Performance of Wetland Plants
By
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Abstract

The main-goal of the constructed wetland project is to create a self-sustaining and balanced lake ecosystem set in the garden city of Putrajaya, the new Federal Government Administrative Centre of Malaysia. The wetlands with an innovative multi-cell multi-stage system is designed for multi-functional uses which include stormwater treatment, provision of habitat, passive recreation, aesthetic amenity, public education and a wetland research centre.

A typical layout of wetland vegetation in cell UW8 planted in 1998 shown not all wetland plants performed very well and as last year *Phragmites karka*, *Lepironia articulata*, *Scirpus grossus*, *Hanguana malayana*, *Cyperus haspan* L while *Saccharum spontaneum* grow poorly.

The same result can be said at other cells and visual observation and operation in maintaining the wetland cell 5 noted species grow and adapt very well : *Hanguana malayana, Phragmites karka, Lepironia articulata, Cyperus halpan* and *Scirpus grossus* that will be discussed in this paper
The primary objective of the Wetland Project is to create a self-sustaining and balanced lake ecosystem in the Garden City of Putrajaya. The other objectives include:

- To create a lake and wetlands ecosystem that is unique in the world;
- To achieve the water quality objective of the lake so that the water is suitable for body contact recreation;
- To provide opportunities for research and development of wetlands for water quality management;
- To create a habitat that is conducive for native floral and fauna conservation and promote as another destination for eco-tourism in the country and
- To be a centre community education.
Considerations on Plant Selection

- Naturally adapted
- For instance related to:
  - Soil moisture
  - Light quality and quantity
  - Wind exposure
  - Air humidity
  - Soil pH
- Natural habitats of these plants
- Appropriate use of plants:
  - Maintenance
  - Longevity and sustainability
  - Design intent
  - Ecology value

- To remove pollutants from both the terrestrial and aquatic environment
- Phytoremediation capabilities of plants.
- Floating plants:
  - High nitrogen and phosphorus
  - Woody emergent
  - Anchor the plant and fauna communities
  - Steady levels of nutrient
Vegetation Selection

- The important role of vegetation in pollutant removal in runoff control systems
  - Taking up nutrient directly
  - Trapping sediment
  - Supporting epiphytic growth
- To use of native wetlands species is adopted to ensure sustainability of the botanical design of wetlands
- The selection of vegetation
  - Structural
  - Functional
- Functional feature
  - Nutrient tolerance and water capacity
  - Water logging
  - Microbial carrying capacity
  - Biomass accumulation rate
- Structural feature
  - Plant height and shade efficiency
  - Refuge value for fish and other aquatic fauna
  - Associated vegetation type etc
- A heterogeneous system
  - Resilience required
    - Environmental variability with fluctuations in flow rate, turbidity and nutrient loadings
- The selection criteria for plants
  - Indigenous species
  - Ease of propagation
  - Availability
  - Aesthetic value
  - Ability to transfer oxygen to the roots
  - biodiversity
The Natural Zonation Of Plants

- In natural ecosystem, distinctive groups of plants are adapted to varying degrees of soil wetness
- The shallow zone
  - Emergent plants
- Deeper Zone
  - The emergent plants are replaced by rooted plants with floating leaves
- Fringed Zone
  - Submerged plants often with free-floating species
- Selecting plants for use in different parts of a landscaped waterbody
The distinct zonation of aquatic and waterlogged tolerant plants can be explained by a set of factors that affect plant growth and development.

- Temperature
- Light
- pH
- Water depth: Water depth is also another point of consideration when selecting plants, for inclusion into urban waterbodies. The amount of oxygen available to the plants varies at different depth within a waterbody. For instance, at a 2m depth, the oxygen content is lower than the oxygen content at the surface. Emergent plants such as *Nymphaea nouchali* Burm.F. and *Phragmites karka* are generally sensitive to water depth and do not grow well in water deeper than 1.2 m.
Selecting Plants With Species Phytoremediation Abilities

- Process of Phytoremediation
  - Ability to accumulate such pollutants
  - Yet no Phytotoxicity
  - Therefore suitable to treat contaminated waterbodies
- Qualify a plant hyperaccumulator
  - The metal or metalloids concentrated by plants in their tissues should be at least 1000ppm (Abhilash et al., 2009; Liu et al., 2007)
- Special care to dispose of the plant containing high level of pollutants/contaminants
A list of common plants with the ability to accumulate different types of heavy metals and metalloids is shown in table.

<table>
<thead>
<tr>
<th>Plant Name</th>
<th>Scientific name</th>
<th>Common name</th>
<th>Heavy metals/Metalloids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salvinia molesta</td>
<td>Giant Salvinia</td>
<td>Cr, Ni, Pb, Zn</td>
<td></td>
</tr>
<tr>
<td>Eichorrmia crassipes</td>
<td>Water Hyacinth</td>
<td>Cd, Cr, Cu, Hg, Pb, Zn</td>
<td></td>
</tr>
<tr>
<td>Hydrilla verticillata</td>
<td>Hydrilla</td>
<td>Cd, Cr, Cu, Pb</td>
<td></td>
</tr>
<tr>
<td>Ipomoea aquatic</td>
<td>Kangkong</td>
<td>Cd, Hg, Pb</td>
<td></td>
</tr>
<tr>
<td>Lemna minor</td>
<td>Lesser Duckweed</td>
<td>Cd, Hg, Pb</td>
<td></td>
</tr>
<tr>
<td>Melastoma malabathricum</td>
<td>Senduduk</td>
<td>Al</td>
<td></td>
</tr>
<tr>
<td>Typha angustifolia</td>
<td>Cattail</td>
<td>Cd, Cu, Pb</td>
<td></td>
</tr>
<tr>
<td>Pistia strariotes</td>
<td>Water kettuce</td>
<td>Cr, Cu, Hg, Pb</td>
<td></td>
</tr>
<tr>
<td>Chrysopogon zizanioides</td>
<td>Vertiver Grass</td>
<td>Pb, Zn</td>
<td></td>
</tr>
<tr>
<td>Pityrogramma calomelanos</td>
<td>Silver Fern</td>
<td>As, Cu, Hg, Pb</td>
<td></td>
</tr>
<tr>
<td>Cyperus alternifolius</td>
<td>Umbrella Plant</td>
<td>Cd, Cu, Pb, Zn</td>
<td></td>
</tr>
</tbody>
</table>

Cr: Chromium; Ni: Nickel; Pb: Lead; Zn: Zinc; Cd: Cadmium; Cu: Copper; Hg: Mercury; Al: Aluminium; As: Arsenic
Emergent Plants

- Waterlogged tolerant plants rooted in the substratum.
  - Roots
  - Lower parts of the stems
  - Some of the leaves

- Emergent plants Growth in
  - Shallow water
  - Waterlogged soil
  - Stem
  - Estuaries

- Soft-stemmed emergent
  - *Typha* *spp*
  - *Lepironia articulata* Reproduce rapidly
  - Difficult for the other plants to get established
  - Grow in pure stands in some habitat

- High density growth pattern
  - Absolute competitive edge over other plant
    - Space
    - Sunlight
Project Description

* The Wetland of Putrajaya is the first manmade wetland and the site covers a total area of 200 hectares.
* Diversified with flora and fauna it also serves the exact functionally and benefit
  - enjoyment
  - education
  - health
  - inspiration
* The wetland was developed to act as a powerful tool in protecting the environment against degradation
Wetland of Putrajaya was built in adaptation of a multi-cell and multistage design strategy.

- Water level
  - increase longitudinally from the entry to exit point.
  - different depth which allows the water to flow naturally through the system and finally into the lake of Putrajaya.

- Wetlands and Cells are divided as follows:
  - Upper North Wetlands (8 cells)
  - Upper West Wetlands (8 cells)
  - Upper East Wetlands (3 cells)
  - Lower East Wetlands (2 cells)
  - Upper Bisa Wetlands (2 cells)
  - Central Wetlands (1 cell)

- The Wetland areas are categorized into two areas.
  - A Wetland zone
    - Permanently flooded
    - Macrophytic
      - Shallow part
      - Open ponds in deeper parts
      - Ornamental ponds
  - Zone of intermittent inundation (ZII)..
    - flooded during the high flow
    - species adaptable to intermittent flood conditions.
Macrophytic Zone (Wetland Zone)
The macrophytic zone is the zone of permanent inundation. There are three different zones within this area and are defined by the water depths.

- **Shallow marsh (0 – 0.3 m water)**
  - Eleocharis variegata
  - Eriocaulon longifolium
  - Fimbristylis globulosa
  - Fimbristylis miliae
  - Hanguana malayana
  - Ludwigia adscendens
  - Ludwigia octovalvis
  - Phylidrum
  - Polygonum barbatum/pulchrum
  - Saccharum spontaneum
  - Scleria sumatrensis

- **Marsh (0.3 – 0.6 m)**
  - Eleocharis dulcis
  - Fuirena umbellate
  - Lepironia articulate
  - Phylidrum lanuginosum
  - Scirpus grossus
  - Scirpus mucronatus
  - Typha augustifolia/Alocasia

- **Deep Marsh (0.6 – 1 m)**
  - Lepironia articulate
  - Phragmites karka
  - Scirpus grossus
  - Scirpus mucronatus
  - Typha augustofolia

Zone of Intermittent Inundation (ZII)
This zone is divided into two different zones with various species planted within it.

- **The Lower Fringing Littoral Zone (Zone F1) (0 – 0.3 m water level)**
  - Alocasia macrorrhiza
  - Alstonia spathulata
  - Colocasia gigantea/esculenta
  - Commelina nudiflora
  - Crinum asiaticum
  - Cyperus halpan
  - Cyperus compactus
  - Cyperus digitatus
  - Dillenia suffructosa
  - Eleocharis variegata
  - Eugenia longifolia
  - Eriocaulon longifolium
  - Fimbristylis milicia
  - Ludwigia octovalvis
  - Pandanus implexus
  - Ploiarium alternifolium
  - Polygonum barbatum
  - Rhynchospora corymbosa
  - Saraca thaipingisis
  - Xanthosoma spp.

- **Swamp Forest on Higher Ground (Zone F2) (0.3 – 1.5m above normal water level)**
  - Alstonia spathulata
  - Artocarpus heterophyllus
  - Caryota mitis
  - Centella asiatica
  - Commelina nudiflora
  - Cerbera odollam
  - Cratoxylon arborescens
  - Dillenia suffructiosa
  - Eleocarpus nitidus
  - Eugenia aquae
  - Eugenia longifolia
  - Ficus benjamina
  - Ficus microcarpa
  - Flagellaria indica
  - Garcinia mangostana
  - Hibiscus tiliaceus
  - Ixora javanica
  - Ixora umbellate
  - Lansium domesticum
  - Licuala spinosa
  - Litsea teysmanni
  - Melaleuca cajuputi
  - Nepenthes gracilis
  - Pomentia pinnata
  - Santiria ribiginosa
  - Saraca thaipingisis
<table>
<thead>
<tr>
<th>Station</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
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</thead>
<tbody>
<tr>
<td>LE1</td>
<td>93</td>
<td>90.9</td>
<td>91.2</td>
<td>88.6</td>
<td>89.7</td>
<td>88.4</td>
</tr>
<tr>
<td>UB2</td>
<td>90.8</td>
<td>91.6</td>
<td>84.6</td>
<td>83.5</td>
<td>80.8</td>
<td>85.3</td>
</tr>
<tr>
<td>UE1</td>
<td>92.4</td>
<td>91.7</td>
<td>90.7</td>
<td>85.4</td>
<td>87.2</td>
<td>84.5</td>
</tr>
<tr>
<td>UN8</td>
<td>83.1</td>
<td>83.8</td>
<td>83.3</td>
<td>81.9</td>
<td>78.4</td>
<td>78.7</td>
</tr>
<tr>
<td>UW7</td>
<td>89.1</td>
<td>88.5</td>
<td>86.7</td>
<td>84.8</td>
<td>85.2</td>
<td>85.5</td>
</tr>
<tr>
<td>Lake</td>
<td>93.9</td>
<td>93.5</td>
<td>91.5</td>
<td>88.7</td>
<td>90.4</td>
<td>90.5</td>
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<tr>
<td>WQI Class I (&gt;92.7)</td>
<td>92.7</td>
<td>92.7</td>
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<td>92.7</td>
<td>92.7</td>
<td>92.7</td>
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<tr>
<td>WQI Class II (76.5 - 92.7)</td>
<td>76.5</td>
<td>76.5</td>
<td>76.5</td>
<td>76.5</td>
<td>76.5</td>
<td>76.5</td>
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</tbody>
</table>
Figure 1. Water Quality Index (average) at Lake and Wetland Stations, Putrajaya
Figure 2. Water Quality Index (average) at Wetland Stations, Putrajaya
## Summary of a Wetland Cell Structure and Function

<table>
<thead>
<tr>
<th>ZONE</th>
<th>COMPONENT</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inlet Zone</strong></td>
<td><strong>Inlet</strong></td>
<td>– Provides passage of water by gravity to wetlands</td>
</tr>
<tr>
<td></td>
<td><strong>Energy dissipater</strong></td>
<td>– Provides protection for the bed of channels and the inlet of wetland by reducing the energy of the water and preventing soil erosion. May be applicable to any part of the wetland where there are potential erosion problems.</td>
</tr>
<tr>
<td></td>
<td><strong>Reed bed</strong></td>
<td>– Provides support for microbial biofilms that facilitate nutrient transformation, organic flocculation, filtration of pollutants enhancement of sedimentation and provision of oxygen to sediment to enhance bacterial decomposition of organic matter</td>
</tr>
<tr>
<td><strong>Macrophyte Zone</strong></td>
<td></td>
<td>– Increase biodiversity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Provides a range of habitats for macro and micro fauna</td>
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<tr>
<td></td>
<td></td>
<td>– Enhances setting of liner soil and sediment particles and associated pollutants such as heavy metals nutrients and pesticides</td>
</tr>
</tbody>
</table>
### Summary of a Water Cell Structure and Function

<table>
<thead>
<tr>
<th>ZONE</th>
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<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macrophyte Zone</td>
<td>Sedimentation forebays</td>
<td>➢ Reduce sediment loads to reed bed zones ensuring higher clarity for effective plant growth</td>
</tr>
<tr>
<td></td>
<td>Open Water</td>
<td>➢ Improves water quality both within and downstream of wetlands which in turn improves health of ecosystem</td>
</tr>
<tr>
<td></td>
<td>Island</td>
<td>➢ Allows UV (sunlight) penetration for disinfection</td>
</tr>
<tr>
<td></td>
<td>Edge water plants</td>
<td>➢ Enhances mixing of water columns and reduces short circuiting</td>
</tr>
<tr>
<td></td>
<td>Water level control Structures</td>
<td>➢ Provides deep-water habitat for bird, fish, invertebrates, frogs, turtles, creates a refuge during droughts or dry times.</td>
</tr>
<tr>
<td></td>
<td>Trash racks</td>
<td>➢ Provides landing and secure areas for waterfowl. Contacts with planted areas enhance virtual attraction of the wetlands</td>
</tr>
<tr>
<td></td>
<td>Weirs</td>
<td>➢ Provides isolated habitat for bird shelter, refuge and nesting</td>
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<tr>
<td></td>
<td></td>
<td>➢ Provides a visually appealing focus to the wetlands</td>
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<tr>
<td></td>
<td></td>
<td>➢ Create habitats diversity along the shoreline for invertebrates and wading birds</td>
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<td></td>
<td></td>
<td>➢ Provides water quality improvement</td>
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<td></td>
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<td>➢ Prevent access</td>
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<td></td>
<td></td>
<td>➢ Allows capture of highly polluted flows for retrieval or recycling</td>
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<td></td>
<td></td>
<td>➢ Allows water level control for a range of purposes including</td>
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<tr>
<td></td>
<td></td>
<td>➢ Operation and maintenance</td>
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<td></td>
<td></td>
<td>➢ Predetermined water regimes to be implemented for greater diversity or to specifically encourage particular species</td>
</tr>
<tr>
<td></td>
<td></td>
<td>➢ Manipulation of water level for water plant establishment</td>
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<td></td>
<td></td>
<td>➢ Prevents litter and debris from entering wetlands and degrading water quality, aesthetics and health of ecosystem</td>
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<tr>
<td></td>
<td></td>
<td>➢ Impounds stream flows to create a pool</td>
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<tr>
<td></td>
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<td>➢ Sets normal operating water levels in wetlands</td>
</tr>
</tbody>
</table>

### Open Water Zone

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Island</td>
<td></td>
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<tr>
<td>Edge water plants</td>
<td></td>
</tr>
<tr>
<td>Water level control Structures</td>
<td></td>
</tr>
<tr>
<td>Trash racks</td>
<td></td>
</tr>
<tr>
<td>Weirs</td>
<td></td>
</tr>
</tbody>
</table>
Generally, the wetland plants conditions for all wetland system in Putrajaya are in good condition except these 5 plants species (*Phragmites karka, Lepironia articulata, Cyperus haspan, Hanguana malayana* and *Scirpus mucronatus L.*) seemed to grow and established quite well due to the efficiency and nutrition uptake themselves and as a result harvesting and thinning need to be done regularly and perhaps recommended for quick establishment of wetland area. The wetland vegetation did not encounter any major problems related to weeds, pest and disease.

The sedimentation due to construction activities gives an impact to the Putrajaya plant survivability. Therefore immediate solutions need to be taken to overcome this problem in order to ensure the healthy growth of the wetland plants. Regular inspection should be carried out to ensure that the hydraulic structures and mechanical components for the wetland are functioning accordingly. Extreme water level (too high or too low) which is resulted from hydraulic and mechanical failures may give adverse effects on the plant survivability.
Conclusion….
Last but not least, thinning or pruning of the over-matured wetland plants is essentially required as it is observed that some of the wetland plants (especially *Phragmites karka* and *Hanguana malayana*) have been establishing ‘too well’ in certain wetland cells.
Thank you