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STUDY ON AQUATIC PLANT SPECIES (*Salvinia natans, Neptunia oleracea and Hydrilla verticillata*) AS PHYTOINDICATOR FOR NUTRIENT EXCESS

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Abstract
Aquatic plants are excellent phytoindicator because they respond to nutrients, light, toxic, contaminants, metals, herbicides, turbidity, water level change and salt. However, the negative impact of excessive nutrients on riverine and palustrine systems, estuaries and coastal waters give a serious global problem. Nutrients that arise rapidly from expanding urban areas, agricultural and industrial activities caused a boom in aquatic plant growth. Due to the capabilities of aquatic plants to utilize large amounts of nitrogen and phosphorus and thus remove them from the water; the aim of the research is to study the potential of aquatic plant species to be used as phytoindicator for unhealthy environment such as polluted freshwater bodies. In this study, twenty samples of water were collected each from 3 different localities where Salvinia natans, Neptunia oleracea and Hydrilla verticillata were abundant and dominant. All the water samples were analyzed for nitrite, nitrate, ammonium and phosphate. H. verticillata was found to be the best phytoindicator for phosphate pollutant at highest level whereas S. natans and N. oleracea were observed to be useful phytoindicator for unhealthy environment in fresh water bodies for nitrogen and phosphate contaminants. Therefore, aquatic plant species can be fully utilized as an effective tool to detect excessive nutrients in water bodies that might otherwise be difficult to detect.

Keywords: Aquatic Plant, Phytoindicator, Nutrient Excess, Nitrogen, Phosphorus, Ammonia, Nitrite, Nitrate.

1. Introduction

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).

Aquatic plants need two essential nutrients to grow which are nitrogen (N) and phosphorus (P). In a healthy fresh water bodies the amount of nutrient is small. In contrast, large amount of nutrients in fresh water bodies cause to main water pollution. Ammonium ($NH4+$), nitrite ($NO2-$) and nitrate ($NO3-$) are the most common ionic (reactive) forms of dissolved inorganic nitrogenin aquatic ecosystems (Wetzel (2001); Rabalais (2002). These ions can be present naturally as a result of atmospheric deposition, surface and groundwater runoff, dissolution of nitrogen-rich geological deposits, N2 fixation by certain prokaryotes (cyanobacteria with heterocysts, in particular), and biological degradation of organic matter (Wetzel (2001); Rabalais (2002)). Concentrations of inorganic nitrogenous compounds ($NH4+$, $NO2-$, $NO3-$) in ground and surface waters are hence increasing around the world, causing significant effects on many aquatic organisms and, ultimately, contributing to the degradation of freshwater, estuarine, and coastal marine ecosystems (Smith et al. (1999), Philips et al. (2002); Rabalais (2002)).

The negative impact of excessive nutrients on riverine and palustrine systems, estuaries and coastal waters is recognized as a serious global problem. Nutrients, primarily nitrogen and phosphorus, arise from

rapidly expanding urban areas, agricultural and industrial activities. Fertilizers, detergents and organic debris are among the sources of excess nutrients for nitrogen and phosphorus.
Normally, excess nitrogen makes its way into groundwater, rivers and streams as water runoff or by seeping into groundwater. Nitrogen does not bind to water, but plants absorb it and convert it to energy for growth. Unused nitrogen washes down streams and into lakes. Well-oxygenated aquatic areas easily use the extra nitrogen, causing a boom in aquatic plant growth. These nutrient inputs can trigger undesirable eutrophication, resulting in unhealthy algal blooms, spreading of certain aquatic macrophytes, oxygen depletion and loss of key species, resulting in widespread degradation of many freshwater ecosystems (Smith et al. 1999). In fact, eutrophication is the most widespread water quality problem in the world (Carpenter et al., 1998).

High ammonia concentrations can stimulate excessive aquatic production, toxic to aquatic life and indicate pollution. Excess nitrogen in lakes can contribute to accelerated eutrophication. Nitrogen can enter the water when bacteria called blue-green algae convert or “fix” nitrogen gas into ammonia for use in their tissues. Because of this bacterial “fixing” capability, there is an unlimited supply of nitrogen to aquatic systems (INCEV, 2008). Aquatic macrophytes can utilize large amounts of nitrogen and phosphorus and thus remove them from the water. Many researchers have investigated the nitrogen and phosphorus removal capacities of different aquatic plants (Coleman et al. (2001); Lauchlan et al. (2004); Hunter et al. (2001)).

2. Methodology

Sampling and Analytical Methods.

30 samples were collected in triplicate in plastic containers at selected sites using standard methods of collection. Water samples then were stored at 40C in laboratory until required for further analysis of nutrients. Those samples were tested using HACH spectrophotometer (HACH, 1989), in order to detect different nutrients, which were ammonium (NH4), nitrite (NO2), nitrate (NO3) and phosphate (PO4).

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.

3. Result and Analysis

The abundance of *S. natans, N. oleracea,* and *H. Verticillata* (Figure 1) is strongly associated with the presence of nitrate, nitrite, ammonium and phosphate (Table 2). The ranges in concentration (µg/l) for all types of nutrients level were either absent or detected at lower concentration or natural level up to higher concentration or toxic level as shown in Table 2. All the results were based on National Water Quality Standards for Malaysia (Table 1) for determination of contaminant level.

Table 1: National Water Quality Standards for Malaysia

Parameter	Class (µg/l)				
	I	IIA/IIB	III	IV	V
NO_2	Natural levels or absent	0.400	0.400	-	Level above IV
NO_3		7.000	-	5.000	
P		0.200	0.100	-	
NH_4	0.100	0.300	0.900	2.700	>2.700

Souces: DOE (2006)

Figure 1: Abundance of macrophytes at three different sites at Kelantan, Pahang, and Selangor.
(a. *S. natans* b. N. Oleracea and c. & d. *H. verticillata*)

Table 2: Analysis of NO_3, NO_2, NH_4 and P concentration (μg/l) measured at six different sites of freshwater bodies at Kelantan, Pahang and Selangor

		Concentration (μg/l)			
		Nitrate (NO_3)	**Nitrite (NO_2)**	**Ammonium (NH_4)**	**Phosphate (P)**
S. natans	Average	0.575	0.006	0.023	0.964
	Min.	1.400	0.015	0.100	4.920
	Max.	1.000	0	0	0.100
S. natans	Average	0.579	0.008	0.049	1.433
	Min.	1.000	0.012	0.120	4.140
	Max.	0.200	0.004	0.020	0.100
N. Oleracea	Average	0.058	0	0.388	0.293
	Min.	0.300	0.003	0.490	0.460
	Max.	0	0	0.250	0.130
N. Oleracea	Average	0.070	0	0.020	1.794
	Min.	0.300	0.002	0.070	2.960
	Max.	0	0	0	1.270
H. Verticillata	Average	0.100	0.003	0.020	0.180
	Min.	0.100	0.003	0.018	0.180
	Max.	0.101	0.003	0.020	0.185
H. Verticillata	Average	1.150	0.154	0.370	0.578
	Min.	1.100	0.151	0.370	0.400
	Max.	1.200	0.155	0.370	0.690

All the results can be grouped according to aquatic plant species characteristics as follow:

i. Floater (*S. natans*) – Table 2 showed that the abundant of *S. natans* indicate the presence of nitrate (NO_3), nitrite (NO_2), ammonium (NH_4), and phosphate (P) with a wide range of concentrations. Average of phosphate (P) concentrations were detected higher or exceed the National Water Quality Standards (NWQS)-class III for Malaysia protection of aquatic life and recreational use.

ii. Submerge (*H. verticillata*) - Average concentration of ammonium (NH_4), and phosphate (P) in water bodies are considerably greater than National Water Quality Standards (NWQS)-class II for Malaysia that likely reflects a potential impact on aquatic life and recreational use. However, the abundance of *H. verticillata* indicate other nutrients too such as nitrate (NO_3) and nitrite (NO_2) which were detected at lower concentration.
iii. Emerge (*N. oleracea*) - Results showed that natural levels of ammonia (NH_4) and phosphate (P) were detected with the abundance of *N. oleracea* indicate that particular environments were in unstable condition. The Average of phosphate (P) concentrations were detected higher or exceed the National Water Quality Standards (NWQS)-class III.

The highest concentrations of nutrients excess were detected in *S. natans, H. verticillata* and *N. oleracea* for ammonium and phosphate. It can be concluded that the presence of ammonium is strongly associated with the higher concentration of phosphate. However the relative distributions of nitrate and nitrite did not necessary correlate to the toxic levels of ammonium and phosphate. High levels of ammonium and phosphate may be detected from the abundance of aquatic plant species especially *S. natans, H. verticillata* and *N. oleracea.*

5. Conclusion

The macrophytes that have been identified in freshwater bodies have limited ability as indicators of water quality disturbance. However, some species can survive in the polluted water including nutrient excess. These nutrient inputs can trigger undesirable eutrophication, resulting in unhealthy algal blooms, spreading of certain aquatic macrophytes, reduce oxygen concentration and loss of key species, resulting in widespread degradation of many freshwater ecosystems. The presence and abundance of these species have a range of adverse effects on freshwater bodies habitat structure that in turn affect aquatic life diversity and distribution patterns, assemblage composition and aquatic food web structure. Therefore, *S. natans, N. oleracea and H. verticillata* can be indicator for nutrient excess such as ammonia and phosphorus.

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