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BIO-MONITORING APPROACHES FOR WATER QUALITY ASSESSMENT IN TWO WATERBODIES AT TIRUVANNAMALAI, TAMIL NADU INDIA

N. Ramakrishnan

Department of Botany, Govt. Arts College, Tiruvannamalai, Tamil Nadu, India

Abstract

Most parts of Tamil Nadu face scarcity of drinking water due to conflicts over usage and degradation of water resources. The level of degradation of water resources can be quantified by bio-monitoring technology more than conventional chemical methods. The use of living organisms for monitoring and surveillance of water quality originated from and is used extensively in western countries only, so this attempt is to evaluate the efficacy of a bio-monitoring approach to monitor the water quality in our area's water resources.

In this present investigation several biological communities including phytoplankton, periphyton, microphytobenthos and aquatic macrophytes have had been considered apart from the various physico-chemical factors like water temperature, pH, alkalinity, free CO₂, dissolved oxygen, nitrate, phosphate and calcium assessments of water quality in two freshwater bodies at Tiruvannamalai from April 2000 to March 2001. From the basic biological data various pollution indices like Saprobic index, Nyggard's index, Palmers algal pollution index, biological index and Shannon-Weiner index were calculated to quantify the water quality of the water bodies.

Results showed that the bio-monitoring approaches with the chemical analysis for a 12 months period in two water bodies produced many significant correlations indicating 32 of the 40 comparisons between biological pollution indices (5 kinds) and chemical analysis (8 parameters) were statistically significant ($r > 0.316$; $p \leq 0.05$). The Nyggard's index and biological index were significantly correlated with all physico-chemical parameters ($r > 0.356$; $p \leq 0.05$). Shannon - Weiner index was significantly ($r > 0.415$ and 0.327) associated with phytoplankton population density in all combinations.

Considering all the parameters and biotic indices it was clearly shown that the water body II was less polluted than the I water body. The bio-monitoring approach was not static. This can be further modified to suit our area to monitor the quality of water in it's natural condition for the particular usage of water.

Introduction

Biological monitoring or bio-monitoring, is the use of biological response to assess changes in the environment, generally changes due to anthropogenic causes. Bio-monitoring programs may be qualitative,

semi-quantitative or quantitative. Bio-monitoring is a valuable assessment tool that is receiving increased use in water quality monitoring programs of all types (Kennish, 1992).

Bio-monitoring involves the use of indicators, indicator species or indicator communities. Generally benthic macro invertebrates, fish / or algae are used. Certain aquatic plants have also been used as indicator species for pollutants including nutrient enrichment (Philips and Rainbow, 1993; Batiuk *et al.*, 1992). The presence or absence of the indicator or of an indicator species or indicator community reflects environmental conditions. Absence of a species is not as meaningful as it might seem as there may be reasons, other than pollution, that result in its absence [eg. Predation, competition or geographic barriers which prevented it from ever being at the site]. Absence of multiple species of different orders with similar tolerance levels that were present previously at the same site is more indicative of pollution than absence of a single species. It is necessary to know which species should be found at the site or in the system. A great deal of work has been done on using algae as bio-indicators of pollution (Mohanty, 1983; Reddy and Venkateswarlu, 1986; Tripathy, 1989; Mohapatra & Mohanty, 1992).

Algal growth is dependent on sunlight and nutrient concentrations. An abundance of algae is indicative of nutrient pollution (De Lange, 1994). Moreover algae are sensitive to some pollutants at levels which may not visibly affect other organisms in the short term or may affect other communities at higher concentrations (Mitchell & Stapp, 1992).

Advantages

- In the present investigation algae is used as indicator organisms because of the following advantages,
- Algae have very short life cycles and rapid reproduction.
- Algae tend to be most directly affected by physical and chemical environmental factors.
- Sampling is easy and inexpensive which requires few persons for assessment and has a lesser impact on other organisms.
- Standard methods exist. (Plafkin *et al.*, 1989).

For a number of years there has been a series of proposals indicating that one or more algae could be used as organisms indicative of water quality (Palmer, 1959). He also demonstrated that algal assemblages could be used as indicators of clean water or polluted water. Later, Patrick (1971) also described a technique which could be useful in determining water quality. She proposed that an examination of the diatom flora would give a good idea of the water quality of a water body. Nevertheless, clean water would support a great diversity of organisms, whereas polluted water would yield just a few organisms, with one or few dominant forms (Trainor, 1984). In this venture, the microalgae have great potential for monitoring and evolving the water quality of the water bodies in our area (Venkataraman *et al.*, 1994).

Considering all the above facts, the present study was undertaken in two natural freshwater bodies in Tiruvannamalai for the determination of water quality using algae as bio-monitors.

Problem of the Present Investigation

One method is to routinely survey the various algal species occurring in lakes, wetlands, rivers, and streams in order to evaluate the biological health, or biological integrity, of the resource surveyed. This type of survey is called biomonitoring or biosurveying.

Materials and Methods

For phytoplankton population filtering 10L of water through bolting silk, Periphyton and microphytobenthos and macrophytes were collected from the soil, rock base and surfaces of the rocks in the pond. The major physico-chemical factors estimated were water temperature, pH, alkalinity, free CO₂, dissolved oxygen, nitrate, phosphate and calcium. (Golterman, 1969 and APHA, 1985).

Filtered phytoplankton, periphyton, micro-phytobenthos samples were fixed and preserved in 4% formalin and identified using the keys provided by Prescott (1951), Desikachary (1959), Randhawa (1959), Gandhi (1967), Philipose (1967) and Gonzalves (1981). For counting phytoplankton a microtransect method was followed as described by Edmondson (1974).

Data analysis : From the basic biological data various pollution indices like saprobic index, Nygaard's index (Nygaard, 1949), Palmer's algal pollution species index (Palmer, 1969), biological index and Shannon-Wearner index (Shannon & Wearner, 1949) were calculated to qualify the water quality of the water bodies. Both the biological and physico-chemical parameters were analysed statistically using computer programming in STATISTICA, Student Edition, Release 5.0 of Microsoft Corporation (1996).

Results and Discussions

The results of the physico-chemical parameters are shown in Figure 2a-h. Water temperature increases from December (23.10°C) in pond II and from January (25.10°C) in pond I and attains its peak value during July (29.20°C for pond I and 30.10°C for Pond II) in both the ponds. This result is in conformity with Kumar and Singh (2000) and Chandhari *et al* (2001). The Ponds were alkaline throughout the period of study. pH of the water bodies ranged from 7.10 to 9.10. The minimum value was noticed during November 2000 in both the ponds and maximum during April and May for the Pond II and I respectively. The increased pH value during April and May 2000 was due to increased concentration of bicarbonate alkalinity. The present results had in conformity with our earlier findings (Ramakrishnan, 1990; 1991 and Ramakrishnan, Ganesan, and Thevanthan, 2000). Free CO₂ was observed only from the month of July 2000 to January 2001 in both the water bodies. Maximum values (56.70 mg/l for pond I and 51.20 mg/l for pond II) were observed during November

2000 and minimum value (36.20 mg/l) for pond I noticed during January 2001 whereas minimum value (32.50 mg/l) for pond II observed in July 2000.

During the present investigation the amount of dissolved oxygen (DO) ranged between 5.10 to 8.52 mg/l for both the ponds. The minimum values were observed during rainy months and maximum values were noticed in February 2001 in both the ponds. This present result was in conformity with Kumar & Singh (2000). Nutrient salts like Nitrate – N, Phosphate - P and calcium attained its maximum values during the rainy months due to inflow of rain water and its minimum value was observed during summer months showing negative correlation with phytoplankton population. This is in conformity with results of Singh (1993) ; Mishra and Yadav (1978).

Figure 2a

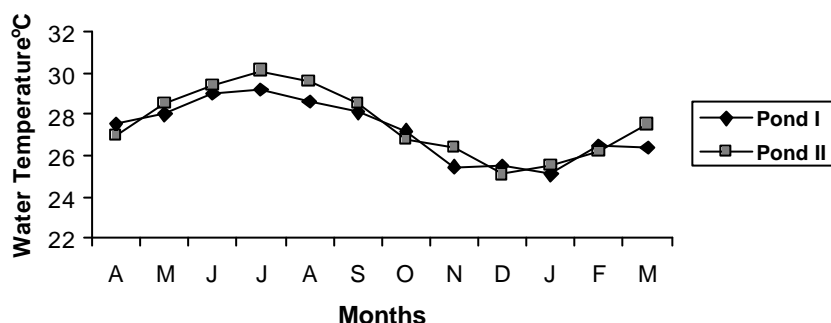


Figure 2b

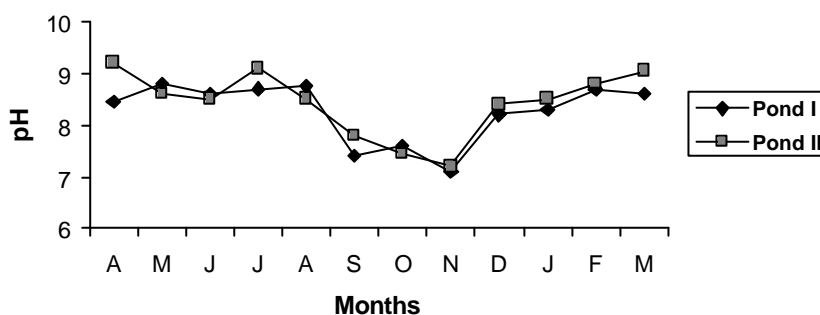


Figure 2c

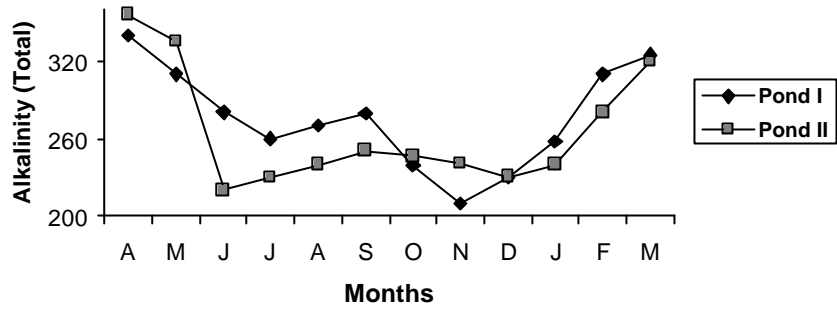


Figure 2d

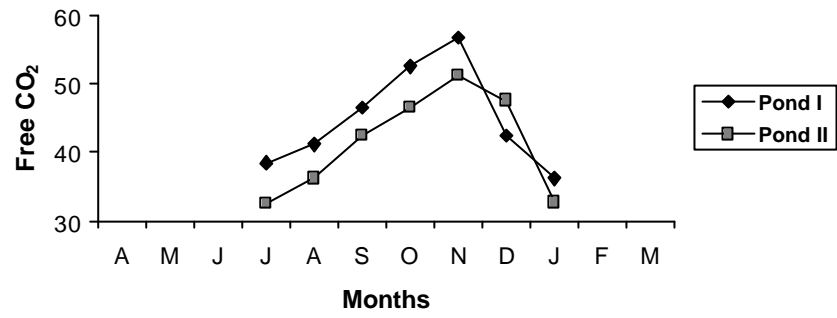


Figure 2e

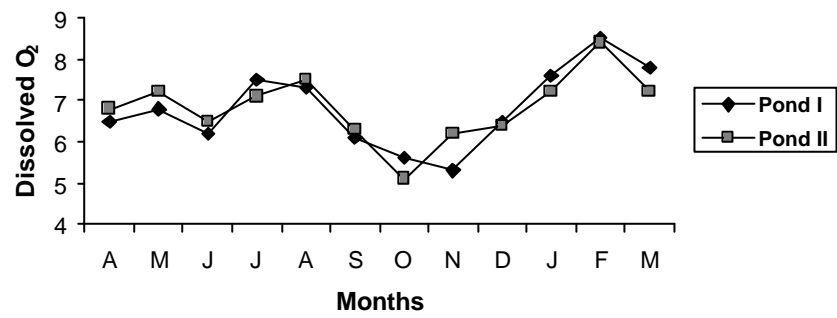


Figure 2f

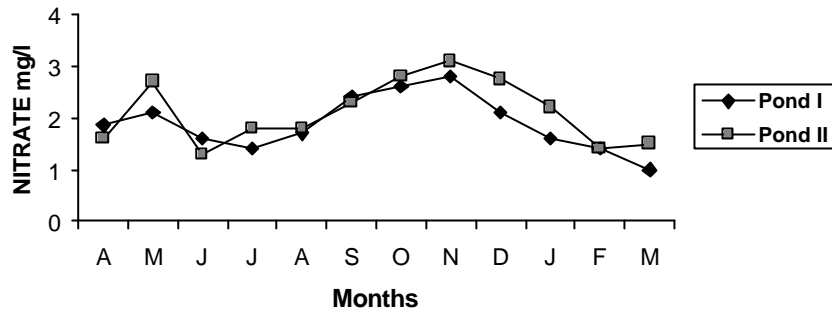


Figure 2g

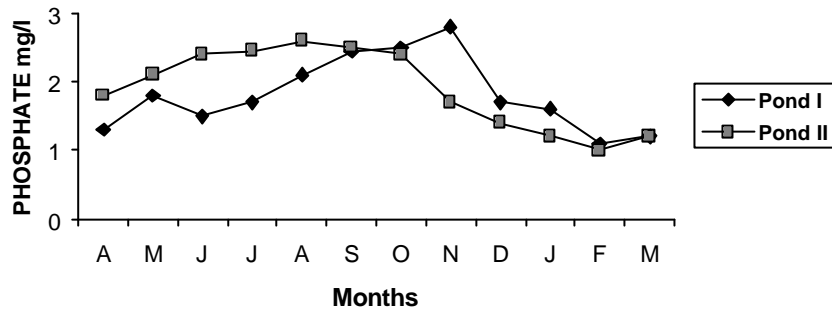
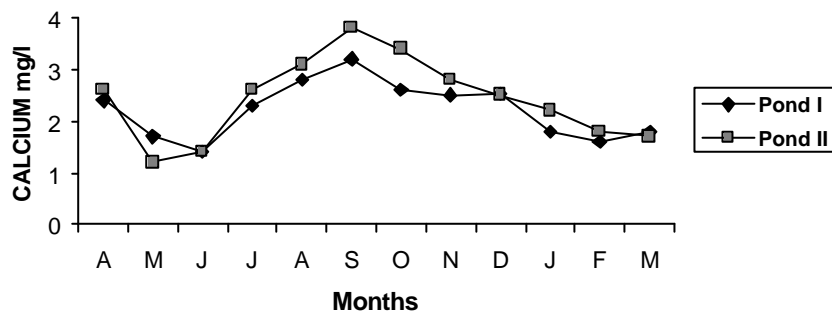
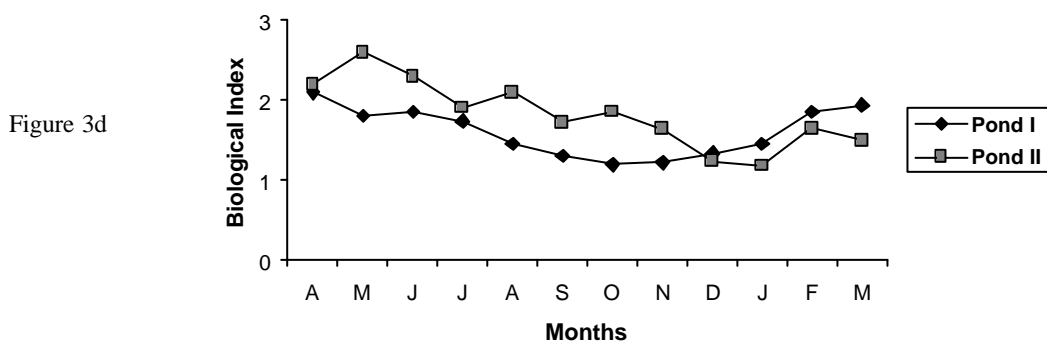
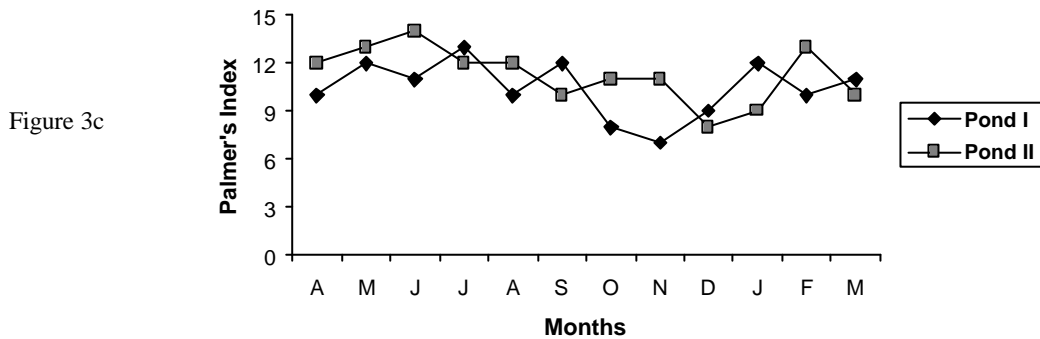
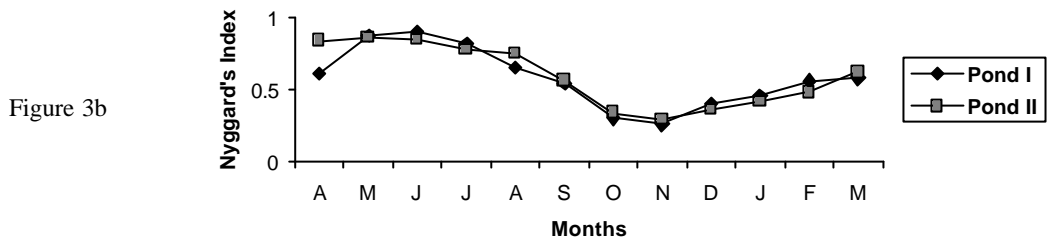
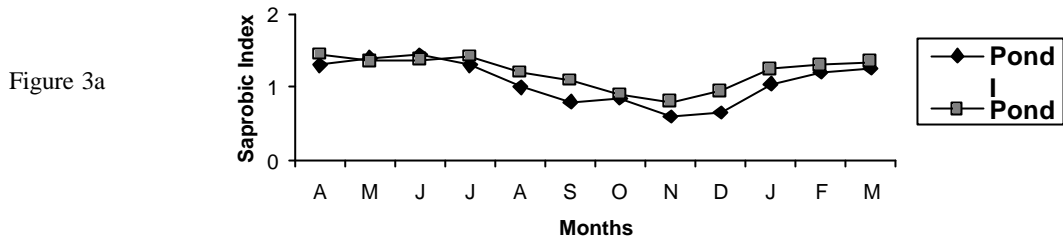


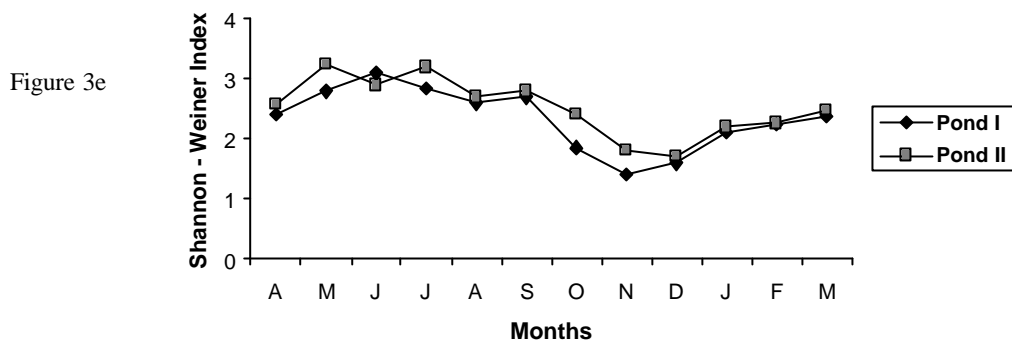
Figure 2h



A perusal of Figure 3 a-e reveals that the various biological indices showed their minimum values during rainy and winter months (October to January) due to low phytoplankton populations with high nutrient content (Saikia and Bordoloi, 1994; Sahu *et al* 1996). The maximum values were observed during summer months, coinciding with maximum growth of algal populations. The saprobic index values ranged from 0.60 to 1.45 in both the ponds clearly indicating the water bodies were oligosaprobic in nature. The Nyggard's index of the two ponds ranged from 0.26 to 0.90. The observed values clearly indicated their water bodies were obiotrophic in nature (Yyas & Kumar, 1968 ; Hosmani, 2002)

Palmer's pollution (species) index ranged from 7 to 14 in both the ponds and clearly indicated the water bodies were slowly progressing towards a eutrophic nature (Parvateesam & Mishra, 1993). Biological index ranged from 1.18 to 2.60 also confirming the less polluted nature of the water bodies. Shannon – Weiner index ranged between 1.40 to 3.24 for both the ponds, minimum values were observed during rainy months and the maximum values were recorded during summer months. This result was also in conformity with our earlier findings (Ramakrishnan 1991).





The correlation coefficient (r^2) analysis was made between 8 kinds of physico-chemical parameters with 5 kinds pollution indices and presented in Table 1. The major combinations ie between water temperature, pH, Total alkalinity and dissolved oxygen with pollution indices showed significant positive correlation, whereas free CO₂ and nutrients like nitrate and calcium combinations showed significant negative correlations. The nutrient, phosphate with all pollution indices showed positive correlation except saprobic index showed no correlation. The statistical analysis clearly indicated that the water bodies were less organically polluted whereas pond II is approaching a more eutrophic nature than the pond I.

Table -1. Correlation (r^2) value between the physico-chemical parameters and bio-monitoring indices significance level $p < 0.05$

	Ponds	Saprobic index	Nyggard's index	Palmer's species index	Biological index	Shannon - Weiner index
Water Tempt.	I	0.2935	0.5264	0.2206	0.0977	0.7177
	II	0.2294	0.5728	0.3625	0.4610	0.7522
pH	I	0.5885	0.6155	0.2235	0.2235	0.5342
	II	0.6917	0.4367	0.0501	0.0267	0.1624
Total Alkalinity	I	0.5674	0.2873	0.2164	0.7471	0.3341
	II	0.2029	0.1596	0.0395	0.1332	0.0474
Free CO ₂	I	-0.07022	-0.4268	-0.1295	-0.8528	-0.2677
	II	-0.6629	-0.4357	-0.3541	-0.2228	-0.1899
Diss. O ₂	I	0.2422	0.1388	0.2762	0.2785	0.0913

	II	0.3915	0.1215	0.0811	0.00018	0.0300
Nitrate	I	-0.4755	-0.3213	-0.3369	-0.5171	-0.2491
	II	-0.6317	-0.3439	-0.2052	-0.0315	-0.1534
Phosphate	I	-0.4985	-0.2658	-0.1914	-0.7143	-0.1270
	II	0.000	0.1886	0.1402	0.3882	0.3998
Calcium	I	-0.4838	-0.2697	-0.0691	-0.3882	-0.0718
	II	-0.3270	-0.1528	-0.1584	-0.0586	-0.0330

Conclusion

On the basis of present study the following conclusions can be drawn.

- All measurements in natural water bodies demand a planned systematic approach to enable the generation of proper data on water quality
- Emphasis is being laid on monitoring biological variables, because biological monitoring systems can be cheaper requiring less sophisticated instruments
- Biomonitoring reflect the integrated expression of pollutional load

Recommendations

1. Further proper development of other parameters in biological monitoring systems must be stimulated.
2. The frame work objective, functions, techniques - of a monitoring system on biological variables must be well observed to enable proper use and affect of these efforts
3. The use of biological variables in biomonitoring appears to be quite cost - effective, shows a wide range of response, and thus may be very useful.
4. Nevertheless, based on experience, a number possible indicators have been used under different conditions in India and elsewhere.

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