

Chapter – 6

SUMMARY

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Indore is situated in 22.2-23.05 north latitude and 75.25-76.16 east longitude having an area of 3896 Sq. Km. in Western region of Madhya Pradesh on the southern edge of the Malwa plateau. Two water bodies namely Pipliyapala pond and Sirpur pond were selected for this study in Indore.

The present work is on the study of Chytridiomycetous and Hyphomycetous aquatic fungi of water bodies of Indore and impact of various physico-chemical factors on their occurrence is also taken in to consideration.

The aquatic Fungi belonging to class Chytridiomycetes and Hyphomycetes were tried to isolate from above mentioned ponds. Pattern of occurrence and distribution of the aquatic fungi of these classes were investigated by monthly collection of water samples during March-2009 to February-2011 and impact of various physicochemical factors like temperature, pH, dissolved oxygen, free carbon-di-oxide, dissolved solids, BOD, Phosphate, nitrate, nitrite and chloride contents of water on the occurrence of fungal population were studied.

Chytridiomycetous fungi provide themselves as an excellent food source to many life forms, but they also recycle key nutrients back to the environment. These fungi use enzymes outside of their body to break down nutrients. After the nutrients have been broken down, such fungi digest them. This process of external-digestion helps to preserve useful nutrients by returning them back to the environment.

The 1,250 species of Chytridiomycetous fungi that have been described are in five orders (Chytridiales, Spizellomycesales, Neocallimastigales, Monoblepharidales, and Blastocladales). The Occurrence of such fungi in an ecosystem depends upon various physical and chemical parameters. Their frequency and distribution in a system also fluctuate with seasons and water bodies.

The name Chytridiomycota is derived from the Greek word *chytridion*, meaning "little pot", describing the structure containing unreleased spores. Chytridiomycetous fungi are unique among all fungi having motile stage in their life cycle; no other fungi have this trait. These motile stages take the form of zoospores. These sperm like cell require water and it is thus not surprising that Chytridiomycetous fungi live in permanently or temporarily aquatic habitats.

The other group is known as Lignicolous freshwater aquatic Hyphomycetes or Ingoldian fungi. The major input or source of these fungi is of plant materials of aquatic environment comes from leaf fall which, contains a range of endophytes of terrestrial origin. These endophytes are soon replaced by characteristics group of hyphomycetes with specialized spores. A typical succession takes place analogous in compost and terrestrial leaf litter

Butler, E.J. (1912) observed for the first time *Allomyces*, a new genus of Chytridiomycetous fungus from India. Sparrow (1933, 1933b, 1960, 1968, 1973b), worked extensively on taxonomy of Inoperculates Chytridiaceous organisms and Monoblepharidales. Coker and Matthews (1937), worked on taxonomic aspects of Blastocladales,

Monoplephariadales and Saprolegniales. Foust (1937), found a new species of *Rozella* parasitic on *Allomyces*. Emerson (1941) worked on the life cycles and taxonomy of *Allomyces*. Coker (1946) wrote notes on water molds of Saprolegniaceae group of fungi. Emerson, (1954) worked on biology of water moulds. Johnson (1956) contributed, for the morphology and taxonomy of genus *Achlya*.

John (1958) studied Indian aquatic fungi with reference to sexual reproduction in *Gonapodya polymorpha*. Perrott (1960) contributed for taxonomic identification on number of aquatic fungi found from Indian sub continent. Karling (1966) studied on Indian Chytrids. Ram Dayal and Thakurji_(1968a,1969) studied on aquatic fungi of Varanasi, four more fungi viz., *Achlya apiculata*, *Achlya oblongata* var. *oblongata*, *Blastocladiella simplex* and *Pythiogeton ramosum* have been isolated and described. Thakurji (1970 and 1979) recorded some aquatic fungi from Gorakhpur. Chowdhry and Agarwal, (1981) did taxonomic studies on aquatic fungi from India. Hasija, and Khan, (1982, 1982a, 1982b) recorded Indian Chytrids from Jabalpur. Dubey (1982) recorded the *Allomyces*, *Aqualinderella*, *Dictyuchus* and *Pythium* from Bhopal. Prabhuji (1984) worked on taxonomy of *Brevilegnia* from Banaras. Bhairavnath and Manoharachary (1985) did mycological studies of two water bodies from Andhra. Dasgupta and John (1988) recorded a large number of new species of chytrids from Lucknow. Khulbe (2001) wrote "A manual of Aquatic Fungi" on Chytridiomycetes and Oomycetes water molds from Nainital.

Aquatic hyphomycetes or Ingoldian were recorded by Kar (2006) from Mizoram, Sati and Bisht (2006) investigated for their carbon requirement. Sati, *et al* (2009) from riparian plants of Nainital, Karamchand Sridhar

(2009) found such from Konaje (west coast) and Sampaje (Western Ghat) streams of India. Patil and Bores (2011), from foam samples Tapti and Panzara rivers of North Maharashtra.

Seasonal variations of aquatic fungi were studied by Chowdhry and Agarwal (1980) from Delhi, Hasija and Khan (1987) from Jabalpur lakes, Gupta and Mehrotra (1989) as well as Kumar (2000) recorded in Panda stream of Karnataka.

The results of work carried out during present studies have been summarized as follows:

(A) Pipliyapala and Sirpur ponds of Indore city were selected for the present study. Water samples were collected from four stations of each water body. Monthly water sampling was carried out from March 2009 to February 2011 and various physico-chemical parameters were employed. These parameters are listed below.

- (I) Temperature,
- (II) pH,
- (III) Dissolved Oxygen
- (IV) Dissolved Carbon-di-oxide,
- (V) Dissolved Solids.
- (VI) BOD,
- (VII) Phosphates,
- (VIII) Nitrates,
- (IX) Nitrites and
- (X) Chlorides

These were analyzed according to APHA (2005) and recorded as mentioned in table 1, 2 & 3.

Table-1

**Seasonal variations in the physico-chemical factors of Pipliyapala
Pond Water- March 2009-February 2011**

N	Parameters	Summer '09 March, April, May and June	Rainy '09 July, Aug. Sept. and Oct.	Winter '09-10 Nov. Dec. Jan. and Feb	Summer'10 Mar., April ,May June	Rainy'10 July ,Aug. Sept. and Oct.	Winter'10-11 Nov. Dec. Jan. and Feb
	Temp. °C	25.0- 31.9	24.4 - 26.8	15.5 - 22.07	24.35 - 30.7	21.75 - 25.15	15.47-24.32
	pH	7.1 - 7.6	7.1 - 7.7	7.2 - 7.47	7.1-7.8	7.05 - 7.35	7.0 - 7.2
	Dissolved Oxygen(mg/l)	6.3 - 7.1	6.7 - 7.5	7.5 - 7.82	7.0-7.4	7.1 - 7.3	7.0 - 7.2
	Free CO ₂ (mg/l)	00.00	00.00	00.00	00.00	00.00	00.00
	Dissolved Solid (mg/l)	92.8 - 116.0	106.5 - 123.6	116.75 - 151.5	102.25- 130.25	106.5 - 109.75	97 - 108.75
	BOD (mg/l)	0.79 - 2.0	1.95 - 2.07	1.42 -1.65	0.8-1.9	0.8 -1.05	0.50 - 0.55
	Phosphate (mg/l)	0.28 - 0.44	0.46 - 0.67	0.35 - 0.61	0.39 - 0.86	0.35 - 0.46	0.24 - 0.29
	Nitrate(mg/l)	0.37 - 0.51	0.36 - 0.67	0.27 - 0.43	0.34 - 0.45	0.21 - 0.44	0.20 - 0.33
	Nitrite (mg/l)	0.01 - 0.05	0.02 - 0.07	0.01 - 0.02	0.011 - 0.019	0.014 - 0.023	0.02 - 0.03
0	Chloride (mg/l)	35.6 - 56.0	34.8 - 54.17	43.3 - 76.9	45.9 - 57.55	41.75 - 67.5	60.25 - 68.75

Table-2**Seasonal variations in the physico-chemical factors of Sirpur Pond****Water- March 2009-February 2011**

S.N	Parameters	Summer'09 March, April, May and June	Rainy'09 July, Aug. and Sept. Oct.	Winter'09 -10 Nov. Dec. Jan. and Feb	Summer'10 Mar, April, May and June	Rainy'10 July, Aug. Sept. and Oct.	Winter'10- 11 Nov. Dec. Jan. and Feb.
1	Temp °C	25.0 - 32.0	23.5 - 25.8	15.6 - 22	25 - 31	21.9 - 25.8	17.8 - 24.6
2	pH	7.4 - 7.7	7.3 - 7.7	7.4 - 7.6	7.4 - 7.9	7.3 - 7.5	7.1 - 7.3
3	DO(mg/l)	6.2 - 7.1	6.6 - 7.5	7.6 - 8.5	6.8 - 7.5	7.0 - 7.2	6.2 - 6.9
4	Free CO2 (mg/l)	00 - 00	00 - 00	00 - 00	00 - 00	00 - 00	00 - 00
5	Dissolved Solid (mg/l)	100.5 - 121.0	106.0 - 121.5	123.0 - 139	108.5 - 125.0	107.2 - 116.2	108.2 - 120.0
6	BOD (mg/l)	2 - 2.2	1.7 - 2.1	1.8 - 2.0	0.95 - 2.2	0.82 - 1.25	0.4 - 0.5
7	Phosphate (mg/l)	0.36 - 0.67	0.48 - 0.55	0.36 - 0.57	0.24 - 0.92	0.33 - 0.49	0.18 - 0.22
8	Nitrate (mg/l)	0.34 - 0.53	0.40 - 0.62	0.33 - 0.41	0.36 - 0.62	0.39 - 0.66	0.28 - 0.34
9	Nitrite (mg/l)	0.01 - 0.05	0.015 - 0.035	0.02 - 0.06	0.011 - 0.016	0.015 - 0.017	0.021 - 0.026
10	Chloride(mg/l)	28.4 - 42.7	27.55 - 53.75	33.8 - 68.4	37.9 - 64.75	29.0 - 52.0	67.0 - 72.8

Table-3

**Comparison of variations in physico-chemical factors of Pipliyapala
and Sirpur Pond Water – March 2009-February 2011.**

Parameters	Summer'09-10 March, April, May and June PP	Rainy '09-10 July, Aug. Sept. and Oct. PP	Winter 09-11 Nov. Dec. Jan. and Feb PP	Summer'09-10 Mar, April , May June SP	Rainy'09-10 July ,Aug. Sept. and Oct. SP	Winter'09-11 Nov. Dec. Jan. and Feb SP
Temp. °C	24.35 -31.9	21.75-26.8	15.47-24.32	25 – 32.0	21.9 – 25.8	15.6 -24.6
pH	7.1-7.8	7.05 - 7.35	7.0-7.47	7.4- 7.9	7.3 - 7.6	7.1 - 7.6
Dissolved Oxygen(mg/l)	6.3-7.4	6.7 - 7.5	7.0 -7.82	6.2 - 7.5	6.6 - 7.5	6.2 – 8.5
Free CO ₂ (mg/l)	00.00	00.00	00.00	00.00	00.00	00.00
Dissolved Solid (mg/l)	92.8-116.0	106.0-123.6	97 -151.5	99.6-123.6	104.6-120.1	108.2-137.0
BOD (mg/l)	0.8- 2.0	0.8 - 2.07	0.50 -1.63	0.95-2.2	0.82-2.1	0.4-2.0
Phosphate (mg/l)	0.39 - 0.85	0.35 - 0.67	0.24 - 0.61	0.24-0.92	0.33-0.55	0.18-0.57
Nitrate(mg/l)	0.34 - - 0.51	0.21 - 0.67	0.20 - 0.43	0.36-0.53	0.39-0.66	0.28-0.4
Nitrite (mg/l)	0.01 - 0.05	0.01 - 0.03	0.01-0.03	0.011-0.05	0.015-0.035	0.02-0.24
Chloride (mg/l)	35.6 - 57.55	34.8 - 67.5	43.3 - 76.9	28.4-64.75	27.55-53.75	33.8-72.8

PP=Pipliyapala Pond

SP=Sirpur Pond

(B) Monthly collection of water samples for the isolation of Chytridiomycetous and Hyphomycetous aquatic fungi of Pipliyapala and Sirpur ponds were done as per Emerson (1954) and Johnson (1956), Sparrow (1957,60), Willoughby (1956,58), Ingold (1975b) and Subramanian(1971).

(C) A total twenty two fungal forms of class Chytridiomycetes and four of Oomycetes were recorded, viz. *Chytriomycetes appendiculatus*; *Chytriomycetes aureus*; *Chytriomycetes hyalinus*; *Chytriomycetes nodulatus*, *Chytriomycetes spinosus*; *Cladochytrium replicatum*; *Cladochytrium tenue*; *Karlingiomycetes granulatus*; *Nowakowskiella elegans*; *Nowakowskiella multispora*; *Polychytrium aggregatum*; *Rhizidium Sp.*; *Rhizophydium Sp.*; *Septochytrium marilandicum*; *Septochytrium Sp.*; *Allomyces anomalus*; *Allomyces arbuscula*; *Allomyces javanicus*; *Allomyces moniliformis* ; *Blastocladia globosa*, *Catenaria anguillulae*; *Gonapodya prolifera*; *Aphanomyces laevis*; *Achlya prolifera*; *Dictyuchus monosporus*; *Pythiopsis cymosa*.

In addition to above following aquatic hyphomycetes (Ingoldian fungi) viz. *Alatospora acuminata*; *Anguillospora longissima*; *Flagellospora curvula*; *Varicosporium elodeae*; *Speriopsis padatospora*; and *Variacosporium scoparium* were recorded from different aquatic substrates of Pipliyapala and Sirpur pond.

Thus in present study out of 32 species of fungi isolated, 22 species belong to Chytridiomycetes, 4 to Oomycetes and 6 to Hyphomycetes.

(D) Seasonal study from Pipliyapala Pond :

The study on relationship between seasonal occurrence of aquatic fungi and water quality of Pipliyapala Pond yielded the following results during **Summer** (March-09 to June-09 & March-10 to June-10)-

- *Chytriomycetes aureus*; *Cladochytrium replicatum*; *Polychytrium aggregatum*; *Allomyces javanicus*; *Blastocladia globosa*; *Pythiopsis cymosa* were not recorded.
- *Nowakowskiella elegans*; *Cladochytrium tenue*; *Nowakowskiella multispora*; *Rhizidium Sp.*; *Septochytrium marilandicum*; *Gonapodya prolifera* had low (0.1 to 3%) occurrence.
- *Chytriomycetes appendiculatus*; *Chytriomycetes hyalinus*; *Chytriomycetes nodulatus*; *Chytriomycetes spinosus*; *Karlingiomyces granulatus*; *Rhizophyidium Sp.*; *Septochytrium Sp.*; *Allomyces arbuscula*; *Aphanomyces laevis*; *Dictyuchus monosporus* had moderate occurrence (3.1 to 8%).
- While *Allomyces anomalus*; *Allomyces moniliformis*, *Catenaria anguillulae*; *Achlya prolifera* had high occurrence (8.1 to 14 %).

The summer season fungi from Pipliyapala Pond were influenced by variation of Temperature (24.35 -31.9⁰C), pH(7.1-7.8);Dissolved Oxygen (6.3-7.4 mg/l);Dissolved Solid (92.8-116.0 mg/l)); BOD (0.8- 2.0 mg/l);Phosphate (0.28 - 0.85 mg/l); Nitrate (0.34 - 0.51mg/l); Nitrite (0.01 - 0.05 mg/l),and Chloride (35.6 - 57.55 mg/l).

During **Rainy Season** (July-09 to October-09 & July-10 to October-10) almost all fungi were recorded.

- *Chytriomyces aureus*; *Chytriomyces hyalinus*; *Cladochytrium replicatum*; *Cladochytrium tenue*; *Karlingiomyces granulatus*; *Nowakowskiella elegans*; *Nowakowskiella multispora*; *Polychytrium aggregatum*; *Rhizidium Sp.*; *Rhizophydium Sp.*; *Septochytrium marilandicum* ;*Septochytrium Sp.*; *Dictyuchus monosporus*; *Catenaria anguillulae*; *Pythiopsis cymosa* were of low Occurrence (0. 1 to 3%)
- *Chytriomyces appendiculatus*; *Chytriomyces nodulatus*, *Chytriomyces spinosus*; *Allomyces anomalus*; *Allomyces arbuscula*; *Allomyces javanicus*; *Allomyces moniliformis* *Catenaria anguillulae*; *Gonapodya prolifera*; *Aphanomyces laevis*; and *Achlya prolifera*; were of moderate Occurrence (3.1 to 8%).
- No fungi were recorded in high (8.1 to 14 %) occurrence group.

The rainy season fungi from Pipliyapala Pond were influenced by variation of Temperature (21.75-26.8°C); pH (7.05 - 7.35); Dissolved Oxygen(6.7 - 7.5 mg/l); Dissolved Solid (106.0-123.6 mg/l); BOD (0.8 - 2.07 mg/l); Phosphate (0.35 - 0.67 mg/l); Nitrate(0.21 - 0.67 mg/l); Nitrite (0.01 - 0.03 mg/l); and Chloride (34.8 - 67.5 mg/l).

During **winter** (Nov-09 to Feb.-10 and Nov-10 to Feb.-11) almost all the fungi were recorded.

- The low occurrence (0. 1 to 3%) fungi were *Karlingiomyces granulatus*; *Nowakowskiella elegans*; *Nowakowskiella*

multispora; *Allomyces anomalus*; *Allomyces arbuscula*;
Allomyces javanicus; *Allomyces moniliformis*; *Catenaria*
anguillulae; *Achlya prolifera*; *Dictyuchus monosporus*;
Alatospora acuminata; *Anguillospora longissima*; *Flagellospora*
curvula; *Varicosporium elodeae*; *Speriopsis padatospora*;
Variacosporium scoparium;

- Moderate Occurrence (3.1 to 8%) fungi were *Chytriomycetes appendiculatus*; *Chytriomycetes aureus* ; *Chytriomycetes hyalinus*; *Chytriomycetes nodulatus*, *Chytriomycetes spinosus*; *Cladochytrium replicatum*; *Cladochytrium tenue*; *Polychytrium aggregatum*; *Rhizidium Sp.*; *Rhizophyidium Sp.*; *Septochytrium marilandicum*; *Septochytrium Sp.*; *Blastocladia globosa*; *Gonapodya prolifera*; *Aphanomyces laevis*; *Pythiopsis cymosa*.
- Whereas, no fungi recorded in high occurrence (8.1 to 14 %) group.

The winter season fungi from Pipliyapala Pond were influenced by variation of Temperature (15.47-24.32 °C); pH (7.0-7.47); Dissolved Oxygen(7.0 -7.82 mg/l); Dissolved Solid (97 -151.5 mg/l); BOD (0.50 -1.63 mg/l); Phosphate (0.24 - 0.61 mg/l); Nitrate(0.20 - 0.43 mg/l); Nitrite (0.01-0.03 mg/l); Chloride (43.3 - 76.9 mg/l).

(E) Seasonal study from Sirpur Pond :

The study on relationship between seasonal occurrence of aquatic fungi and water quality of Sirpur pond yielded the following results during **summer** (March-09 to June-09 & March-10 to June-10)-

- *Cladochytrium tenue*; *Nowakowskiella elegans*; *Blastocladia globosa*; *Gonapodya prolifera*; were not recorded.
- The low occurrence (0.1 to 3%) fungi were *Chytrium aureus*; *Cladochytrium replicatum*; *Nowakowskiella multispora*; *Polychytrium aggregatum*; *Rhizophyidium Sp.*; *Septochytrium Sp.*; *Allomyces arbuscula*; *Allomyces javanicus*; *Dictyuchus monosporus*; *Pythiopsis cymosa*.
- Moderate Occurrence (3.1-8%) fungi were *Chytrium appendiculatus*; *Chytrium hyalinus*; *Chytrium nodulatus*, *Chytrium spinosus*; *Karlingiomyces granulatus* *Rhizidium Sp.*; *Septochytrium marilandicum*; *Achlya prolifera*;
- High Occurrence (8.1 to 14 %) fungi were *Allomyces anomalus*; *Allomyces moniliformis*; *Catenaria anguillulae*; *Aphanomyces laevis*;

The summer season fungi from Sirpur Pond were influenced by variation of Temperature (25 – 32⁰ C); pH(7.4- 7.9); Dissolved oxygen(6.2 - 7.5 mg/l); Dissolved Solid (99.6-123.6 mg/l); BOD (0.95-2.2 mg/l); Phosphate (0.24-0.92 mg/l); Nitrate(0.36-0.53 mg/l); Nitrite (0.011-0.05 mg/l) and Chloride (28.4-64.75 mg/l).

During **rainy season** (July-09 to October-09 & July-10 to October-10) almost all the fungi recorded .

- The low occurrence (0.1 to 3%) fungi were *Chytrium nodulatus*, *Cladochytrium replicatum*; *Cladochytrium tenue*; *Karlingiomyces granulatus*; *Nowakowskiella elegans*; *Polychytrium aggregatum*; *Rhizidium Sp.*; *Rhizophyidium Sp.*;

Septochytrium marilandicum; *Septochytrium Sp.*; *Aphanomyces laevis*; *Pythiopsis cymosa*.

- Moderate Occurrence (3.1-8%) fungi were *Chytriomycetes aureus*; *Chytriomycetes hyalinus*; *Chytriomycetes spinosus*, *Nowakowskiella multispora* ; *Allomyces anomalus*; *Allomyces javanicus*; *Allomyces moniliformis* ; *Blastocladia globosa*; *Catenaria anguillulae*; *Gonapodya prolifera*; *Achlya prolifera*; *Dictyuchus monosporus*.
- High occurrence (8.1 to 14 %) fungi were *Chytriomycetes appendiculatus* and *Allomyces arbuscula*;

The rainy season fungi from Sirpur Pond were influenced by variation of Temperature (21.9 – 25.8⁰ C); pH (7.3 - 7.6); Dissolved Oxygen (6.6 - 7.5 mg/l); Dissolved Solid (104.6-120.1 mg/l); BOD (0.82-2.1 mg/l); Phosphate (0.33-0.55 mg/l); Nitrate(0.39-0.66 mg/l); Nitrite (0.015-0.035 mg/l) and Chloride (27.55-53.75 mg/l).

During **Winter** (Nov-09 to Feb.-10 and Nov-10 to Feb.-11) 32 forms of fungi were recorded.

- The low occurrence (0.01 to 3%) fungi were *Karlingiomyces granulatus*; *Nowakowskiella elegans*; *Nowakowskiella multispora*; *Allomyces anomalus*; *Allomyces arbuscula*; *Allomyces javanicus*; *Allomyces moniliformis*; *Catenaria anguillulae*; *Aphanomyces laevis*; *Achlya prolifera*; *Dictyuchus monosporus*; *Pythiopsis cymosa* ; *Anguillospora longissima*; *Flagellospora curvula*; *Speriopsis padatospora*. *Variacoparium scoparium*;

- Moderate occurrence (3.01-8%) fungi were *Chytriomyces appendiculatus*; *Chytriomyces aureus*; *Chytriomyces hyalinus*; *Chytriomyces nodulatus*, *Chytriomyces spinosus*; *Cladochytrium replicatum*; *Cladochytrium tenue*; *Polychytrium aggregatum*; *Rhizidium Sp.*; *Rhizophydium Sp.*; *Septochytrium marilandicum*; *Septochytrium Sp.*; *Blastocladia globosa*; *Gonapodya prolifera*; *Alatospora acuminata*; *Varicosporium elodeae*.
- No fungi recorded in range of (8.01 to 14 %) high occurrence group.

The winter season fungi from Sirpur Pond were influenced by variation of Temperature (15.6 -24.6 ° C); pH (7.1 - 7.6); Dissolved Oxygen(6.2 – 8.5 mg/l); Dissolved Solid (108.2-137.0 mg/l); BOD (0.4-2.0 mg/l); Phosphate (0.18-0.57 mg/l); Nitrate(0.28-0.4 mg/l); Nitrite (0.02-0.06 mg/l) and Chloride (33.8-72.8 mg/l).

On the basis of observations made during the study of Pipliyapala and Sirpur Pond water for the seasonal occurrence of aquatic fungi, it was observed that no single factor is responsible for growth and occurrence of aquatic fungi but it is the cumulative effect of various factors which control their growth and occurrence. Still it seems that low to moderate temperature of winter favors their growth as maximum 32 fungal forms were found in winter followed by rainy and summer season in both water bodies.

The water bodies of Pipliyapala and Sirpur ponds are used by local people for drinking, bathing fisheries culture and for other purposes. The water from these two water bodies has been used for drinking ever since these bodies have come to an existence. Even today the water is used for drinking. Thus it appears that the presence of these fungal forms is not adversely affecting the health of the people.