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# Seasonal Variations of Diatoms Epiphytic on the Roots of Water Hvacinth [*Eichhornia crassipes (Mart.) SOLMS*]

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**KEY WORDS** Epiphytic diatoms. Water Hyacinth. Seasonal Variations. Water Quality.

**ABSTRACT** In this investigation, an attempt has been made to study the seasonal variations of epiphytic microflora, especially diatoms, attached to the adventitious roots of water hyacinth growing in lotic waters polluted by urban and agro-industrial wastes. Epiphytic algae were largely represented by Bacillariophyceae, Chlorophyceae, Euglenophyceae, and Cyanobacteria in the decreasing order of abundance. A total of 59 genera belonging to above algal groups were recorded. Although, qualitatively diatoms ranked second to green algae, quantitatively their relative percentage to total algal population was the highest throughout the period of investigation and attained maxima during spring. The dominant forms were *Navicula*, *Nitzschia*, *Synedra*, *Fragilaria*, *Cyclotella* and *Gomphonema* at various sites. Data were subjected to analysis of community parameters *viz*., Shannon-Weiner index (H') and Morisita's similarity index, as also correlations between the epiphytic diatoms and environmental variables.

## INTRODUCTION

The role of periphytic communities in monitoring eutrophication and pollution has attracted the attention of limnologists since past two decades (Lowe, 1974; Lange-Bertalot, 1979; Goldsborough and Robinson, 1985; Sabater et al., 1987; Watanbe et al., 1988; Nather Khan, 1990; Rushforth and Brock, 1991; Nwankwo and Akinsoji, 1992; Müller, 1994). However, most of the earlier studies on water quality evalution as also seasonal variations include exposure of artificial substrates for periphytic colonization in free-water column (Castenholz, 1960; Saldeckova, 1962; Patrick 1973; Blinn, 1986; Sabater et al., 1987). In comparision, a few investigations have been conducted to study seasonal periodicity of algal assemblages on natural substrates *e.g.*, floating and submerged macrophytes, rocks etc.

The objective of this study was to investigate the seasonal variations in abundance as well as species composition of algal assemblages with special reference to diatoms epiphytic on floating macrophyte *Eichhornia crassipes* growing in lotic waters and relate them with physico-chemical parameters.

## MATERIALS AND METHODS

### *Study Sites*

These investigations were conducted in a sub-tropical basin of river Yamuna and an associated drain-Najafgarh drain. River Yamuna flows for 48 kms through the city states of Delhi from north to south, leaving the city near Okhla barrage. The river has an average depth of 1.25 m and breadth varies between 200-400 m along the course (Fig. 1). Najafgarh drain and 16 other drains of various catchment areas discharge untreated sewage and agro-industrial wastes directly into the river Yamuna. As a result, various stages of eutrophication are noticed in the drains as also in the river basin. Four stations were selected for this study. Stations A and B were located on the western bank of river Yamuna. Stations C and D were situated on Najafgarh drain, which alone contributes 51% of untreated BOD load into the river Yamuna.

### *Methods of Analysis*

Water samples for the analysis of physico-chemical parameters and epiphytic diatoms attached to the roots of water hyachinth were collected once every month for a year. Procedures adopted for the analysis of chemical parameters *viz.*, hardness, chlorides, alkalinity, silica,

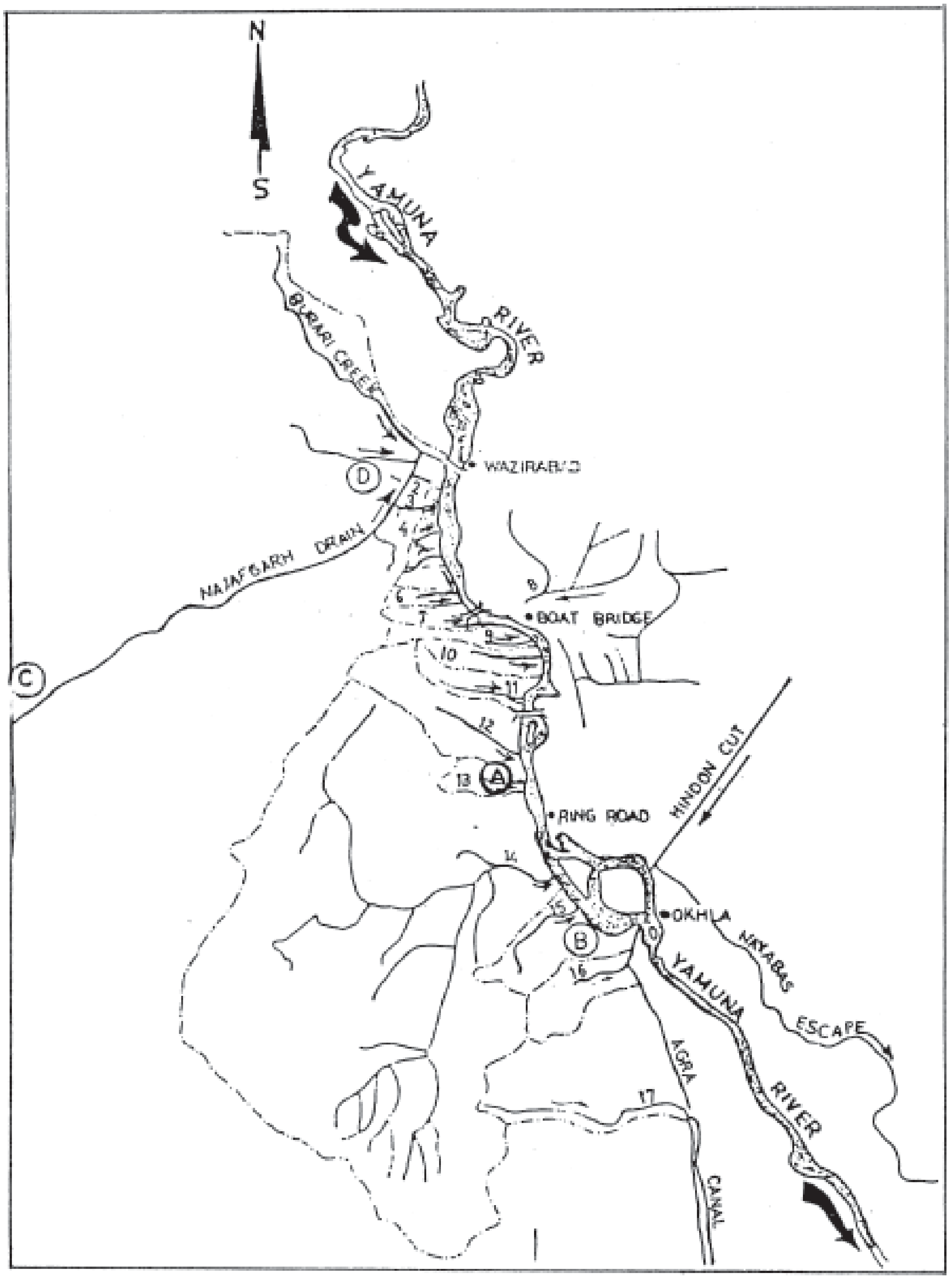


**Fig. 1. Map depicting river Yamuna through its course in the National Capital Territory of Delhi showing location of various drains and sampling stations *viz*., A, B, C, and D**

ortho-phosphates, nitrites, BOD, COD, DO were according to Standard Methods (APHA, 1989) and nitrates according to Fresenius et al. (1987). For epiphytic samples, water hyacinth plants were collected with minimum disturbance. A method was standardised for the quantification of epiphyton on the roots of water hyacinth. Roots were detached from plants and taken in proportionate amont of filtered water sample in a beaker and shaken vigorously. Cells were counted in Sedgewick-Rafter cell. Results have been expressed as number of cells/root unit (for details refer Kaur, 1991; Kaur and Mehra, 1994). Diatoms were identified using frustule size, shape, and ornamentation (Tiffany and Britton, 1952; Desikachary, 1959; Krammer and Lange-Bertalot, 1986, 1988, 1989).

### *Data Analysis*

Data were subjected to Shannon-Weiner index (H'). Similarity in genera among various seasons at different stations was determined using Morisita's similarity index. The distribution of epiphytic diatoms were correlated with physico-chemical variables and other epiphytic algal groups using computer programme by Krebs (1989).

## RESULTS

Temperature at all the stations ranged between 15° and 34°C. pH of the water ranged from neutral to slightly alkaline at the study sites. Conductivity was highest at station C and it ranged between 1310 and 1630 $\mu Scm^{-1}$, whereas at other stations it varied from 510 and 820 $\mu Scm^{-1}$. In all the stations water was generally hard. During the study period, DO was absent at stations C and D, whereas at stations A and B it remained within a low range. Maximum concentration of chlorides was recorded during winter at stations A, B and C and during monsoon at station D. The concentration of silicates was high at all the sampling sites and recorded maxima during winter. Higher concentrations of nitrates were recorded in all the sampling sites and they attained maxima during winter at stations A and D, and during spring at stations B and C. Relatively higher concentrations of ortho-phosphates were observed at stations C and D. BOD was high at all the stations and recorded maxima during monsoon. Range of variations for the selected environmental variables are shown in table 1.

The averages of some of the selected physico-chemical parameters were subjected to the weight score of Crude Pollution Index (DeZwart, 1991) to ascertain water quality. Data analysis revealed that quality of water at stations A, B and C varied from moderately to highly polluted during the study period, whereas station D continued to be highly polluted throughout the period of investigation.

**Table 1: Range of variations in physico-chemical characteristics at the study sites**

| *Stations/ Parameters* | *A* | *B* | *C* | *D* |
|---|---|---|---|---|
| Temp°C | 16-30 | 15-31.5 | 18.5-32 | 19.5-34 |
| pH | 7.3-7.6 | 6.8-7.8 | 7.3-8.3 | 7.2-7.6 |
| DO | 1.8-4.8 | 0.8-1.8 | 0 | 0 |
| Conductivity, $\mu Scm^{-1}$ | 570-790 | 575-740 | 1310-1630 | 510-820 |
| TOT. HARD. | 188-218 | 160-220 | 280-390 | 152-226 |
| Chlorides | 42-105 | 37-98 | 23.2-192.2 | 38.4-194 |
| Silicates | 7.6-18.5 | 5.2-30.4 | 6.4-33.0 | 8-21.2 |
| Nitrates | 0.1-1.06 | 0.1-0.89 | 0.21-0.29 | 0-0.49 |
| Phosphates | 0.16-0.87 | 0.42-0.85 | 1.09-1.38 | 0.95-1.36 |
| $BOD_5$ | 31.4-87.2 | 36.4-76.0 | 51.3-126 | 54.3-128.6 |

Results other than tempereratures, pH and conductivity, are expressed in $mgL^{-1}$. [TOT. HARD.-Total hardness]

Epiphytic algae on the roots of water hyacinth were largely represented by Bacillariophyceae, Chlorophyceae, Cyanobacteria and Euglenophyceae. A total of 59 genera of algae have been identified, of which 18 belonged to diatoms, 29 to green algae, 6 to blue-green algae and remaining to euglenoids. Although, qualitatively diatoms ranked second to green algae, quantitatively they were most abundant at all the stations during the period of investigation. An analysis of epiphytic diatom population from different stations revealed that their abundance varied markedly during different seasons (Figs. 2-5).

Maximum diversity in diatom population was recorded at station A, whereas maximum density was observed at station C. However, among all the stations, peak for diatom population was recorded during spring. Maxima with 1310 diatoms/root unit and 1945 diatoms/root unit were recorded at stations A and B, respectively (Figs. 2,3). The most common forms were *Fragilaria, Pinnularia, Cymbella, Gomphonema, Melosira and Tabellaria* (Table 2). Among the eight taxa recorded from each of the remaining two stations, *Gomphonema, Nitzschia, Cyclotella,* and *Stauroneis* with 2135 diatoms/root unit contributed to maxima at station C, whereas *Epithemia, Nitzschia, Cyclotella,* and *Fragilaria* contributed to the peak with 1985 diatoms/root unit at station D (Table 2, Fig. 5).

Species diversity of epiphytic diatoms ranged between 1.4 and 3.48 at station A, between 2.1 and 3.0 at station B, between 1.8 and 2.7 at station C and between 2.5 and 2.9 at station D (Fig. 6).

**Table 2: List of epiphytic diatoms and their relative abundance during the period of investigation. [- =absent; x =rare; xx =frequent; xxx=very frequent; xxxx =abundant]**

| | *Stations* | | | |
|---|---|---|---|---|
| | *A* | *B* | *C* | *D* |
| *Cyclotella* | xx | xx | xxxx | xxxx |
| *Cymbella* | x | xx | - | xxx |
| *Diatoma* | xx | - | xx | - |
| *Epithemia* | - | - | - | xxx |
| *Fragilaria* | xx | xxx | xxx | xx |
| *Frustulia* | x | x | - | x |
| *Gomphonema* | xxx | xx | xxx | x |
| *Gyrosigma* | .xx | xx | xxx | xxx |
| *Gomphonesis* | x | x | - | - |
| *Melosira* | x | xx | xx | xxx |
| *Meridion* | - | - | x | x |
| *Navicula* | xx | xxx | xx | xxx |
| *Neidium* | x | x | xxx | xxx |
| *Nitzschia* | xx | xx | xxxx | xxxx |
| *Pinnularia* | xx | xxx | xxx | x |
| *Stauroneis* | xxx | xxx | xxx | xxx |
| *Surirella* | xx | xx | xxx | xx |
| *Synedra* | x | xxx | xxxx | xxx |
| *Tabellaria* | x | xx | xx | xxx |

Comparison of epiphytic diatoms during different seasons among four stations revealed that maximum similarity was recorded between stations A and B during autumn and monsoon, between stations B and D during spring and between stations A and C during summer (Table 4).

Correlations between epiphytic biota and environmental variables revealed that weak to strong negative correlation existed between diatoms and temperature, DO, pH, Cl, BOD, whereas positive correlations were recorded with conductivity, $PO_4$-P, total algae, Chlorophyceae and Cyanobacteria (Table 3).

**Table 3: Correlation coefficient analysis of total epiphytic diatoms with physico-chemical parameters and between diatoms and epiphytic flora**

| | *Stations* | | | |
|---|---|---|---|---|
| | *A* | *B* | *C* | *D* |
| ***A. Physico-Chemical parameters*** | | | | |
| Temperature | -.501* | - | .622* | -.558** |
| pH | -.820* | -.722* | -.521** | -.576** |
| Chlorides | - | .543** | - | -.533** |
| $B.O.D._5$ | -.764* | -.634 | - | -.525** |
| $NO_3$ -N | -.681* | .711* | .804* | .522** |
| $PO_4$ -P | .944* | -.524** | .664* | .685* |
| $SiO_2$ | .744* | .864* | .741* | .630* |
| ***B. Epiphytic Flora*** | | | | |
| Chlorophyceae | .735* | - | .595** | - |
| Cyanobacteria | .860* | .925* | .789* | .745* |
| Euglenophyceae | .936* | .905* | .597** | .616* |
| Total Algae | .942* | .910* | .802* | .831* |

Level of significance : * = at 1% level
** = at 5% level
- = not significant

## DISCUSSION

The physico-chemical characteristics of River Yamuna have been studied in detail during last 30 years (Rai, 1962, 1974a, b; Mathur, 1965; Kundra et al., 1977; Subramanian and

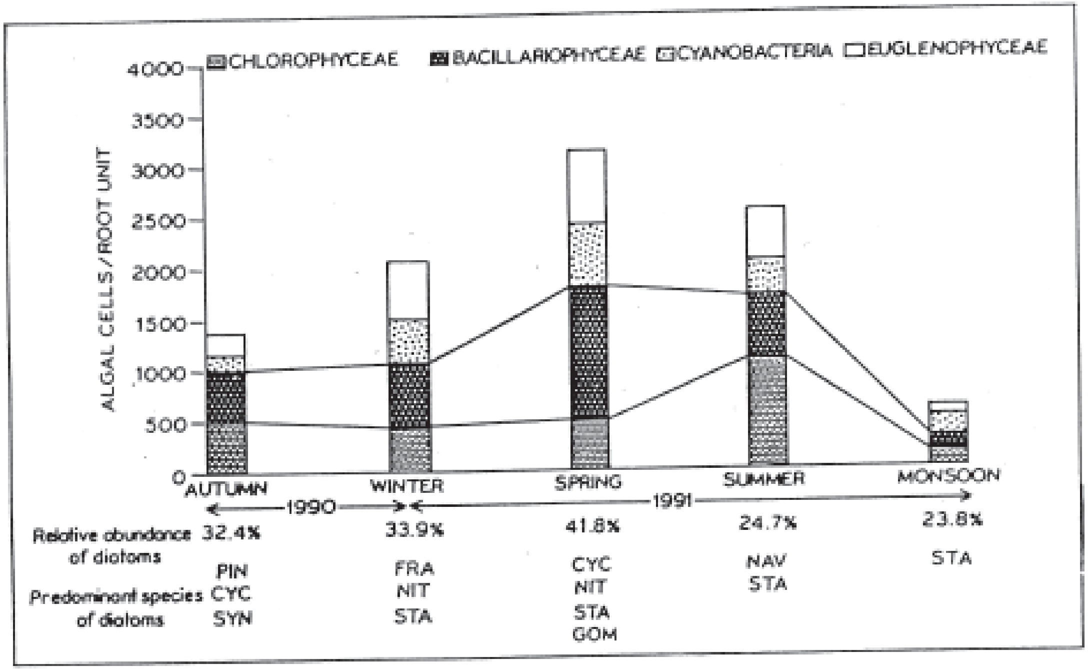


**Fig. 2. Seasonal variations in the total epiphytic algal cells highlighting the relative abundance of ditoms at station A. Abbreviations of predominant species of diatoms are as follows :**
**PIN - *Pinnularia*; CYC - *Cyclotella*; SYN - *Synedra*; FRA - Fragilaria; NIT - *Nitzschia*; STA - *Stauroneis*; GOM - *Gomphonema*; NAV - *Navicula***

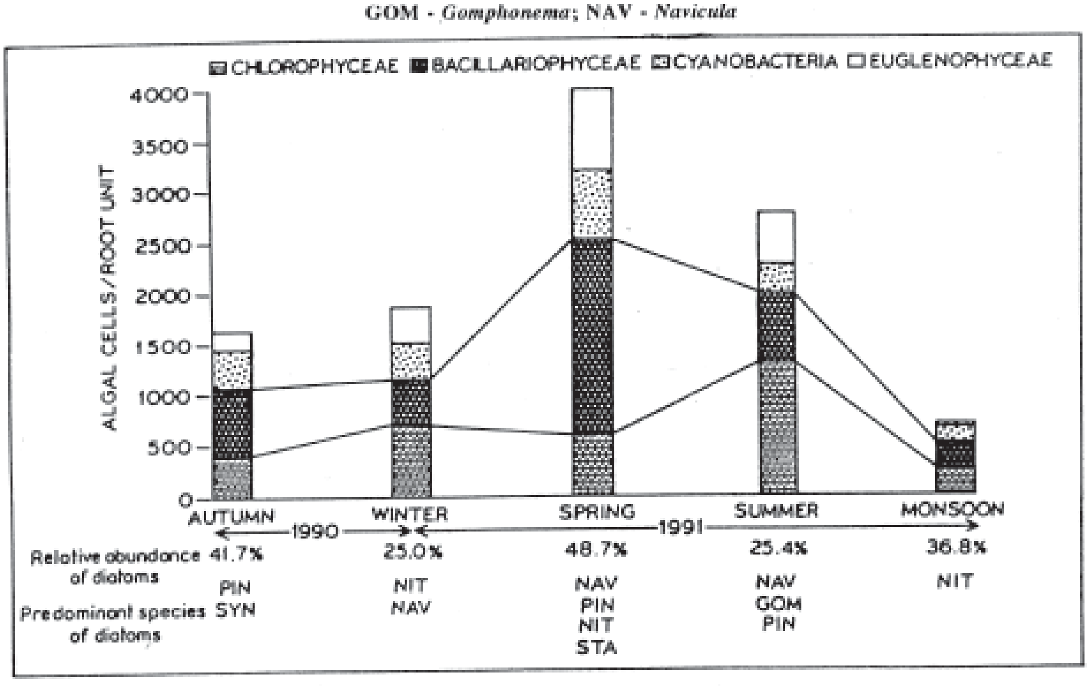


**Fig. 3. Seasonal variations in the total epiphytic algal cells highlighting the relative abundance of diatoms at station B. Abbreviations of predominant species of diatoms are as follows :**
**PIN - *Pinnularia*; SYN - *Synedra*; NIT - *Nitzschia*; NAV - *Navicula*; STA - *Stauroneis*; GOM - *Gomphonema***

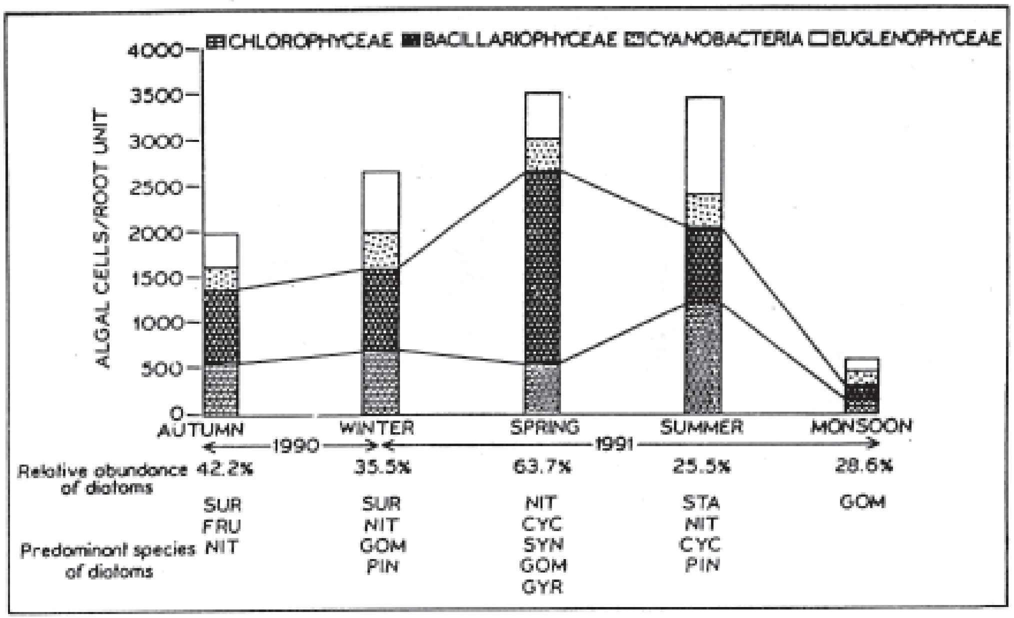


**Fig. 4. Seasonal variations in the total epiphytic algal cells highlighting the relative abundance of diatoms at station C. Abbreviations of predominant species of diatoms are as follows :**
**SUR - *Surirella*; FRU - *Frustulia*; NIT - *Nitzschia*; GOM - *Gomphonema*; PIN - *Pinnularia*; CYC - *Cyclotella*; SYN - *Synedra*; GRY - *Gyrosigma*; STA - *Stauroneis***

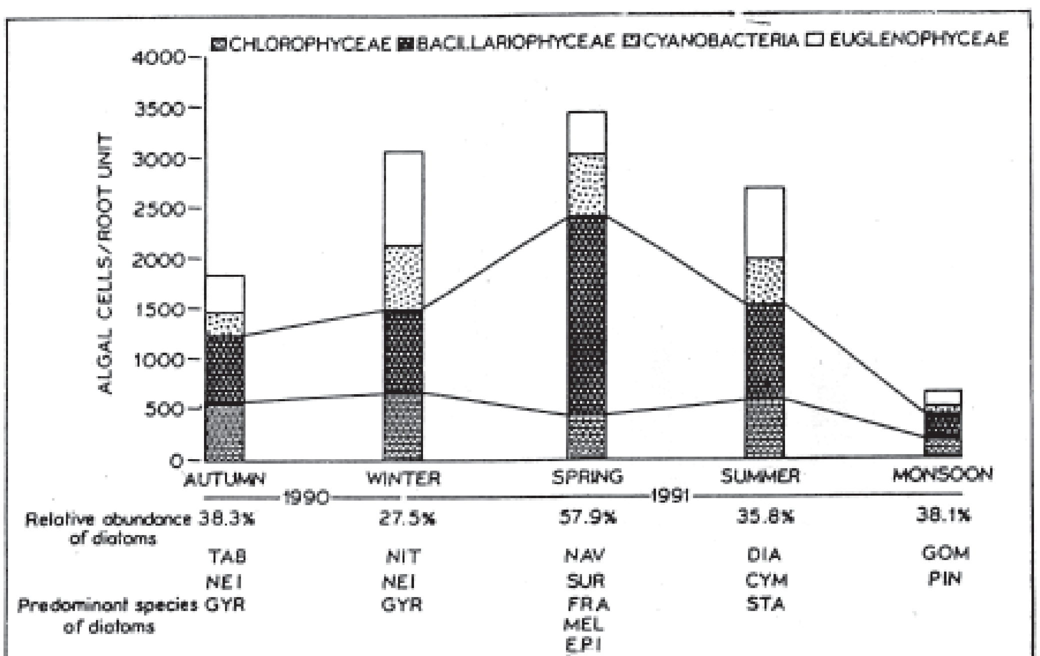


**Fig. 5. Seasonal variations in the total epiphytic algal cells highlighting the relative abundance of diatoms at station D. Abbreviations of predominant species of diatoms are as follows :**
**TAB- *Tabellaria*; NEI - *Neidium*; GYR - *Gyrosigma*; NIT - *Nitzschia*; NAV - *Navicula*; SUR - *Surirella*; FRA - Fragilaria; MEL - Melosira; EPI - *Epithemia*; DIA - *Diatoma*; CYM - *Cymbella*; STA - *Stauroneis*; GOM - *Gomphonema*; PIN - *Pinnularia***

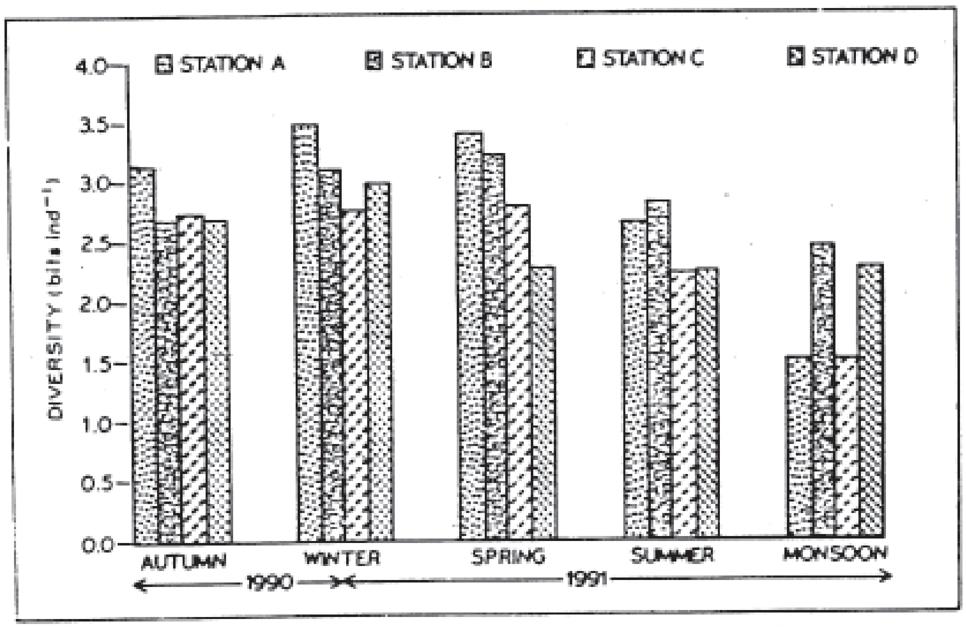


**Fig. 6. Shannon-Weiner diversity indices for epiphytic diatoms at four sampling stations during different seasons**

**Table 4: Similarity Index of the epiphytic diatoms among four stations during different seasons. Bold values indicate maximum similarities between the stations**

| *Seasons* | *Stations/ Stations* | *A* | *B* | *C* | *D* |
|---|---|---|---|---|---|
| Autumn | A | 1.01 | | | |
| | B | **.80** | 1.01 | | |
| | C | .35 | .20 | 1.01 | |
| | D | .72 | .52 | .42 | 1.01 |
| Winter | A | 1.01 | | | |
| | B | **.83** | 1.02 | | |
| | C | .66 | .39 | 1.01 | |
| | D | .52 | .55 | .33 | 1.01 |
| Spring | A | 1.01 | | | |
| | B | .76 | 1.01 | | |
| | C | .59 | .45 | 1.00 | |
| | D | .59 | **.80** | .54 | 1.00 |
| Summer | A | 1.01 | | | |
| | B | .55 | 1.01 | | |
| | C | **.57** | .38 | 1.00 | |
| | D | .29 | .34 | .28 | 1.00 |
| Monsoon | A | 1.01 | | | |
| | B | **.41** | 1.01 | | |
| | C | .23 | .21 | 1.01 | |
| | D | .00 | .07 | .38 | 1.01 |

Sitasawad, 1984; Bhargava, 1985; Trivedi et al., 1985; Khurshid, 1989; Menon, 1990) and that of Najafgarh drain by Bulusu and Sharma (1966) and Dakshini and Soni (1979, 1982). A comparison of the present data with those of eariler studies indicates that water quality has further deteoriated at both the sites. Although, the nutrient load in the segments of river Yamuna as also in Najafgarh drain has increased, they still support a rich and diverse biotic community. Recent studies conducted by DeZwart (1991) revealed that as a result of above physico-chemical changes, the composition of plankton populations have also undergone significant variations during last thirty years.

Earlier studies on species composition and seasonal dynamics of phytoplankton were made on river Yamuna at Delhi (Rai, 1962, 1974 b; Hortobagyi, 1969). These studies revealed that diatoms dominated the phytoplankton followed by green and blue-green algae. In addition, seasonal progressions involving basically year-round predominance of diatoms with short pulse of green algae have also been reported in Asian rivers (Kundra et al., 1977; Trivedi et al., 1985; Nather Khan, 1990 and Nwankwo and Akinsoji, 1992), European rivers (Swale et al., 1969; Kiss, 1984; Simm, 1985; Descy, 1987), and Australian rivers (Chessman, 1985).

In the present study, it was observed that among the periphytic algal communities, qualitatively green algae dominated the epiphytic assemblages on the roots of water hyacinth, whereas numerically diatoms were more predominant throughout the investigation. This is in confirmity with earlier reports of Nwankwo (1984, 1986). Similiar observations have also been made with reference to other macrophytes *i.e.*, *Lemna minor* (Goldsborough and Robinson, 1985), on *Pistia* sp. (Nwankwo and Akinsoji, 1988), *Potamogeton* sp. (Cattaneo and Kalff, 1978), *Phragmites australis* (Müller, 1994) and on artificial substrates (Castenholz, 1960; Cattaneo and Kalff, 1978; Nather Khan, 1990).

During this investigation, it was observed that among the epiphytic algal community, diatoms recorded maxima during spring at all the stations. This is in concurrence with observations of Kiss (1984) in river Hungary, Goldsborough and Robinson (1985) in Delta marsh, Canada, Watenbe et al. (1988), Acs and Kiss (1991) in river Danube, Hungary, Nwankwo and Akinsoji (1992) on coastal waters in Nigeria and Buczko and Acs (1994) in Danube river.

Lund (1950), Lange-Bertalot (1979), Sabater et al. (1987) and Nather Khan (1990) have observed that following spring maxima, diatom population declined at the onset of summer, which have been attributed to exhaustion of dissolved silica. In our study also, decline in diatom population during summer was due to lowering of dissolved silica levels.

Seki et al. (1988) reported that forms like *Fragilaria*, *Melosira* and *Synedra* were the most abundant diatoms during the growth period of water hyacinth. In our study, predominance of above forms was observed during summer, which is the growth period of macrophyte under observation.

Seasonal periodicity in the composition as also abundance of diatoms have been recorded at different stations and this can be correlated to the changing physico-chemical profiles of sampling sites. Our observations are in accordance with those of Lowe (1974), Lange-Bertalot (1979), Kiss (1984), Sabater et al. (1987), Nather Khan (1990), and Müller (1994).

Sabater et al. (1987, 1988) and Biggs (1989) recorded negative correlations of epiphytic diatoms with temperature, DO, $SiO_2$-Si and positive correlations with $PO_4$-P and conductivity. Similar correlations have been recorded in this study also.

The use of epiphytic diatoms in monitoring water quality has been well documented in literature. Attempt has been made in this study to analyze the composition of epiphytic diatoms in relation to water quality. Patrick and Hohn (1956) had observed that due to organic pollution, rare and intolerant species do not survive, whereas more tolerant species tend to become exclusively dominant. In our study also certain tolerant forms of diatoms *viz.*, *Nitzschia, Cyclotella* and *Synedra* were recorded from all the stations, but they were more predominant at stations on Najafgarh drain which has a regular inflow of untreated sewage.

During the period of investigation, species diversity was low in the highly polluted stations on Najafgarh drain. Similar observations have been reported by Dakshini and Soni (1979, 1982).

Sabater et al. (1987), Nather Khan (1990), and Nwankwo and Akinsoji (1992) have listed some species of diatoms as indicators of water quality. Some of these taxa have also been recorded in the present study.

## CONCLUSIONS

1. Seasonal changes of epiphytic diatoms on the roots of water hyacinth were recorded at all the stations during spring season.

2. Differences in species diversity at stations could be related to changes in water quality.
3. Some diatom genera reported to act as bio-indicators were recorded in this study also.

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