International Journal of Sustainable Energy and Environmental Research
2014 Vol. 3, No. 4, pp. 178-184
ISSN(e): 2306-6253
ISSN(p): 2312-5764

AQUATIC PLANTS AS ECOLOGICAL INDICATOR FOR URBAN LAKES EUTROPHICATION STATUS AND INDICES

Rashidi Othman[1] --- Nurul Azlen Bt Hanifah[2*] --- Razanah Ramya[3] --- Farah Ayuni Bt Mohd Hatta[4] --- Wan Syibrah Hanisah Bt Wan Sulaiman[5] --- Maheran Bt Yaman[6] --- Zainul Mukrim Bin Baharuddin[7]

[1,2,3,4,5]*International Institute for Halal Research and Training (INHART), Herbarium Unit,* [6,7]*Department of Landscape Architecture, Kulliyyah of Architecture and Environment Design, International Islamic University Malaysia, Kuala Lumpur, Malaysia*

ABSTRACT

There is an increasing pursuit of utilizing plants as a gear to predict, describe and diagnose environmental stresses. Being united swiftly with their environments, granting them to offer beneficial information on the condition of the aquatic environment. The aquatic plant species are effectively reliable indices as water status indicators. Their ability in taking up metal and toxic pollutants has shown their level of strength as well as tolerance in any concentration levels. Eutrophication is also being associated with the existence of aquatic plants. This widespread crisis in water bodies is made by over enrichment with nitrogen (N) and phosphate (P). Excess nutrients can trigger undesirable eutrophication, resulting in unhealthy algal blooms, spreading of certain aquatic macrophytes, depletion of oxygen and loss of key species, resulting in widespread degradation of many freshwater ecosystems. A broad number of physico-chemical parameters and biological characteristics render the degree of quality of water resources. Supervising above parameters is a crucial part to classify the magnitude and origin of any pollution load. The study was carried out to determine the levels of Nitrite (NO2), Nitrate (NO3) and Phosphate (PO4), in different stations of urban lakes in Kuala Lumpur and Selangor. The significant outcome of this research is the abundance or loss of certain key species can be used as indicator for eutrophication state and level for urban lakes management and maintenance.

Keywords: Aquatic plants, Phytoindicator, Eutrophication, Urban lake, Ecological indicator, Physico-chemical

1. INTRODUCTION

Striving to reach good water quality and deteriorating on water sources are continuously levering as the growth of population speeds, changes in level of living standards and industrialization. In recent times, the world suffers the problem in assessing to the freshwater

† Corresponding author

sources and its availability (Water, 2007). This issue has become a major concern in worldwide. Water crisis becomes a daily nightmare for billions of people throughout the whole world.

The usage of hazardous chemicals in manufacturing industries and agriculture cause severe water pollution as waste from these industries goes directly into nearby rivers, lakes and pools. This not only affects the quality of water but also pose danger to several endangered aquatic species (Rai *et al.*, 2010). Hydrology and watershed characteristics, for example, soil type and land use have greatly impaired the lakes and directly influencing strong loads of nutrients into the water (Kosten *et al.*, 2009). In addition, compact human inhabitants is one of the influential element that birth more N loads in both tropical and subtropical systems. Human population density and agricultural land use, for instance, are one of the dominant influences N loads in both tropical and subtropical systems (Kosten *et al.*, 2009).

Majorities of urban lakes are man-made ecosystem, therefore in some cases, nutrient loadings are born through the excavation activities made by human to provide building materials for residential development. Meanwhile, some of them are coming from the enlargement of smaller water bodies to provide recreational activities in an urban park (Naselli-Flores, 2008). Urban watershed is knowable to generate numbers of phosphorus unit area resulted from stormwater runoff compared to other watersheds. Together flows with secondary phosphorus are urban wastewater discharges and failing septic systems sewage runoff. These secondary phosphorus loads are being patterned by most urban watersheds. Limited or unavailability assesses to fresh water to go into or out has minimized the capacity of urban lakes to dilute the nutrient loads inside them. This allowed the enhancement of phytoplankton biomass production, thus, decreasing underwater light availability.

Eutrophication is a rapidly growing environmental crisis in freshwater and marine systems worldwide. Over-nutrient enrichment in water caused an accelerated increase of algae on higher forms of plant lifetime. It leads to an unstable balance of organism in water and to the quality of water itself (Chislock *et al.*, 2013). Human activities accidently discharged of N and P into the water system. Both of these nutrients enter aquatic ecosystems via the air, surface water or groundwater (Anderson *et al.*, 2008; Azizuddin *et al.*, 2014). For instance, urban wastewater is the primary source in Asia and Africa. Numerous attempts have been managed to cater this eutrophication issue by improving the nutrient-removal efficiency of wastewater treatment plant. Eutrophication is easily detected once summer algal existed; they are made by a rapid, intensive growth of some algae populations. Algae is the predominant species in lakes and water reservoirs while blue-green algae and diatome predominate in rivers (Balcerzack, 2006).

According to Sudaran *et al.* (2012), nutrients are the main agricultural pollutants in Malaysia. Nitrogen and Phosphorus are nutrients that bring 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 recreation area.

The idea of applying aquatic plants to purify the eutrophic water system is a way in achieving green based technology. Thus, the study was carried out to determine the levels of Nitrite (NO2), Nitrate (NO3) and Phosphate (PO4), in different stations of urban lakes in Kuala Lumpur and Selangor. Hence, the aquatic plants can be manipulated as ecological indicators to determine aquatic ecosystem changes.

2. MATERIALS AND METHODS

2.1. Sample Collection and Laboratory Analysis (Ex Situ Parameters)

Ten water samples were collected in triplicate using a clean sample container. Those samplings were accomplished within the targeted period in order to protect the nutrients inside. The samples were examined within 30 days as it kept frozen below -20°C. Preservation of samples was done by the addition of 2.5ml chloroform in 500 ml of water for further analysis. They were filtered before proceed to the next stage of nutrients analyzing. DR 2800 Spectrophotometer was used to detect different study nutrients which are nitrite (NO2-N), nitrate (NO3-N) and phosphate (PO4-3). All representative values were displayed by mean value and standard deviation. Physico-chemical analysis was done on site using the YSI 5556 MPS (Multiprobe system). The measured parameters are dissolved oxygen (DO) in mg/L, pH, salinity in ppt, conductivity in µS/cm and total dissolved solids (TDS) in mg/L.

2.3. Statistical Analysis

Analysis of variance (ANOVA) was calculated to test the validity of the data and the significance of the variation of different study nutrients which are nitrite (NO2-N), nitrate (NO3-N) and phosphate (PO4-P)

3. RESULTS AND DISCUSSION

Analysis of variance showed significant difference ($p<0.001$) between aquatic plants species widespread and nutrient level (phosphate, nitrite and nitrite) with different ranges at 10 urban lakes in Kuala Lumpur and Selangor. As shown in Figure 1, the nutrient excess of all sites studied were different ranges. Six types of aquatic plants were identified as abundance at selected sites except at Tasik Shah Alam and Tasik Setapak Jaya known as *Hydrilla verticillata*, *Ipomea aquatica*, *Nelumbo nucifera*, *Chlorella* sp., *Phragmites australis* and *Cabomba caroliniana* were analyzed for nutrient excess and eutrophic level. From the observation, only at Tasik Perdana found two aquatic plants which are *Nelumbo nucifera* and *Cabomba caroliniana.* This clearly demonstrates that freshwater environment with abundance of invasive aquatic plant species can have an important influence and indication on the accumulation of nutrient sontents. All site were detected with high level of nitrate (NO3) compared to phosphate (PO4) and nitrite (NO2) (Figure 1). In fact some aquatic plants have express ability of bioconcentration therefore, the accumulation of nutrients and heavy metals are increasing (Shaharuddin *et al.*, 2012). In addition, macrophytes play key functions in biochemical cycles, through, for example, organic carbon production, phosphorous mobilisation and the transfer of other trace elements (Jeppesen *et al.*, 2009). In general, productivity is limited by the supplies of phosphate and nitrogen such as nitrate, but other nutrients may also be important such as inorganic carbon, calcium and potassium (Thiebaut *et al.*, 2008).

Many studies showed that even if the external nutrient loading decreased, elevated temperature and evapotranspiration may lead to a higher nutrient concentration in lake (Jeppesen *et al.*, 2009; 2011). Urban lake combining the cultural and natural landscape act as important recreation site compared to non urban lake (Chen *et al.*, 2009). These nutrients are subjected to losses by leaching and surface runoff when the soils are saturated. Water quality is weakened and water availability is reduced because of accelerated eutrophication (Carpenter *et al.*, 1998). In contrast, large amount of nutrients in fresh water bodies cause to main water pollution. Overload of nutrient stimulate the rapid growth of plants and algae, clogging waterways and sometimes creating blooms of toxic blue-green algae which is called eutrophication. As a result, the plants and algae die and decompose because they use large quantities of oxygen (O_2). So the amount of oxygen left for other aquatic species will be reduced. In fact, it can cause to a completely oxygen less environment that can sustain nothing except a few species of anaerobic bacteria (Vestergaard and Sand-Jensen, 2000).

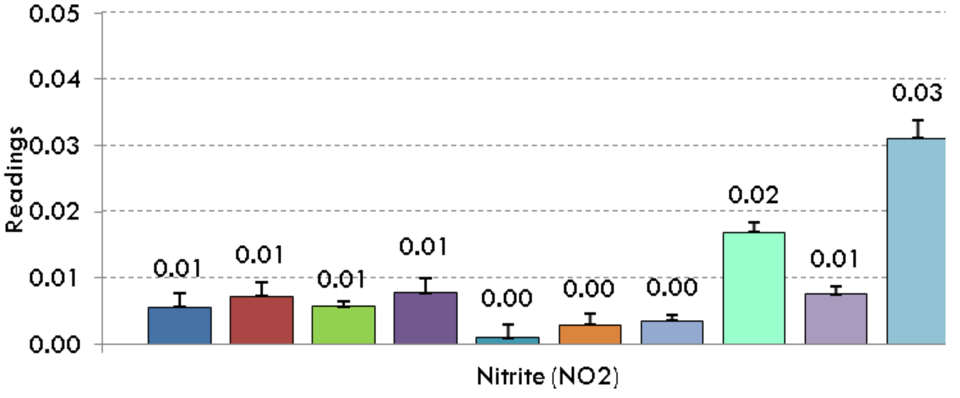
4. CONCLUSION

In conclusion, there is a correlation between the effect of nutrients (phosphate, nitrate and nitrite), aquatic plant species and locations studied as indicator for urban lake eutrophication level. In addition, different localities will determine high level of eutrophication. Since the urban lake in Kuala Lumpur and Selangor are man made lake, the level or eutrophic are at class III to structure of the lake and so forth. All species showed excess phosphate categorized in class III, which means those floaters were a great phytoindicator for excess phosphate at the same time become a bio indicator for eutrophication phenomenon. Results for excess ammonium, nitrite and nitrate were varied among 10 sites which indicated that most of the sites undergone nitrification phenomenon. Aquatic plant species can be applied in park and urban design to monitor changes in an environment especially in aquatic ecosystem which can act as a phytoindicator and at the same time enhancing intrinsic and recreation values which can contribute to mitigate the urban climate. Further study should carry out to deal with the water security problems of urban areas with high population and fast urbanization under climate change.

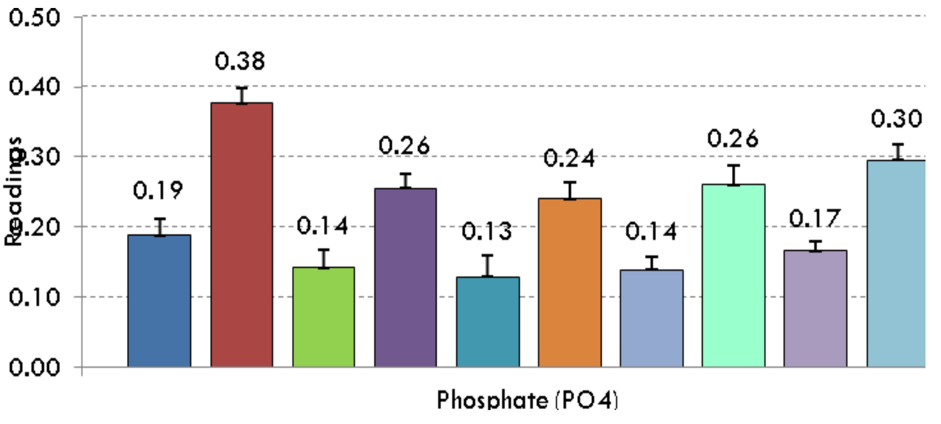
5. ACKNOWLEDGMENT

The authors would like to thank the Ministry of Higher Education (MOHE) and International Islamic University Malaysia (IIUM) for the Research Grant RACE140-020-0018 and FRGS13-052-0293-.

A.



B.



C.

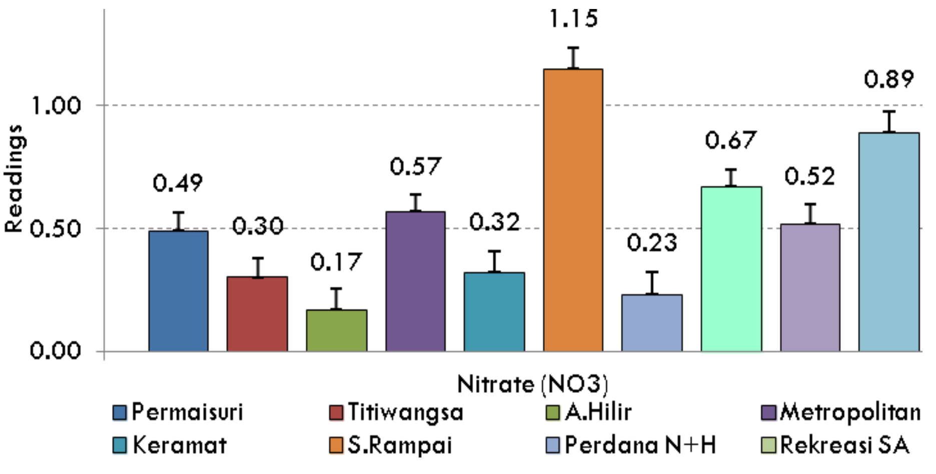


Figure-1. Assessment of Phosphate (PO4), Nitrite (NO2) and Nitrate (NO3) at 10 sites of urban lakes in Kuala Lumpur and Selangor.

A. Concentration ranges of Phosphate (PO4) at 10 sites of urban lakes

B. Concentration ranges of Nitrite (NO2) at 10 sites of urban lakes

C. Concentration ranges of Nitrite (NO3) at 10 sites of urban lakes

REFERENCES

Anderson, D.M., J.M. BuZkholder, W.P. Cochlan, P.M. Glibert, C.J. Gobler, C.A. Heil and G.A. Vargo, 2008. Harmful algal blooms and eutrophication: Examining linkages from selected coastal regions of the United States. Harmful Algae, 8(1): 39-53.

Azizuddin, A.D., N.A.M. Ali, K.S. Tay, M.R.B. Abas and B.R. Simoneit, 2014. Characterization and sources of extractable organic matter from sediment cores of an urban lake (Tasik Perdana), Kuala Lumpur, Malaysia. Environmental Earth Sciences, 71(10): 4363-4377.

Balcerzack, W., 2006. The protection of reservoir water against the eutrophication process. Polish J. of Environ. Stud, 15(6): 837-844.

Carpenter, S.R., N.F. Caraco, D.L. Corell, R.W. Howarth, A.N. Sharpley and V.H. Smith, 1998. Nonpoint pollution of surface waters with phosphorus and nitrogen. Ecological Application, 8(3): 559-568.

Chen, Q., W.P. Hu and J.N. Zhang, 2009. Advances in research on the buildup and rainfall runoff wash-off of urban surface pollutants. Resour Environ Yangtze Basin, 18(10): 992–995.

Chislock, M.F., E. Doster, R.A. Zitomer and A.E. Wilson, 2013. Eutrophication: Causes, consequences, and controls in aquatic ecosystems. Nature Education Knowledge, 4(4): 10.

Jeppesen, E., B. Kronvang and M. Meerhoff, 2009. Climate change effects on runoff, catchment phosphorus loading and lake ecological state, and potential adaptations. J Environ Qual, 38(5): 1930–1941.

Jeppesen, E., B. Kronvang and M. Meerhoff, 2009; 2011. Climate change effects on runoff, catchment phosphorus loading and lake ecological state, and potential adaptations. J Environ Qual, 38(5): 1930–1941.

Kosten, S., V.L. Huszar, N. Mazzeo, M. Scheffer, L.D.S. Sternberg and E. Jeppesen, 2009. Lake and watershed characteristics rather than climate influence nutrient limitation in shallow lakes. Ecological Applications, 19(7): 1791-1804.

Naselli-Flores, L.U.I.G.I., 2008. Urban lakes: Ecosystems at risk, worthy of the best care. In Proceedings of Taal 2007: The 12th World Lake Conference. IND, 1333: 1337.

Rai, P.K., A. Mishra and B.D. Tripathi, 2010. Heavy metal and microbial pollution of the river Ganggi: A case study of water quality at Varnasi. Aquatic Ecosystem Health and Management, 13(4): 352-361.

Shaharuddin, R.I., N.H. Mohd Latiff, W.N.A. Wan Muhammad and R. Othman, 2012. The use of macrophytes as indicators of heavy metals in aquatic ecosystem. Presented at 1st International Conference on Innovation and Technology for Sustainable Built Environment 2012 (ICITSBE 2012). 16-17 Apri, Perak, Malaysia.

Sudaran, M.J.S., T. Deeptha and D. Ashutosh, 2012. Phyto-remediation of dairy-waste water using constructed wetland. International Journal pf Pharma and Bio Sciences, 3(3): 745-755.

Thiebaut, G., F. Di Nino, M.N. Peltre and P. Wagner, 2008. Management of aquatic exotic plants: The case of elodea species. Proceedings of Taal 2007: The12th World Lake Conference. pp: 1058-1066.

Vestergaard, O. and K. Sand-Jensen, 2000. Alkalinity and trophic state regulate aquatic plant distribution in Danish lakes. Aquatic Botany, 67(2): 85-107.

Water, U.N., 2007. Coping with water scarcity: Challenge of the twenty-first century. Report for World Water Day 2007.

BIBLIOGRAPHY

Balcerzak, W., 2006. The protection of reservoir water against the eutrophication process. Polish Journal of Environmental Studies, 15(6): 837.

Cairns, J.J., 2006. Ecological restoration in an era of ecological disequilibrium. Asian Journal of Experimental Science, 20(1): 1-6.