Seasonal Variation of Aquatic Fungi

Chapter - 5

SEASONAL VARIATION OF AQUATIC FUNGI

Fungi are adapted to a diverse array of freshwater ecosystems. In streams and rivers, flowing water provides a mechanism for downstream dispersal of fungal propagules. Aquatic hyphomycetes, conidia are morphologically adapted (tetraradiate and sigmoid) for attachment to their substrates (leaf litter and woody debris from riparian vegetation) in flowing water (Webster and Davey, 1984). Autumn-shed leaves of riparian trees represent one of the major energy sources for stream communities (Allen, 1991). About 2000 fungal species have been reported to date from submerged decaying substrates, as spores in water, parasites of aquatic plants or animals, are associated with decaying macrophytes in wetlands (Manoharachary, 2008).

Table 6. Fungal diversity in fresh water habitats

Fungal division	Number of species
Chytridiomycota	576
Trichomycetes	148
Ascomycota (Meiosporic)	500
Basidiomycota	11
Aquatic hyphomycetes (Mitosporic)	300
Aero-aquatic fungi (Mitosporic)	90
Miscellaneous mitosporic fungi	405
Fungi on emergent macrophytes	600
Freshwater or amphibious lichens	100
Oomycota (Saprolegniales)	138

Species of aquatic hyphomycetes are vary seasonally, from leaf to leaf and from site to site, depending on a variety of factors (Barlocher, 1992). Seasonal and latitudinal changes are thought to be mainly due to differences in water temperature (Barlocher and Kendrick, 1974; Iqbal and Webster, 1973; Suberkropp, 1984, 1992), which can result in distinct summer and winter assemblages in temperate streams (Suberkropp, 1984). Site differences within a stream are most closely correlated with altitude or factors associated with it (Fabre, 1998; Raviraja, *et al.,* 1998a), which may include shifts in water chemistry, current or riparian vegetation (Gonczol, 1989; Raviraja *et al.,* 1998b; Shearer and Webster, 1985a).

Materials and Methodology

For leaf litter analysis submerged leaves of different species were collected in sterile polythene bags from each sampling site and washed several times in water in the laboratory to remove extraneous materials. From each leaf, 24 segments (5 mm) were cut, eight along the midrib and eight each along the two margins and grouped separately. One segment type from each group was picked randomly and transferred to the Petri-dishes with 20 ml of distilled water for incubation (at 28±2°C).

The next day each disc was observed directly in the petridish and then taken on a slide and mounted in 0.05% Trypan Blue stain under a coverslip. The developing and released conidia were again observed. The percent frequency of occurrence of each species was calculated on the basis of its presence on the number of leaves studied. The average monthly frequencies for every species were calculated.

Results and Discussion

A total 66 species was recorded during this study period, among them *Alatsaspora acuminata, anguillospora longissima, tetraploa aristata, clavariopsis aquatica* and *Tetracladium marchalianum,* was observed throughout the year. The conidial number in water was maximum in winter season followed by rainy season and summer season. Aquatic fungi were recorded in different season during 2009-2012 (Table 7-9).

The aquatic hyphomycete community consists of all species colonizing submerged leaves. In the present investigation different techniques were used like random leaf sampling of different species of plant, foam analysis among them foam analysis is best method to study the diversity of aquatic fungi. The aquatic hypphomycetes are considered as successful colonizers on plant leaves in the all sites. Similar observations were also recorded (Shearer and Webster, 1985).

The pH, temperature, dissolved oxygen and BOD, were recorded in different season content of waters in the lakes is (Table 7-9). In present study the pH range is between 6.9-7.9 mg^{-1}, temperature 20-30°C, acidity 1.2-3.9 mg^{-1}, alkalinity, EC 52-205, DO 5.8-9.5 mg^{-1}.

Table 7. Seasonal variation of species diversity during 2009-10

	Pre-monsoon	Monsoon	Post-monsoon
Taxa S	47	65	50
Individuals	9549	13701	9857
Dominance D	0.02205	0.01594	0.02067
Simpson 1-D	0.9779	0.9841	0.9793
Shannon H	3.831	4.156	3.895

Table 8. Seasonal variation of species diversity during 2010-11

	Pre-monsoon	Monsoon	Post-monsoon
Taxa S	43	60	54
Individuals	8793	13588	12178
Dominance D	0.02453	0.01714	0.01932
Simpson 1-D	0.9755	0.9829	0.9807
Shannon H	3.732	4.08	3.966

Table 9. Seasonal variation of species diversity during 2011-12

	Pre-monsoon	Monsoon	Post-monsoon
Taxa S	54	52	54
Individuals	11172	11027	10693
Dominance D	0.01933	0.01996	0.01931
Simpson 1-D	0.9807	0.98	0.9807
Shannon H	3.965	3.931	3.966

Fig. 11, 12 and 13 shows graphical representation of taxa dominance and individuals.

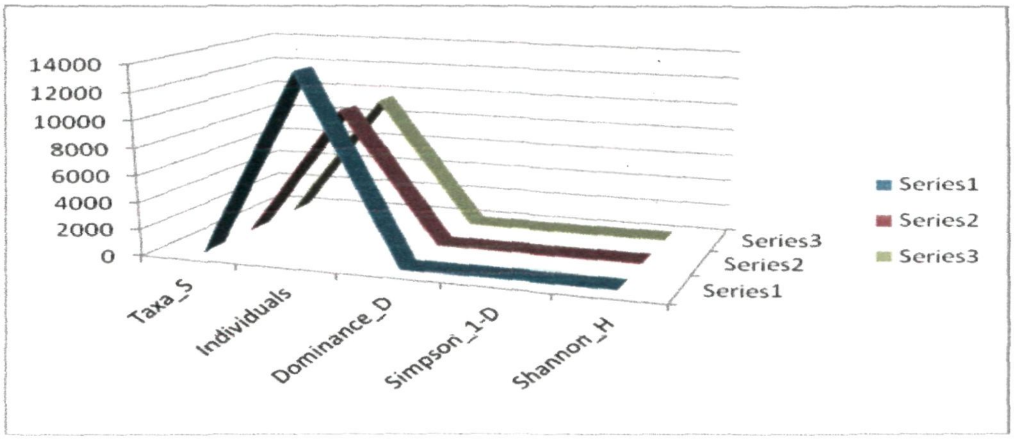

Fig. 11. Seasonal variation of individuals, 2009-10

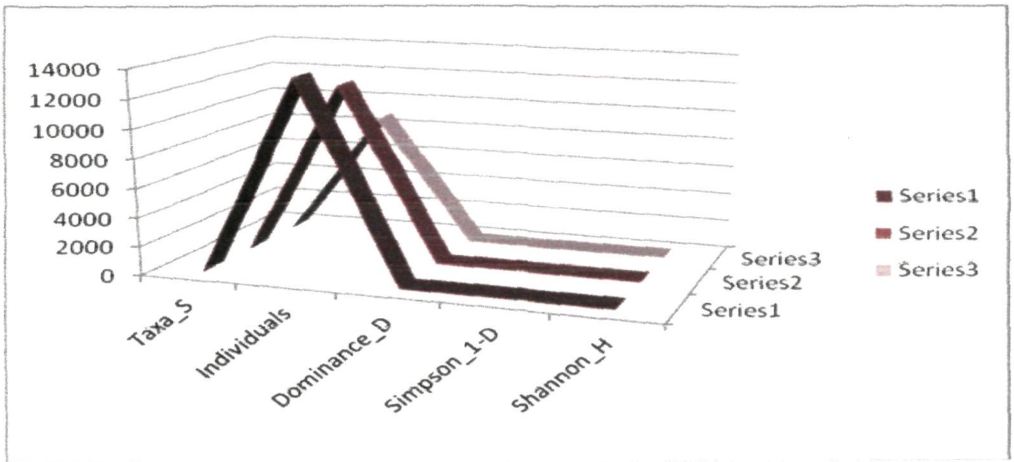

Fig. 12. Seasonal variation of individuals, 2010-11

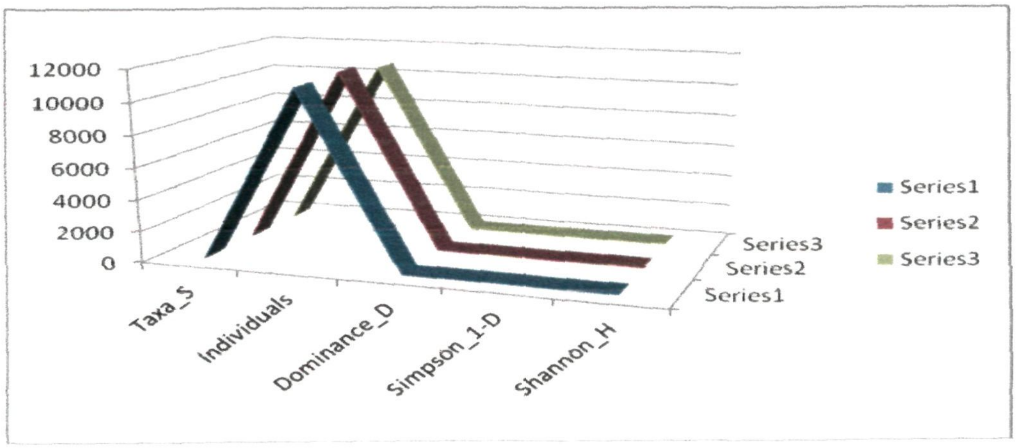

Fig. 13. Seasonal variation of individuals, 2011-12

During present study surveyed, the monsoon species appeared throughout the year. These included species like *Alatsaspora acumonata, Anguillospora longissima, Tetraploa aristata, Clavariopsis aquatica, Clavariopsis aquatica, Tetracladium marchalianum* and *Triscelosphorus monoonosporus*. Other species recorded throughout the year were *Flagcllospora curvula, Tetraploa aristata, Tetracladium marchalianum* and *Tetracladium marchalianum*. Similar findings were obtained by Sridhar and Kaveriappa (1989).

The dissolved oxygen of water influences the occurrence of aquatic hyphomycetes. In the present study, the range *DO in* between *5.8-7.0 is* favours for the occurrence of the aquatic fungi (Rajashekhar and Kaveriappa, 1993; Rajashekhar, 1994). These results suggest that a positive correlation between dissolved oxygen and number of species. Some earlier studies have also led to similar conclusions (Tubaki, 1957; Nilsson, 1964). But no such correlation between dissolved oxygen and occurrence of hyphomycetes was found in the studies of some streams of Wisconsin (Woelkerling and Baxter, 1968).

The pH, and temperature also affects diversity of aquatic fungi, in present study pH range is 6.9-7.3 mg^{-1} and temperature range is between 20°C to 26°C is favours for occurrence of the aquatic fungi (Table 10-18). Similar findings were obtained (Rajashekar and Kaveriappa, 2003). According to Marvanova (1984), in Czechoslovakia, there is rich fungal diversity in the streams passing through beech forests above 500-700 m ASL. Although the altitude has no direct effect on the occurrence of fungi, its indirect effects such as variation in temperature, vegetation, rainfall etc. might be responsible for the differences in species richness.

Although *Tetraploa aristata, Lunulospora curvula* and *Tetracladium marchalianum* acquired the topmost positions among the fresh water hyphomycetes during the study period having its normal seasonal fluctuation, some of the species manifested a strong affinity for a particular type of leaf. Similar findings were studied (Barlochcr, 1992b).

In the fresh water, these preferences were observed on different kinds of bait leaves. With the exception of temperature, not a single factor is generally strong enough to explain the presence or absence of a species in a stream (Barlochcr, 1992b). If the temporal fluctuation is ignored and the fidelity of hyphomycetes species to particular bait leaves observed, some species behaved differently to different leaf type. For example, on bait leaves of *Bamboo* sp., *Flagcllospora penicillioides* and *Lunulospora curvula* showed exceptional fidelity. On bait leaves of *Eucalyptus*. *F. penicillioides, L. curvula* and *Triscelophorus monosporus* were mostly present. On bait leaves of *Fungamia, Anguillospora longissima, C. aquatica, L. curvula* and *Tetracladium marchalianum* were most commonly observed and on bait leaves of *Occasia* sp., *Altaspora acuminate,* *Flabellospora multiradiata, triscelophorous monosporus, L. curvula* and most common. This preferential association may be highlighted by the fact that the character species in the Associations of fresh water hyphomycets formed on different types of leaves were different.

The aquatic fungi colonizing on submerged leaves, twigs, so many authors were observed (Willough and Archer, 1973; Iqbal and Webster, 1977; Sanders and Andersen, 1979; Chamier and Dixon, 1982; Shearer and Lane, 1983). Leaves of *Eucalyptus* had a very characteristic and restricted assemblage of species. Usually the total number of species on these leaves was lesser than on other types. This is also indicated by a lower percentage of similarity throughout the year between random leaves and bait leaves of *Eucalyptus* sp. provided the species on random leaves are considered to be the actively sporulating species in fresh water.

Table 10. Physico-chemical parameters during pre-monsoon season, 2009-10

Parameters	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7	Station 8	Station 9	Station 10	Station 11	Station 12	Station 13	Station 14
pH	7.71	7	7.1	7.2	7.2	7.5	7.6	7.9	7.9	7.6	8	7.9	8.1	7.2
WT	22	22	21	22	20	22	23.2	23.6	24.3	24.9	25	25.6	19	20
AT	24	26	23	25	27	27	28	29	30	30	29	27	21	21
EC	127	98	106	114	98	143	144	126	98	102	115	152	221	205
ALK	14.5	12.5	11.4	14.5	9.8	8.5	11	12.5	9.5	14.5	11	12.5	14	11
Aci	3.0	2.7	2.5	2.9	3.1	2.7	2.8	3.0	2.7	3.4	3.3	3.7	2.5	2.8
DO	6.2	6.7	7.2	7.6	7.7	7.7	7.8	7	7	6.9	6.9	6	7.5	7.8
BOD	2.2	1.6	1.4	1.55	1.6	1.8	2	2	2.1	2.2	2.1	3	1.2	1.2

Table 11. Physico-chemical parameters during monsoon season, 2009-10

Parameters	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7	Station 8	Station 9	Station 10	Station 11	Station 12	Station 13	Station 14
pH	7.2	6.8	7	7.5	6.5	7.2	7.6	7.9	6.5	7.2	6.5	7.5	7.8	7.5
WT	24	25	24	22	26	24	22	24	26	25	22	24	26	24
AT	26	26	27	26	28	28	28	29	28	28	26	22	28	26
EC	98	68	98	86	114	98	112	82	78	80	104	112	94	78
ALK	9.6	8.9	7.8	0.5	11	9.5	8.5	8.8	9.6	8.5	9.5	8.5	9.8	11
Aci	2.9	2.7	2.5	3.2	3.6	2.8	1.9	1.8	2.2	2.4	1.8	2.8	2.6	2.2
DO	6.8	6.6	7.5	7.2	7.4	6.8	7.8	7.9	6.8	6.75	7.2	7.1	7	6.8
BOD	3.2	2.8	0.5	1.5	1.25	2.5	0.95	0.5	2.5	2.5	0.95	1	0.95	2.2

Table 12. Physico-chemical parameters during post-monsoon season, 2009-10

Parameters	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7	Station 8	Station 9	Station 10	Station 11	Station 12	Station 13	Station 14
pH	7.1	7.4	6.8	6.5	7.2	7.5	7.5	6.5	7	7.4	6.5	6	7.1	7.2
WT	20	21	19.5	20	22	20.5	18.5	20	22	21	19.5	22	24	20.5
AT	22	24.5	22	24	24	25.5	20	22.5	24	22	20	24	26	22.5
EC	68	52	72	68	82	98	78	65	72	98	164	98	114	78
ALK	12.5	14.5	12.5	9.5	14.5	11	12.5	15.5	12	14.5	12	14	10.5	12
Aci	3.9	2.5	2.5	4.5	2.5	4.5	2.5	1.5	4.5	3.5	2.5	3.5	2.5	3.5
DO	7.2	6.5	7.5	6.8	7.5	7.5	7.5	6.8	5.5	7.17	7.5	8.5	7.45	6.5
BOD	0.5	3.2	1.5	2.5	0.75	0.75	1.5	2.75	3.5	0.5	0.5	0.25	1.5	3.5

Table 13. Physico-chemical parameters during pre-monsoon season, 2010-11

Parameters	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7	Station 8	Station 9	Station 10	Station 11	Station 12	Station 13	Station 14
pH	6.8	6.4	7.25	7.1	6.5	7.5	7.1	7.5	6.95	7.8	7.5	7.2	7.3	7.5
WT	25	24	23	24	23	22	24	22	24	23	22	24	26	25
AT	28	26	27	26	26	26	26	28	27	26	27	26	28	28
EC	68	72	88	82	78	62	78	88	114	98	142	115	111	98
ALK	12.5	10.5	9.5	12.5	9.8	10.5	9.5	8.2	9.6	9.5	10.5	9.5	9.5	8.5
Aci	1.4	1.8	1.8	2.4	2.2	2.4	1.8	2.4	2.8	1.8	2.4	3.2	3.5	1.8
DO	6.2	7.2	7.4	7.8	6.2	6.8	7.9	7.9	7.1	7.2	7.4	7.2	7.4	6.8
BOD	3.3	1.5	0.95	1.2	2.4	2.2	0.5	0.75	0.95	0.5	1.25	0.95	1.25	2.8

Table 14. Physico-chemical parameters during monsoon season, 2010-11

Parameters	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7	Station 8	Station 9	Station 10	Station 11	Station 12	Station 13	Station 14
pH	7.2	6.9	7.4	7.4	7	7.5	6.9	6.9	71	7	7.5	7	7.5	6.9
WT	20	22	20	19	21	22	20.5	21	22	22	19.5	22	20	21
AT	21	24	23	22	21	22	22	24	22	30	24	22	24	21
EC	122	99	128	98	148	120	135	114	180	114	98	126	175	198
ALK	9.8	9.5	8.5	11.5	12.5	11	13.5	11	10.5	14	12.5	11	9.5	12
Aci	2.9	2.4	2.6	2.4	2.8	2.8	3.2	3.2	2.6	3.2	2.8	2.2	1.4	1.2
DO	6.4	6.3	7.2	6.4	6.2	7.2	6.8	6.2	6.8	6.2	6.5	5.8	7.2	7.4
BOD	2.4	2.2	1.4	1.8	2.4	1.5	2	2	2.5	2.4	2.2	3.2	0.9	0.85

Table 15. Physico-chemical parameters during post-monsoon season, 2010-11

Parameters	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7	Station 8	Station 9	Station 10	Station 11	Station 12	Station 13	Station 14
pH	7.5	6.5	7.45	7	6.5	7	7.5	6.5	6.75	7	6.5	7.25	6.75	7
WT	19.5	20	21	22	23	22	21	22	20	19.5	20	22	23	20
AT	22	24	22	24	25	24	22	24	22	21	24	24	24	24
EC	56	78	78	89	67	78	79	72	74	88	98	78	68	70
ALK	9.5	10.5	11.5	14.5	10.5	12.6	11	12	9	10.5	11	12.5	10.5	9.5
Aci	2.4	3.5	3.5	2.5	4.5	2.5	2.8	2.5	3.5	2.8	3.5	2.5	2.5	2.5
DO	7.2	7	6.5	6.75	7.5	5.75	7.5	6.5	7.5	7.5	6.5	8.5	9.5	7.5
BOD	0.5	0.75	3.5	3.5	0.15	3.75	1.5	3.5	1.75	0.5	2.75	0.25	0.25	0.75

Table 16. Physico-chemical parameters during pre-monsoon season, 2011-12

Parameters	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7	Station 8	Station 9	Station 10	Station 11	Station 12	Station 13	Station 14
pH	7.2	6.8	7.1	6.8	7.5	7.2	7.1	6.5	7.5	6.5	7	7.2	7	6.9
WT	22	26	24	26	24.5	22	22	24	25	26	27	26	24	24
AT	24	28	27	28	26	26	24	26	26	29	28	28	26	26
EC	88	58	72	66	86	76	77	58	85	86	72	66	72	84
ALK	9.5	10.4	10	9.5	11.5	12.5	9.1	9.2	10.5	9.5	8.5	2.5	8.5	12.5
Aci	2.4	2.4	3.2	2.8	2.4	2.6	2.8	2.2	2.6	1.8	2.3	1.8	3.3	2.5
DO	7.2	6.8	7.2	6.2	7.2	6.2	7.2	7.2	6.8	7.2	6.2	7.2	6.8	7.2
BOD	0.75	2.5	0.75	2.5	0.5	2.4	0.5	0.75	2.5	1.25	2.5	1	2.5	2.5

Table 17. Physico-chemical parameters during monsoon season, 2011-12

Parameters	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7	Station 8	Station 9	Station 10	Station 11	Station 12	Station 13	Station 14
pH	6.9	7.2	7.5	6.8	6.5	7.4	6.8	6.5	7.2	7.8	7.5	6.5	7.5	7.1
WT	23	22	24	22	21	22	20	23	22	21	22	24	22	20
AT	24	24	24	24	25	24	26	24	24	24	24	25	24	22
EC	148	126	114	124	182	98	118	118	128	285	126	114	122	112
ALK	10.5	9.5	12.5	11	14.5	20	11	9.5	9.2	9.5	10.5	9.5	8.5	1
Aci	3.0	2.7	2.5	2.9	3.1	2.7	2.8	3.0	2.7	3.4	3.3	3.7	2.5	2.8
DO	7.5	6.4	7.2	6.4	7.5	7.4	6.8	7.6	7.6	7.5	6.5	6.5	7.4	7.5
BOD	1.2	2.4	1.2	1.55	1.5	1.6	2.2	1.8	1.8	1.5	2.2	2.6	1.1	1.1

Table 18. Physico-chemical parameters during post-monsoon season, 2011-12

Parameters	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7	Station 8	Station 9	Station 10	Station 11	Station 12	Station 13	Station 14
pH	7.5	7.5	6.5	7	7.4	6.5	6	7.1	7.2	7.45	7	6.5	7	7.5
WT	21	22	23	22	21	22	20	19.5	20	22	19.5	20	21	22
AT	24	24	26	24	22	26	22	24	24	24	22	24	22	24
EC	78	79	72	56	78	78	89	67	68	70	56	98	78	72
ALK	12.5	9.5	14.5	11	12.5	15.5	10.5	11.5	14.5	10.5	12.6	11	12.5	10.5
Aci	3.5	2.8	3.5	2.5	2.5	2.5	2.5	2.8	2.4	3.5	3.5	2.5	4.5	3.5
DO	6.8	5.5	7.17	7.5	8.5	7.45	6.5	7.5	7.5	6.8	5.5	7.17	7.5	7.2
BOD	2.75	3.5	0.5	0.5	0.25	1.5	3.5	0.75	1.5	2.75	3.5	0.5	0.5	0.5

The pH or alkalinity of the water appears to affect fungal species richness but its effects have been difficult to interpret due to variations in the nutrient concentrations in the lakes. Similar findings recorded by (Suberkropp, 2001). According to Baerlocher (1987), no such significant correlation was observed between number of fungal species and any of the chemical parameters in ten soft water streams of New Brunswick and Nova Scotia, Canada. But, when the data were combined with the data obtained for the 16 streams in France, Germany and Switzerland (Eggenschwiler and Baerlocher, 1983).

Several studies have provided indications that water parameters and inorganic nutrients, affect the conidial production to a greater extent than fungal biomass, microbially mediated leaf-litter decomposition (Suberkropp and Chauvet, 1995). These observations also were confirmed by experiments in laboratory (Suberkropp, 1998; Sridhar and Barlocher, 2000). Increased concentrations of conidia in streams with high nutrient concentrations should result in more efficient/faster colonization of new substrata. Once established on plant litter, fungi grow faster with higher nutrient availability. Similar results were obtained (Gulis and Suberkropp, 2004).