UNIVERSITI TEKNOLOGI MARA

CONFERENCE PROCEEDING

ICITSBE 2012

1ST INTERNATIONAL CONFERENCE ON INNOVATION AND TECHNOLOGY FOR SUSTAINABLE BUILT ENVIRONMENT

16 -17 April 2012

Organized by:

Office of Research and Industrial Community And Alumni Networking

Universiti Teknologi MARA (Perak) Malaysia

www.perak.uitm.edu.my

PAPER CODE: GT 38

PHYTOTECHNOLOGY : POTENTIAL OF FLOATERS AS PHYTOINDICATOR FOR NITRIFICATION AND EUTROPHICATION IN UNHEALTHY FRESHWATER BODIES

W Naimatul Asiah, Rashidi Othman,Ruhul 'Izzati and Nur Hanie Mohd Latiff
Department of Landscape Architecture, Kulliyyah of Architecture & Environmental Design,
International Islamic University Malaysia, 53100 Kuala Lumpur, Malaysia,
as_delonix@yahoo.com

Abstract
The aim of this research is to verify the potential of different floating macrophytes as a good phytoindicator for excess nutrients or bioindicator for nitrification and eutrophication in fresh water bodies. Domination of floaters in water bodies were investigated from 3 different states (Selangor, Pahang and Kelantan) in Malaysia. At each state, 15 water samples were collected and analysed for phosphate, ammonium, nitrite and nitrate. Species are varied at each site, namely Lemna minor, Eichhornia crassipes, Neptunia oleracea, Pistia stratiotes, Spirodela polyrhiza and Salvinia molesta. L.minor, E.crassipes and S.polyrhiza were observed as a great phytoindicator for excess nutrient of phosphate and ammonium. Water quality where both species were in abundance was classified in class III and considered polluted according to Interim National Water Quality Standards for Malaysia (INWQS). This finding revealed that all water bodies were detected with the presence of excess nutrients but the levels of concentration are varied. All species were found as potential and effective phytoindicators for nitrification and eutrophication in fresh water bodies.

Keywords: Floating macrophytes, Phytoindicator, Nitrification, Eutrophication, Excess nutrients.

1. Introduction

Aquatic macrophytes are important components of many littoral zones given their contribution of valuable ecosystem services. They store and release nutrients (Carpenter et al., 1986; Granelli et al., 1986) can prevent excessive phytoplankton (Timms et al., 1984; Sondergaard et al., 1998) and provide energy and nutrients to a range of herbivorous organisms (Lodge et al., 1987; Wetzel, 2001). They also serve as habitat for a variety of aquatic organisms including fish (Randall et al., 1996; Sass et al., 2006) and zooplankton (Burks et al., 2002, Jeppesen, 1998). Various aquatic macrophytes, such as water hyacinth (*Eichhornia crassipes*), duckweeds (e.g. *Lemna spp*.), water lettuce (*Pistia stratiotes*), cattail (*Typha latifolia*), and common reed (*Phragmites communis*), have been applied to remove Nitrogen and Phosphorus from eutrophic water. These plants are chosen based on previous studies that documented their ability to survive in nutrient and environments and grow strong roots (Miao et al., 2009).

2. Literature Review

Nutrients are the main agricultural pollutants in Malaysia. Nitrogen and Phosphorus are nutrients that brings threat to ecosystem while exceed its limit. Drainage ditches, irrigation channels, ponds and other waterways are polluted by agricultural runoff from fertilizer rich land such as vegetable farms, fruits and flower nurseries, golf courses and animal farms. More than 63% of the rivers in Malaysia are classified as moderately to highly pollute. They receive urban runoff polluted with domestic sewage discharges and livestock excreta, as well as from agricultural uses and wastewater from factories. The river waters have high concentrations of biological oxygen demand, nutrients and pathogens, resulting in a risk to public health for bathing and fishing, particularly in areas of poor or impoverished human population and water recreational areas (Sima et al., 2008).

Nitrification is an important step in the nitrogen cycle. In short, nitrification can be defined as the process by which ammonia is changed to nitrite, and nitrite to nitrate. Nitrification was initially not seen as a necessity from the point of view of the receiving water but was rather experienced as a cause of eutrophication and nuisance (Fair et al., 1984). Agriculture and urban activities are major sources of phosphorus and nitrogen to aquatic ecosystems. Atmospheric deposition further contributes as a source of nitrogen (Costa et al., 2008). Meanwhile, symptoms of eutrophication include algal scums and toxins derived from algal blooms, massive infestations of certain aquatic plants, increased incidence of water-related diseases turbid water, noxious odors and poor tasting water, depletion of dissolved oxygen and fish kills (UNEP-IETC, 2000). Eutrophication is threatening to human health and can change the aquatic ecosystem itself, which can result to many other implications. Minor eutrophication should be monitored before it spread to major eutrophication and create environmental problems. In recent years, modern chemical methods were developed for measuring increasing eutrophication and acid rain, and concentrations of other pollutants in the environment (Schindler et al., 2008).

The applications of plant in environmental protection strategies are called "Phytotechnologies". Phytotechnologies employ plants to remediate, stabilize or control toxic contaminants from the environment. . Plants can take up various pollutants and nutrients (nitrate, ammonium, phosphorus), metals, metalloids, petrochemical compounds (fuels, solvents), pesticides and soluble radionuclides (Licht at al., 2005; Duggan 2005; Meers et al., 2007).

3. Methodology

3.1 Site study

3 different states in Malaysia have been chosen as a site study for collecting water samples. Those states are Selangor, Pahang and Kelantan. At the same, 5 distinct locations have been identified with abundance of floating macrophytes within the state respectively. In the end, total of 15 different water bodies came along with distinct species of floating aquatic plants have been selected as our site study for water sampling.

3.2 Water sampling

15 samples were collected in triplicate in 1 Litre plastic bottle at selected sites using standard methods of collection. That means, 45 water sample has been taken for laboratory testing. The samples were carefully labelled and transported to the laboratory in an icebox and then stored at 4°C in the laboratory until required for analysis. Those samples were tested using HACH spectrophotometer (HACH, 1989), in order to detect different nutrients, which are ammonium (NH4), nitrite (NO2), nitrate (NO3) and phosphate (PO4).

3.3 Laboratory testing

Water samples were defrosted under room temperature before being tested in the laboratory. By using HACH nutrient manual, water being tested accordingly. Each bottle was then divided into 8 samples for examination. The experiments were sequentially replicated to evaluate the variations. In the end, results of 24 samples will be collected from one 1 site of water bodies. That means, total of 120 water samples were read its concentration of ammonium (NH4), nitrite (NO2), nitrate (NO3) and phosphate (PO4) from each state respectively.

4. Result and Analysis

Excess nutrients of phosphate, ammonium, nitrite and nitrate was detected at all site of Selangor Pahang and Kelantan. All results were based on National Water Quality Standards for Malaysia (Table 2) as a guideline of contamination and pollution level.

Table 1: Mean value of total nutrients; PO4, NH4, NO2 and NO3 measured in 15 different sites of freshwater bodies at Selangor, Pahang and Kelantan.

		Concentration (mg/L)						
		Phosphate (PO4)	**Class**	**Ammonium (NH4)**	**Class**	**Nitrite (NO2)**	**Nitrate (NO3)**	**Class**
Selangor	*N.oleracea1/ L.minor*	4.83±0.92	III	0.38±0.02	IIB	0.01±0.01	1.50 ±0.31	-
	L.minor	5.65±0.20	III	0.90±0.11	III	0	1.03 ±0.17	-
	N.oleracea2	1.86±0.31	III	0.02±0.02	-	0	0.07 ±0.08	-
	S.polyrhizha	1.33±0.49	III	1.14±0.17	III	0	2.54 ±1.20	-

	E.crassipes	3.46±0.25	III	1.14±0.15	III	0.02±0.03	1.78 ±0.61	-
Pahang	*E.crassipes1*	1.31±0.25	III	0.30±0.10	IIB	0	0.46 ±0.15	-
	L.minor	1.87±0.36	III	1.36±0.08	III	0.01±0.02	0.90±0.51	-
	S.molesta	0.79±0.31	III	0.02±0.02	-	0.01±0	0.58±0.31	-
	N.oleracea	0.29±0.09	III	0.44±0.08	IIB	0	0.06±0.10	-
	E.crassipes2/ N.oleracea	0.84±0.24	III	0.91±0.02	III	0	0.51±0.24	-
Kelantan	*S.molesta1/ E.crassipes*	1.20±0.38	III	0.05±0.02	-	0.01±0.00	0.58 ±0.20	-
	P.stratiotes	1.38±0.80	III	0.12±0.17	I	0	0.37±0.17	-
	E.crassipes1	1.31±0.71	III	0.17±0.04	I	0	0.46±0.32	-
	E.crassipes2	0.80±0.22	III	0.54±0.24	IIB	0	0.45±0.07	-
	S.molesta2	0.75±0.19	III	0.10±0.07	I	0.02±0.01	1.25±0.34	-

Table 2: Interim National Water Quality Standards for Malaysia (INWQS)

Parameters	Units	Classes					
		I	IIA	IIB	III	Lv	L
Ammonium (NH^{-}_{4})	Mg/l	0.1	0.3	0.3	0.9	2.7	>2
Nitrite (NO_2)	Mg/l	Natural water level	0.4	0.4	0.4	0.4	Level above IV
Nitrate (NO_3)	Mg/l	Natural water level	7	7	-	5	Level above IV
Phosphate (PO_4)	Mg/l	Natural water level	0.2	0.2	0.1	-	Level above IV

The data of nutrients concentrations in water samples was presented in table 1 which based on INWQS for water classification (table 2). All the results can be grouped according to State as follow:

4.1 Selangor

Results showed that domination of *N.oleracea, L.minor, S.polyrhizha* and *E.crassipes* were classified in class III Furthermore, highest concentration of phosphate was detected in water sample that inhabited by species of *L.minor*. In case of ammonium, abundant of *E.crassipes, S.polyrhizha* and *E.crassipes* were categorized in class III. Nevertheless, all species did not hit any contamination level for nitrite and nitrate concentration

4.2 Pahang

Results revealed that abundant of all species of *E.crassipes, L.minor, S.molesta* and *N.oleracea* were recorded in class III and considered polluted. *L.minor* indicated with the highest concentration of ammonium. Same case with Selangor state, neither contamination nor pollution level was detected for the presence of nitrite and nitrate.

4.3 Kelantan

Results exhibited that abundant of *S.molesta, P.stratiotes* and *E.crassipes* were categorized in class III and *P.stratiotes* was detected to have highest concentration of phosphate. In contrast, excess ammonium that was classified in class IIB and considered contaminated only found in domination *E.crassipes2*. Similar case with Selangor and Pahang state, presence of nitrite and nitrate did not hit the contamination level of INWQS

In general, the highest concentration of phosphate and ammonium were recorded in water samples dominated by *L.minor, S.polyrhizha* and *E.crassipes*. It can be summarized that domination of *L.minor, S.polyrhizha* and *E.crasipes* in water bodies were strongly correlated with nitrification and eutrophication. However the relative distributions of nitrate and nitrite did not necessary correlate to the toxic levels of ammonium and phosphate. All species of *L.minor, E.crassipes, .P.stratiotes, S.polyrhizha, N.oleracea* and *S.molesta* were detected with high concentration of phosphate that was classified in class III and considered polluted which need extensive water treatment. In contrast, abundant of *S.molesta* did not present any contamination level of ammonium. Therefore, *S.molesta* was recognized as a weak phytoindicator specifically for excess nutrient of ammonium. *N.oleracea* also showed its ammonium content was classified in class IIB except 1 site in Kuala Selangor, Selangor which only showed lower concentration of ammonium. Meanwhile, *P.stratiotes* was a good phytoindicator for excess phosphate but not for excess ammonium.

5. Conclusion

Nitrification and eutrophication are the most common threat in water bodies since long decade. However, macrophytes were identified with its healing power to absorb excess nutrients from water bodies. Abundant of those macrophytes was a signal of excess nutrients, at the same time as a bio indicator for nitrification and eutrophication. The experimental fresh water bodies at 15 different locations within Selangor, Pahang and Kelantan showed that all the floaters species have its own potential in detecting different form of nitrogen and phosphorus. Development of phytotechnology especially for floating macrophytes as a bio indicator for nitrification and eutrophication should be continue in order to widen the establishment of the data to submergent and emergent plants. Establishment of data will ensure the community to have a better knowledge and guideline in predicting threat to our environment globally and surrounding landscape specifically.

Acknowledgement

I would like to acknowledge and extend my heartfelt gratitude to my supervisor Asst. Dr Rashidi Othman for his vital guidance and faculty members and staffs of Department of Landscape Arhitecture, IIUM for all their kind support.

References

Burks, R.L., Lodge, D.M., Jeppesen, E., Lauridsen, T.L., (2002). Diel horizontal migration of zooplankton: costs and benefits of inhabiting the littoral. Freshw. Biol. 47, 343–365

Carpenter, S.R., Lodge, D.M., (1986). Effects of submersed macrophytes on ecosystem processes. Aquat. Bot. 26, 341–370.

Costa Jr O.S, Nimmo M, Attrill M.J (2008). Coastal nutrification in Brazil: A review of the role of nutrient excess on oral reef demise. Journal of South American Earth Sciences 25, 257–270.

Duggan, J., (2005). The potential for landfill leachate treatment using willows in the UK – a critical review. Resources, Conservation and Recycling 45, 97–113.

Graneli, W., Solander, D., (1988). Influence of aquatic macrophytes on phosphorus cycling in lakes. Hydrobiologia 170, 245–266.

Fair, G.M., Geyer, J.C., (1954). Water Supply and Waste-Water Disposal. John Wiley & Sons, Inc., New York.

Jeppesen, E., Lauridsen, T.L., Kairesalo, T., Perrow, M.R., (1998). Impact of submerged macrophytes on fish-zooplankton interactions in lakes. In: Jeppesen, E.,Søndergaard, M., Søndergaard, M., Christoffersen, K. (Eds.), The Structuring Role of Submerged Macrophytes in Lakes. Springer-Verlag, New York, pp. 91–114.

Licht, L.A., Isebrands, J.G., (2005). Linking phytoremediated pollutant removal to biomass economic opportunities. Biomass and Bioenergy 28, 203–218.

Lodge, D.M., Lorman, J.G., (1987). Reductions in submersed macrophyte biomass and species richness by the crayfish Orconectes rusticus. Can. J. Fish. Aquat. Sci. 44, 591–597.

Meers, E., Vandecasteele, B., Ruttens, A., Vangronsveld, J., Tack, F.M.G., (2007). Potential of five willow species (Salix spp.) for phytoextraction of heavy metals. Environmental and Experimental Botany 60, 57–68.

Miao Lia,b, Yue-Jin Wub, Zeng-Liang Yub, Guo-Ping Shenga, Han-Qing Yu (2009). Enhanced nitrogen and phosphorus removal from eutrophic lake water by Ipomoea aquatica with low-energy ion implantation. water r e s e arch 4 3, 1 2 4 7 – 1 2 5 6.

Randall, R.G., Minns, C.K., Cairns, V.W., Moore, J.E., (1996). The relationship between an index of fish production and submerged macrophytes and other habitat features at three littoral areas in the Great Lakes. Can. J. Fish. Aquat. Sci. 53, 35–44.

Sass, G.G., Gille, C.M., Hinke, J.T., Kitchell, J.F.,(2006). Whole-lake influences of littoral structural complexity and prey body morphology on fish predator–prey interactions. Ecol. Freshw. Fish 15, 301–308.

Schindler D.W and Vallentyne J.R (2008). The Algal Bowl. Earthscan, London.

Sima C.H, Yusoffa M.K, Shutesb B, Hoc S.C, Mansor M (2008). Nutrient removal in a pilot and full scale constructed wetland, Putrajaya city, Malaysia. Journal of Environmental Management 88, 307–317.

Søndergaard, M., Moss, B., (1998). Impact of submerged macrophytes on phytoplankton in shallow freshwater lakes. In: Jeppesen, E., Søndergaard, M., Søndergaard, M., Christoffersen, K. (Eds.), The Structuring Role of Submerged Macrophytes in Lakes. Springer-Verlag, New York, pp. 115–132.

Taillon, D., Fox, M.G., (2004). The influence of residential and cottage development on littoral zone fish communities in a mesotrophic north temperate lake. Environ. Biol. Fish. 71, 275–285.

Timms, R.M., Moss, B., (1984). Prevention of growth of potentially dense phytoplankton populations by zooplankton grazing in the presence of zooplanktivorous fish in a shallow wetland ecosystem. Limnol. Oceanogr. 29, 472–486.

UNEP-IETC (2000). Planning and management of lakes and reservoirs: an integrated approach to eutrophication. IETC. Osaka/ Shiga

Wetzel, R.G., (2001). Limnology: Lake and River Ecosystems, 3rd ed. Academic Press, San Diego