance of fishes which are the major organisms to control mosquito by eating the wigglers. The removal efficiency of components from wastewater are 74% on TSS, 80% on BOD5, 56% on COD, 46% on TN, and 51% on TN. The location of constructed wetland should be exposed under sufficient sunlight and against building wind in order to provide benefit to macrophytes growth. Also periodical pruning on aquatic plants is very important. The result shows that Macropodus opercularis is well cultured in constructed wetland and has the best performance on mosquito control in Taiwan.

KEYWORDS
constructed wetland, wastewater treatment, maintenance, pruning, wigglers control, tolerance

INTRODUCTION
Constructed wetland is a system imitates the natural wetland to provide the function of wastewater treatment and ecological conservation. Constructed wetlands that integrate physical, chemical, and biological processes, which occur in the substratum soil-water-plant ecosystem, have grown in popularity for wastewater treatment since the early 1970s (Kadlec and Knight, 1996). During the past three decades, constructed wetlands have been used to treat municipal wastewater, industrial wastewater, agricultural and storm runoff, and effluent from livestock operations. The advantages of this technology include moderate capital costs, very low energy consumption and maintenance requirements, and benefits of increased wildlife habitat and landscape aesthetics. Moreover, reclamation and reuse of treated wastewater from constructed wetlands has also been reported. The potential reuse applications include irrigation (Gearheart, 1999), and toilet flushing (House et al., 1999)

A campus typically contains available landscape space, such as a garden, courtyard, and pond. If part of these landscape areas can be use to constructed wetlands, campus wastewater would be economically and efficiently treated and reused with increasing the landscape and ecology. Constructed wetland treatment system therefore becomes a potential exemplar of ecological technology to fit the goals of a sustainable campus.

However, a constructed wetland lacking in maintenance will cause public hygiene problems and environmental risks. In this research, a constructed wetland is applied to treat the wastewater from campus. We study the maintenance on three aspects: decontamination capability, ecological environment and public hygiene. In addition, we experiment on the tolerance of fishes which are the major organisms to control mosquito by eating the wigglers.

MATERIALS AND METHODS

Constructed Wetland-Pond System

The constructed wetland-pond system was located outside the teaching building of the Department of Architectural at National Cheng-Kung University (NCKU). The system construction was completed in September 2003. This system is designed to treat and reuse 5 m³/day of wastewater is 5% of constructed wetland. It collected from the building and enhance the landscape and ecology. The system was connected with the existing septic tank and consisted of a pump tank, one SSF constructed wetland cell, two FWS constructed wetland cells, a scenic pond, a storage tank of reclaimed water, and piping for landscape irrigation (Figure 1). There are 300 students and department staff uses the teaching building on weekdays.

The SSF (subsurface flow system) and FWS (free
water surface flow system) constructed wetland cells are designed to be responsible for secondary treatment of the wastewater in septic tank effluent. The constructed wetlands trenches measuring 2 meters wide * 18 meters long and 4 meters wide * 9 meters long, respectively. They were lined with impermeable plastic liners; each contained a 30 cm layer of local soil at the bottom to support growth of emergent macrophytes. The constructed wetlands were planted with cattail (*Typha Orientalis Presi.*) in the front half and water hyacinth (*Eichhornia crassipes*) in the rear half. The planting density was 4 plants/m² for both wetland cells.

Following constructed wetlands, a 120 m² scenic pond planted with ornamental plants, such as *Cyperus alternifolius*, *Hyprophila pogonocalyz*, *Nuphar shimadai*, *Ludwigia adscendens*, and *Droseraburmanni vahl*, was used for enhancement of landscape aesthetics. The operating at water depth between 0.15 and 0.85 meters. The scenic pond is also capable of further reducing the pollutants remaining in the constructed wetlands effluent. Effluent from the scenic pond was stored in a 50 m³ reclaimed water tank for reuse in landscape irrigation.

![Figure 1 Layout of the constructed wetlands system for treatment and reuse of septic tank wastewater from campus buildings.](image)

**Sample Analysis**

Water samples were collected and monitored weekly from the inlet of SSF and FWS cell, the outlet of FWS cell, and the middle of the scenic pond (Figure 1) at approximately 10 a.m. of the sampling day to investigate the performance of constructed wetlands in treating wastewater and the suitability of treated wastewater for reuse. All water samples collected were stored in an ice container and transported immediately to laboratory for water quality analysis.

Water samples were analyzed for TSS, BOD₅, chemical oxygen demand (COD), total Kjeldahl nitrogen (TKN), ammonium, nitrite, nitrate, total phosphorous, and orthophosphate in the laboratory. Temperature, dissolved oxygen, and pH of the wastewater at each sampling location were also measured in site when sampling was performed. All above measurement methods were according to “Discharge Standard” set by Environmental Protection Administration in Taiwan.

**Maintenance and Management**

The constructed wetland system was funded by the “Green Remodeling Plan for Governmental Building” program of Architecture and Building Research Institute (ABRI). After the establishment of this constructed wetland, ABRI funded the research budget for the observation of water quality, piping and equipments, and the staffs to maintain the pond. In light of the maintenance and management concerns, this article has three purposes: decontamination capability, ecological environment and public hygiene.

**Tolerance Experiment**

NH₄-N, critical thermal and dissolved oxygen (DO) level is a critical factor of fishes and sustainable management of an aquatic ecosystem especially in constructed wetland. This study aims to investigate the lethal thresholds of three major fish in the NCKU...
constructed wetlands. Laboratory tolerance experiments of fish, including *Macropodus opercularis*, *Trichogaster Trichopterus* and *Gambusia affinis*.

**DISCUSSION AND RESULT**

**Decontamination Capability**

Hydrology is an important variable in any wetland design. If the proper hydrologic conditions are developed, chemical and biological conditions will respond accordingly. Several standard descriptors were used to estimate the pollutant-removal performance of the constructed wetland system.

The campus sewage has already been classified as one of the undertaking wastewater, and it cannot be discharged unless it meets the standards. The removal efficiency of components from wastewater are 74% on TSS, 80% on BOD5, 56% on COD, 46% on TN, and 51% on TN, in NCKU constructed wetland. All above measurement methods were according to “Discharge Standard” set by Environmental Protection Administration in Taiwan.

**Ecological Environment**

There are three issues need to be discuss on the ecological environment of construction wetland: biological introduction, plant pruning, and bioinvasion elimination.

*Typha Latifolia, Eichhornia Crassipes* and *Pistia Stratiotes* have great performance on water purification and environmental adaption, and *Macropodus opercularis* has the best tolerance (from tolerance experiment) to prevent mosquito, so they are selected for campus construction wetland. Since the campus construction wetland had been build, different creatures from everywhere of campus moved in and perched.

Plant pruning stage determine on three different plants. The phytoplankton and floating aquatic plants grow very fast. Phytoplankton need to be purged every other week in the spring and summer. Floating aquatic plants need to be pruned once a month or two months. To avoid the laggard growth or been taking over by other plants, do not over pruning floating aquatic plants. The partially-submerged aquatic plants such as *Typha Latifolia, Canna indica L* and *Cyperus Alternifolius* need to be trimmed regularly and heavy pruned every season. For general landscaping aquatic plants such as *Hygrophila pogonocalyx Hayata, Alismatis Rhizoma* and *Nymphaea tetragona Georgi* need to be pruned every half year.

For all the creatures that are invasive without planning (such as dog, *Rana catesbeian*) need to be eliminated to avoid destroying the ecological equilibrium.

**Public Hygiene**

The NCKU constructed wetland is specifically built to deal with human wastewater, proper sanitary engineering techniques should be used to minimize human exposure to pathogens. Measurements of indicator organisms such as fecal and total coliforms should be part of the monitoring of campus wastewater constructed wetland. In NCKU constructed wetland, the removal efficiencies of constituents from wastewater were 96.9% for the total coliforms and 100% for the fecal coliform. The observation of water quality was implemented regularly, and the water quality meets the requirements of “Discharge Standard”, the public hygiene not have the qualm.

**Tolerance Experiment**

The tolerance experiment was carried out for *Macropodus opercularis*, the water critical thermal temperature minimum is 10.8 °C, and the water critical thermal temperature maximum is 40.4 °C, there is no limitation for dissolved oxygen; the tolerance of nitrogen concentration is as high as 561mg/L.

<table>
<thead>
<tr>
<th>Operation</th>
<th><em>Macropodus opercularis</em></th>
<th><em>Trichogaster trichopterus</em></th>
<th><em>Gambusia affinis</em> (Mosquito fish)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical Thermal Maximum (°C)</td>
<td>40.4 ± 0.5</td>
<td>39.7 ± 0.2</td>
<td>41.6 ± 0.8</td>
</tr>
<tr>
<td>Critical Thermal Minimum (°C)</td>
<td>10.8 ± 0.9</td>
<td>12.2 ± 0.5</td>
<td>7.3 ± 1.2</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>No influence</td>
<td>No influence</td>
<td>0.99</td>
</tr>
<tr>
<td>NH₄-N (mg/L)</td>
<td>561.2</td>
<td>464.1</td>
<td>75.7</td>
</tr>
</tbody>
</table>
CONCLUSION

Constructed wetland is a system imitates the natural wetland to provide the function of wastewater treatment and ecological conservation. However, a constructed wetland lacking in maintenance will cause public hygiene problems and environmental risks. In this research, a constructed wetland is applied to treat the wastewater from campus. We study the maintenance on three aspects: decontamination capability, ecological environment and public hygiene. In addition, we experiment on the tolerance of fishes which are the major organisms to control mosquito by eating the wigglers.

The water quality was monitored regularly to meet the requirements of “Discharge Standard” set by Environmental Protection Administration of Taiwan. The removal efficiency of components from wastewater are 74% on TSS, 80% on BOD5, 56% on COD, 46% on TN, and 51% on TN. The location of constructed wetland should be exposed under sufficient sunlight and against building wind in order to provide benefit to macrophytes growth. Also periodical pruning on aquatic plants is very important. The tolerable condition for Mosquito fish is that NH4-N lower than 77mg/L and DO higher than 1 mg/L. The result shows that *Macropodus opercularis* is well cultured in constructed wetland and has the best performance on mosquito control in Taiwan.

References


Campbell, Craig S. and Ogden, Michael H., 1999, Constructed Wetlands in the Sustainable Landscape, John Wiley & Sons, Inc. published, Canada
