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THE USE OF MACROPHYTES AS INDICATORS OF HEAVY METALS IN AQUATIC ECOSYSTEMS

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Abstract
Macrophytes are excellent indicators of environmental quality due to the variety of ways in which they respond to anthropogenic pollution. In environmental impact studies, certain plant species provide valuable information about the chemical state of their environment through their presence. The study focused on assesment of trace element contamination in fresh water bodies where nine different aquatic plant species were abundant and dominant. All the water samples were analyzed for iron (Fe), lead (Pb), copper (Cu), zinc (Zn), nickel (Ni) and manganese (Mn) contamination. Based on the result, the abundance of certain aquatic species indicates high concentration of certain heavy metal within critical range in that particular environment. H.verticillata and N. Nucifera are good indicator for Pb. S. Natans and C. Fuscata indicate high concentration of Fe and Cu. Besides, Zn showed high concentration with C. Fuscata and H. Verticillata. E. Crassipes good indicator for Ni and Mn. The concentrations of metals in aquatic plants can be more than 100 000 times greater than in the associated water. Therefore, macrophyte is effective in responding to heavy metal in low level environmental contamination that might otherwise be difficult to detect.

Keywords: Macrophytes, Indicator, Pollution, Heavy Metal, Freshwater Bodies

1. Introduction

There are many pollutants that contain in aquatic system including heavy metal. They come from many resources either natural or anthropogenic activities in industrial, domestic and agricultural. Trace metals are very significant because many of these metals are essential nutrients when in lower concentrations but they become toxic if their concentrations achieved certain limits **(**O'Dell et al. (1997); Goldhaber et al. (2003); WHO (2004)).Some heavy metals may transform into the persistent metallic compounds with high toxicity, which can be bioaccumulated in the organisms, magnified in the food chain, thus threatening human health (Jin, 1992). Heavy metals are the most abundant and persistent environmental inorganic pollutants. Unlike other pollutants, metals cannot be degraded but the cleanup usually requires their removal (Seebaugh et al. 2005) Thus, ecological engineering offers a simple, cheap and energy efficient method of treating polluted water and wastewater.

2. Literature Review

Malaysia was facing environmental issues since long ago. Rapid development of tin mining which is a traditional industry started at the turn of the century about 100 years ago cause to river pollution. Then after years, other traditional industries such as natural rubber and palm oil production expand, and wastewater from the factories caused further pollution of rivers and seas. According to Malaysia Environmental Quality Report (2008), the estimated number of water pollution sources in Malaysia for 2008 was 17,633 comprising especially of sewage treatment plants, agro-based industries, manufacturing industries and animal farms. About 54.01 percent of the total number of sources was domestic sewage facilities (9,524 sources), followed by manufacturing industries (6, 830 or 38.73 percent), animal farms (788 sources or 4.48 percent) and agrobased industries (491 sources or 2.78 percent). Of the total number of effluent sources identified, Johor had the highest number (1 790, 24.45percent), followed by Selangor (1 693, 23.12 percent), Perak (1255, 17.14 percent) and Perlis had the least number (10, 0.01 percent).

Macrophytes play important functions in biochemical cycles such as organic carbon production, phosphorous mobilisation and the transfer of other trace elements (Jeppesen et al. (1998); Marion and Paillisson (2002)). Futhermore, Macrophytes are one of the plants that have high potential for the phytoremediation of water contaminated with heavy metal (Fritioff (2003); Kamal et al. (2004); McCutcheon and Schnoor, (2003); Peles et al. (2002); Prasad et al. (2005)). Some species have expressive ability of bioconcentration, and therefore, increased accumulation of nutrients and heavy metals (Stanković et al. 2000). High concentrations in plant tissues of some elements may be the result of substantial availability of those elements in the surrounding environment. In this way, aquatic plants can be used as indicators. Because of these key functions, macrophytes are essential for indicators of aquatic ecosystems status, and it is therefore necessary to preserve such communities in freshwaters.

3. Methodology

10 samples were collected in triplicate in plastic containers at selected sites using standard methods of collection. Water samples then were stored at 4^0C and preservation of samples were done by the addition of 2.5ml chloroform in 500 ml of water for further analysis of various physico-chemical parameters and heavy metals (Fe, Pb, Ni, Cu, Zn and Mn). Heavy metal concentration in different water samples were determined by flame atomic absorption spectrometer using the Perkin-Elmer Atomic Absorption Spectrometer. Operational conditions were adjusted in accordance with the manufacturer guidelines to yield optimal determination. Quantification of heavy metals was based upon calibration curves of standard solutions of respective heavy metals. These calibration curves were determined several times during the metal analysis was controlled by including triplicate samples in analytical batches and blanks. The relative standard deviation of the mean of triplicate measurements were <5. Standard methods for the examination of water and waste water, APHA 1995 were used for analyzing various physico-chemical characteristics of polluted freshwater bodies as further detailed by Alka (2004).

4. Result and Analysis

The results of heavy metal concentrations in water samples (Table 1), revealed that type of heavy metal elements in fresh water bodies in Pahang, Perak, Selangor, and Kelantan are strongly influenced by the abundance of certain aquatic plant species as stated below:

***E. crassipes* :** Result showed that the abundant of *E. crassipes* indicate high concentration of Fe, Pb, Ni, Cu and Mn in that particular environment.. The concentration of Ni and Mn in fresh waterbodies in Perak and Kelantan exceeded the limits of recommended range Interim Water Quality Standard for Malaysia- class III, which need extensive treatment for water supply and aquatic ecosystem.

ii. *H. verticillata* : Average concentration of Pb and Zn of water bodies are considerably greater than recommended range Interim Water Quality Standard for Malaysia- class III that likely reflects a potential impact on biota health while concentration of Ni exceeded the limits of recommended range Interim Water Quality Standard for Malaysia- class II.

iii. *N. nucifera* :Average Pb contents observed in water bodies at Perak and Pahang exceeded the value recommended by Interim Water Quality Standard for Malaysia under class III and concentrations of Ni and Zn were greater than class IIB.

iv. *C. fuscata* :Resulst showed that the abundance of *C. fuscata* indicate high concentration of Fe, Cu and Zn in that particular environment. The concentration of Pb and Cu are exceeded the limit of class IIB and class V respectively which need serious attention.

v. *S. natans* :Average concentration of Fe and Cu in water bodies are considerably greater than recommended range Interim Water Quality Standard for Malaysia of class III that likely reflects a potential impact on biota health.

vi. *P. stratoides* :Result showed that the abundance of *P. stratoides* indicate concentration of Fe and Zn in that particular environment. Zn was greater than recommended range Interim Water Quality Standard for Malaysia of class IIB.

Table 1: Mean concentrations and ranges of total heavy metals; iron (Fe), lead (Pb), Nickel (Ni), copper (Cu), mangan (Mn), and zinc (Zn) measured in 16 different sites of freshwater bodies at Perak, Pahang, Selangor and Kelantan.

Locality/ Heavy metal	Species/ Mean heavy metal concentration (mg/l)				
Perak	*E.crassipes*	*E.crassipes*	*H.verticillata*	*N.nucifera*	*N.nucifera*
Fe	0.005	0.355	0.002	0.058	0.008
Class	I	I	I	I	I
Pb	0.087	0.107	0.070	0.159	0.062
Class	III	III	III	III	III
Ni	0.057	0.033	0.011	0.024	0.029
Class	III	IIB	IIB	IIB	IIB
Cu	0.007	0.005	0.004	0.011	0.004
Class	1	I	I	I	I
Mn	0.922	0.042	0.003	0.015	0.059
Class	III	IIB	I	I	II
Zn	0.023	0.007	0.026	0.011	0.009
Class	I	I	I	I	I
Pahang	*C. fuscata*	*E.crassipes*	*N. nucifera*	*N. nucifera*	*S. natans*
Fe	1.610	0.287	0.013	0.710	6.380
Class	IIB	I	IIB	I	IIB
Pb	0	1.390	0.083	0.030	0
Class	-	V	III	IIB	-
Ni	0	0.320	0.018	0	0
Class	-	V	IIB	-	-
Cu	1.610	0.026	0.004	0.710	6.380
Class	V	IV	I	V	V
Mn	0	0.268	0.075	0	0
Class	-	V	IIB	-	-
Zn	0.140	0.090	0.022	0.020	0.020
Class	I	I	I	I	I
Selangor	*E.crassipes*	*P.stratoides*	*H.verticillata*		
Fe	0.370	0.370	0.005		
Class	I	I	I		
Pb	0	0	0.133		
Class	-	-	III		
Ni	0	0	0.023		
Class	-	-	IIB		
Cu	0	0	0.063		
Class	-	-	III		
Mn	0	0	0.003		
Class	-	-	I		
Zn	0.020	0.020	0.078		
Class	I	I	I		
Kelantan	*E.crassipes*	*E.crassipes*	*S. natans*		
Fe	0.257	0.119	0.178		
Class	I	I	I		
Pb	0.207	0.269	0.948		
Class	III	III	III		
Ni	0.080	0.095	0.195		
Class	III	III	IV		
Cu	0.098	0.053	0.086		
Class	III	III	III		
Mn	0.227	0.108	0.151		
Class	V	III	III		
Zn	0.059	0.092	0.062		
Class	IIB	IIB	IIB		

Table 2: National Water Quality Standard for Malaysia

Parameter	Class (mg/l)				
	I	**IIA/IIB**	**III**	**IV**	**V**
Cu	Natural levels or absent	0.02	-	0.2	Level above IV
Fe		1	1	1	
Pb		0.05	-	0.2	
Mn		0.1	0.1	0.2	
Ni		0.05	-	0.2	
Zn		5	-	2	

5. Conclusion

Concentration of heavy metals (Fe, Mn, Zn, Cu, Ni, Pb) in freshwater bodies water samples from Perak, Pahang Selangor and Kelantan varied in relation to aquatic plant species availability and abundances. H.verticillata and N. Nucifera are good indicator for Pb. S. Natans and C. Fuscata indicate high concentration of Fe and Cu. Besides, Zn showed high concentration with C. Fuscata and H. Verticillata and E. Crassipes good indicator for Ni and Mn. Some species turned out to be more successful phytoindicator for certain elements, therefore showing high potential as phytoremediator and phytoindicator for unhealthy environment. The most interesting part is under certain environmental conditions metals may accumulate to toxic concentration and cause certain aquatic plant species become dominant and abundance.

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