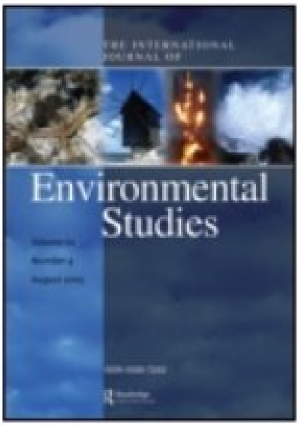

International Journal of Environmental Studies
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/genv20

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Available online: 26 Jan 2007

THE ABILITY OF AQUATIC MACROPHYTES TO MAINTAIN WATER CLARITY IN TWO TROPICAL PONDS

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(Received July 21, 2003)

The ability of aquatic macrophytes to maintain water clarity was investigated in two tropical ponds [1999–2001]. Low chlorophyll-*a* concentration (0.2–3.5 mg/m^3) was observed throughout the study period, which reflected the absence of any algal bloom. At a high coverage ($\geq$ 90%), the ability of *Vallisneria spiralis* to maintain Secchi disk transparency ($>$ 2 m) extended to the deepest point (3.5–4.4 m) even at high Kjeldahl nitrogen (1.2–29.8 mg/l) and total phosphorus levels (0.2–1.2 mg/l).

Keywords: Secchi disk transparency; Total Kjeldahl nitrogen; Total phosphorus; Chlorophyll-*a*; *Vallisneria spiralis*

1. INTRODUCTION

Water is likely to become an increasingly scarce and volatile resource during the 21st century, with water use increasing twice as fast as the population [1]. During the last few decades rapid anthropogenic activities have also led to an excessive supply of nutrients (mainly nitrogen and phosphorus) in water bodies causing eutrophication, which has resulted in a strong decline in macrophyte vegetation and an increased incidence of algal turbidity [2].

In almost all regions of the world, as per public opinion, clear water is synonymous with good quality water. Extensive field surveys in European large shallow lakes have reported a positive relationship between aquatic plants and water clarity [3] and, hence, attempts have been made in the Netherlands to improve the water quality in order to achieve clear and vegetation rich shallow lakes [4].

Innumerable small ponds, often rich in aquatic macrophytes, happen to be a worldwide public water resource, especially in a tropical scenario [5]. In a developing country like India ponds are a vital integral component of the village ecosystem and are extensively used by the people for their subsistence. In a world with mounting pollution levels, there is a need to study the impact of aquatic plants on small water bodies like ponds. Hence, the objective of the present study was to investigate the changes in the coverage of aquatic macrophytes in

TABLE I Morphometry and common features of the study ponds.

	Pond 203	*Pond 206*
Morphometry		
Surface area (ha)	0.4	0.3
Maximum depth (m)	4.4	5.0
Common features	• Artificial, dependent on precipitation • Rectangular and one outlet to drain excess water during rainy season • Surrounded by shading trees, often with over hanging branches which add allochthonous organic matter in the form of dead leaf litter • Garden located on one side as a source of fertilizer run off • Local people used water for bathing and washing clothes	

two ponds with relation to water quality parameters in an effort to recognize the ability of these plants for maintaining water clarity.

2. MATERIALS AND METHODS

2.1. Pond Description

Data were collected from two ponds located in Calcutta, India (22°20′–22°40′ N, 88°10′–88° 40′ E) with a tropical hot and humid monsoon climate. To observe the effect of aquatic plants on water quality; the two ponds selected were such that one (pond 203) supported a luxurient growth of macrophytes while the other (pond 206) had few plants. The morphometry and common features of the two study ponds are given in Table I. Based on an area <1 ha and a maximum depth ≤ 5 m both ponds could be classified as small and shallow.

2.2. Water Sampling

The ponds were sampled monthly between 0900 and 1030 h during the period March 1999–February 2001. A Van Dorn horizontal bottle sampler of 1.5 l capacity was used to collect water samples from five sampling points. Two grab samples (1 m below the surface and 1 m above the bottom) were taken from sampling point 1 which was located at the deepest part of the pond in the open water zone. Grab samples were also collected at 1 m depth from the remaining four sampling points (2, 3, 4 and 5) randomly selected in four directions (North, South, East and West) near the littoral zone at a depth of 1.5–2 m where macrophytes were observed. These points were slightly adjusted with changes in water level and vegetation bed.

2.3. Water Quality Parameters

Important water quality parameters, namely Secchi disk transparency, temperature, chlorophyll-*a*, total Kjeldahl nitrogen and total phosphorus, were studied. Measurements of temperature were carried out *in situ* using a calibrated temperature probe attached with a WQC-20A TOA water quality checker, manufactured by Xebex International Ltd, Tokyo, Japan. Bottles containing water samples for chlorophyll-*a* analysis were kept in an ice bucket to avoid heat shock to the phytoplankton. Chlorophyll-*a* concentration was used as an index of phytoplankton biomass and was measured by using 90% acetone extract of the residue on a membrane filter (0.45 μm porosity) followed by spectrophotometric procedure. Values were corrected for phaeophytin interference. Total Kjeldahl nitrogen was determined by macroKjeldahl method (Tecator, Kjeltec 1026 unit, Höganäs, Sweden) and total phosphorus by HNO_3-H_2SO_4 digestion following spectrophotometric determination. All methods were followed according to APHA [6]. Values for Secchi disk transparency were recorded from April 1999 onwards while chlorophyll-*a* analysis was conducted from the month of June 1999.

2.4. Identification and Coverage of Macrophytes

Identification was followed according to Cook [7]. As an index of macrophyte abundance, coverage of rooted submerged, emergent, free floating and floating leaved plants was estimated. A stratified random design was used to locate 40 sampling points in the littoral zone, where a majority of the macrophytes occurred. At each point cover percentage of each species was estimated by using a 1 m^2 quadrat [8] from three zones (namely surface water for free floating and floating leaved; bottom for rooted submerged and shoreline for emergent plants, each to a maximum cover of 100%).

2.5. Statistical Analysis

The Spearman rank correlation coefficient (r_s) was calculated to determine association among water quality parameters and aquatic plant coverage and regression was done on $\log_{10}$ transformed data according to Snedecor and Cochran [9].

3. RESULTS AND DISCUSSION

3.1. Aquatic Macrophyte Composition

Aquatic macrophyte composition of two ponds are summarized in Table II. Although all four different growth forms of aquatic macrophytes were present in pond 203, *Vallisneria spiralis*, a meadow forming submerged angiosperm was the most dominant flora which formed a dense vegetation bed on the littoral sediment. Pond 206 was devoid of any submerged plant.

TABLE II Aquatic plants observed in the study.

Growth form	*Identification*	*Cover percent*		*Occurrence*	
		Pond 203	*Pond 206*	*Pond 203*	*Pond 206*
Emergent	*Alternanthera philoxeroides*	23	24	September 1999–November 2000	August 1999–December 2000
Free floating	*Lemna minor*	24	3	March 1999–February 2001	December 1999–April 2000, July 2000–February 2001
Rooted with floating leaves	*Nymphoides hydrophylla*	20	13	March 1999–February 2001	September 1999–October 1999, December 1999–February 2001
Submerged	*Vallisneria spiralis*	71	0	March 1999–February 2001	

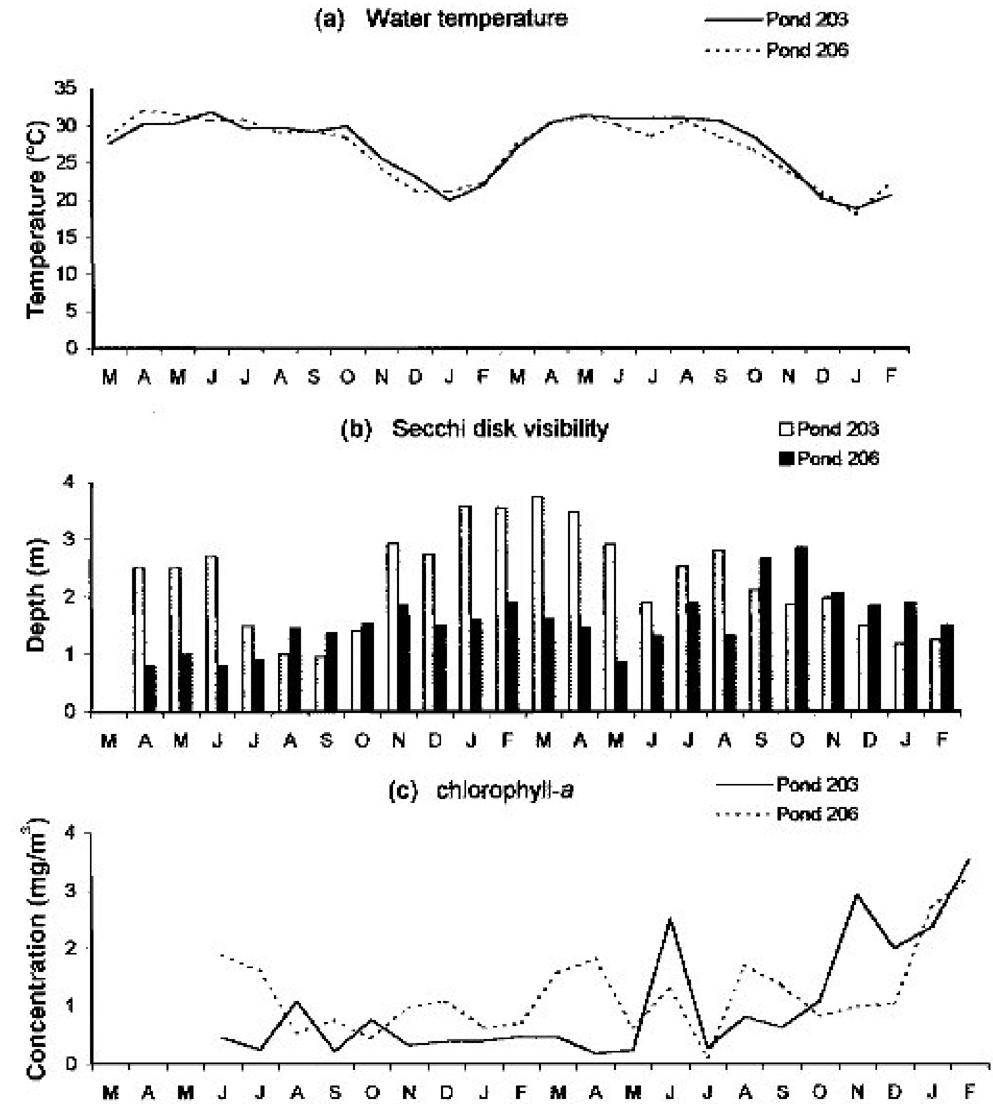

FIGURE 1 Monthly averages of water quality parameters in the two study ponds

3.2. Water Temperature

Two year's of data revealed high water temperature (ranging from 18.0 to 32.1°C, Fig. 1(a)) of both ponds reflecting the occurrence of a mild winter which did not inhibit the growth of aquatic macrophytes during the winter season (Table I).

3.3. Secchi Disk Transparency

Monthly fluctuation of Secchi disk transparency as given in Fig. 1(b), was only recorded from the deepest point of the pond since Secchi disk hit the bottom in the littoral zone (often in pond 203 and sometimes in pond 206). As can be seen from the figure, transparency was much greater in pond 203. Values >2 m could be considered as high transparency level for

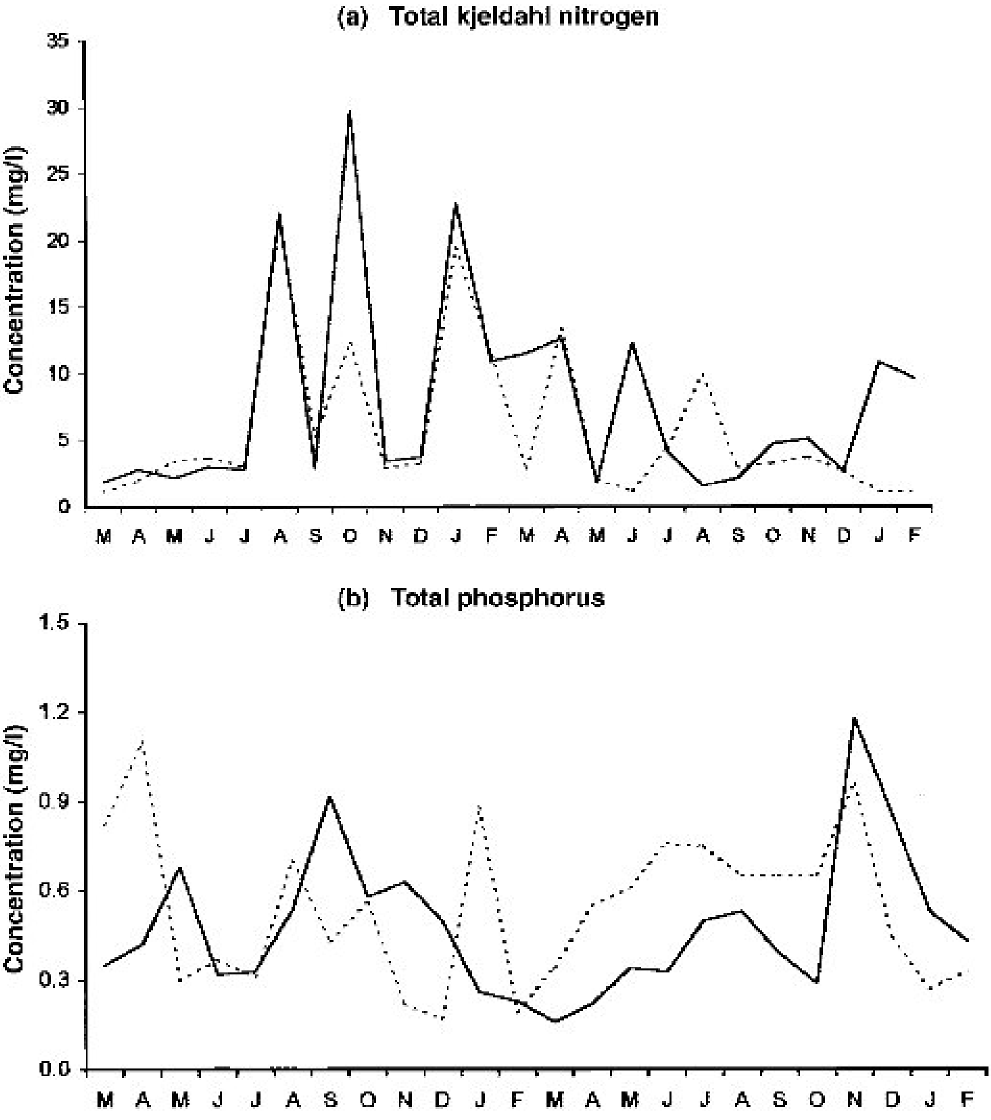

FIGURE 2 Monthly variations of nutrient concentration (– pond 203,—pond 206)

ponds and was observed for 56% of the data set in pond 203 while it was only 13% for pond 206. This might be due to the effect of dense aquatic plants in pond 203 (Table I).

3.4. Chlorophyll-*a*

Monthly average of chlorophyll-*a* concentration, as given in Fig. 1(c), ranged 0.2–3.5 mg/m^3 for both ponds and a comparatively lower chlorophyll-*a* concentration was observed in pond 203 than in pond 206 for 57% of the data set. These values were much lower than values >50 mg/m^3 as reported by Jana and Kundu [10] in two tropical ponds. These low values could probably explain the absence of algal blooms throughout the study period.

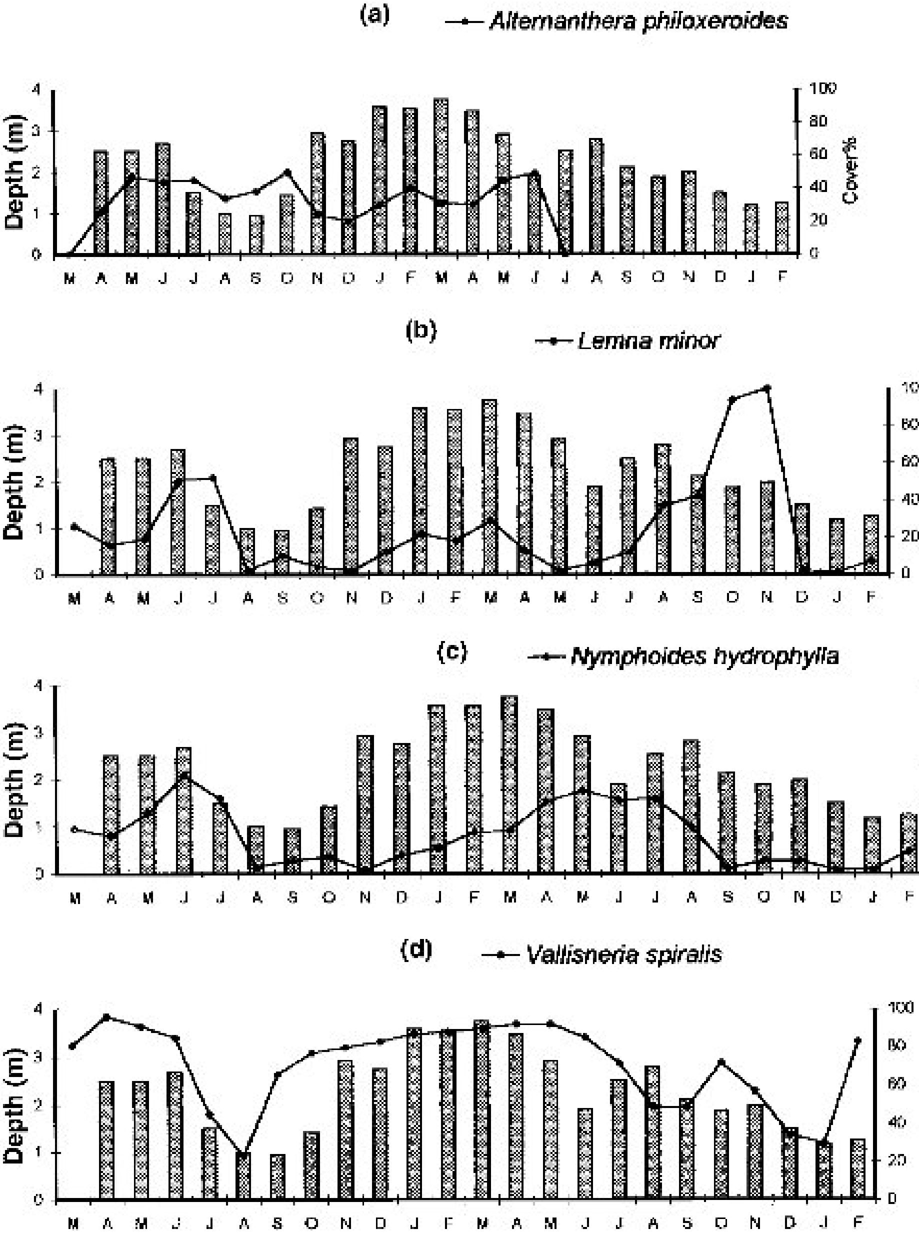

FIGURE 3 Relationships among different types of plants and water transparency in pond 203

3.5. Nutrients

As is evident from Fig. 2(a), a rapid fluctuation of total Kjeldahl nitrogen concentration over a very wide range (1.2 to 29.8 mg/l) was found to be a common feature of both ponds. This could signify the exclusion of nitrogen limitation as a possible explanation for reduced phytoplankton densities observed in the presence of macrophytes. Monthly average of total phosphorus concentration varied from 0.2 to 1.2 mg/l as can be seen from Fig. 2(b). As the mean value of total phosphorus concentration was always greater than 0.1 mg/l, the two study ponds could be classified as hyper-eutrophic based on trophic classification [11]. Nitrogen and phosphorus levels were much higher than those reported for other tropical ponds [12,13].

3.6. Relation between Plant and Water Clarity

Figure 3 shows the cover percent of different aquatic plant types and their relationship with water transparency in pond 203. Among the different types, coverage of *Vallisneria spiralis* (Fig. 3(d)) had a significant positive correlation with Secchi disk transparency measured at the deepest point ($r_s = 0.644$, $R^2 = 0.415$, $n = 23$, $p < 0.01$). No association was found between Secchi disk transparency and cover percent of the other types of acquatic plants.

Throughout the study period, *V. spiralis* was mainly confined to the littoral zone (water level ranging 1.5–2.0 m) where the Secchi disk often hit the bottom. An interesting observation was that when coverage of the plants were ≥90%, a markedly higher Secchi disk transparency (≥3.5 m) was frequently observed in the open water zone also (water level ranging 3.5–4.4 m). In April 2000 (summer), when the water level was 3.5 m, Secchi disk could be seen down to the bottom and a clear bottom view of the pond showed the presence of *V. spiralis* even at the deepest point, which may be indicative of the pronounced clearing effect of submerged flora in this pond. Such a phenomenon was never found in the other pond where any submerged plant was totally absent. Sinha *et al.* [14] reported maximum phytoplankton density in a tropical pond during the month of April. Current knowledge on a large shallow Dutch lake with dense Charophyte meadows [3] reported spring clear water phase and summer turbid phase with Secchi disk transparency of 0.5 m in the open water (depth ranging 2–4 m). This is quite different from tropical ponds, where the plants are found throughout the year and could maintain high water transparency.

The clearing effect of *V. spiralis* was not only pronounced at the deepest point during high coverage but also profound even at high total phosphorus levels ranging 0.2–1.2 mg/l, as observed in this study. This is contrary to reports found in the literature on the presence of submerged plants in temperate shallow lakes. Jeppesen *et al.* [15] suggested that a vegetation dominated clear water state was likely to be unstable beyond a total phosphorus concentration of 0.1 mg/l due to phytoplankton development, resulting in turbid waters. Present data probably show the ability of the plant to grow in enriched tropical ponds. Crowder *et al.* [16] noted Kjeldahl nitrogen concentration ranged 0.39–0.43 mg/l and total phosphorus 0.01–0.03 mg/l in a temperate lake with *V. spiralis*.

4. CONCLUSION

The ability of *V. spiralis* to maintain Secchi disk transparency (>2 m) at a high coverage (≥ 90%) was not only profound along the littoral zone but also extended upto the deepest point of the pond, even at high Kjeldahl nitrogen (1.2–29.8 mg/l) and total phosphorus concentrations (0.2–1.2 mg/l) which could suggest its ability to retard algal biomass at high phosphorus levels. The ecology of ponds in tropical areas appear to be quite different from those of temperate shallow lake systems and hence more research endeavours should be directed towards the study of ponds which happen to be a vital component of the tropical ecosystem for anthropogenic activities.

Acknowledgement

Thanks are due to Mr L. B. Magranti and Mr G. Bhaumik for providing all possible assistance during the fieldwork.

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