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A REVIEW ARTICLE ON DIVERSITY OF ZOOSPORIC FUNGI (MYCODIVERSITY)

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ABSTRACT

Mycology, the versatile branch of biology deals with the study of fungi, consists of several distinct galaxies. Enormous work is done in these galaxies. But aquatic Mycology which deals with the study of aquatic fungi is a virgin branch of biology. Maximum research work has been done on taxonomy of terrestrial fungi rather than aquatic fungi. Study of fresh water fungi started in Europe with the discovery of *Saprolegnia* by Nees (1823). The bulk of the true fungi occurring in fresh water belong to the Phycomycetes although there are a few aquatic Ascomycetes and Fungi Imperfecti (Sparrow 1968).

KEYWORDS: Diversity, Fungi, Aquatic, Fresh water.

INTRODUCTION

Aquatic fungi are those fungi which require aquatic environment to complete some phases of their life cycle. But it is difficult to give a précis and universal definition of aquatic fungi because they show a great diversity. A number of true aquatic fungi are also found in terrestrial habitat where they are ecologically adapted. Abiotic component of aquatic ecosystem are analysed by physico-chemical analysis of water body. These abiotic factors i.e. physico-chemical factors also control diversity of fungi in aquatic environment. Unpolluted water bodies show great diversity of fungi. Fungi are important component of food chain and can colonize almost all the non-living organic matter. Though they are chiefly decomposers and play an important role in dissipation of energy and release of nutrients. They live as saprophytes and convert complex organic material to simple compound by producing extra-cellular enzymes. But some species are pathogenic, which live as parasite and cause harm and

severe diseases in humans, fishes and other biotic components by secreting mycotoxins. These are toxic fungal metabolites.

LITERATURE REVIEW

The science of mycology had its beginning in the eighteenth century. By now, fungi have become the concern of the taxonomists, morphologists, ecologists. Fungi have been very important to human beings from the time immemorial. Study of fresh water fungi started in Europe with the discovery of *Saprolegnia* by Nees (1823). Thaxter (1895-96) worked on peculiar aquatic fungi. In the last decades of 19th century fungi in fresh water habitat were described (de Wildmen, 1893, 1894, 1895; Maurizio, 1899) there are enough reports from various parts of world regarding the occurrence and types of various water moulds. (Butler, 1912; Knief, 1929; Cotner, 1930; Emerson, 1941; Turian, 1961-62; Hill, 1969; Youtt, 1973). Paterson (1910) gave the first definite biological systematic account of Danish fresh water Phycomycetes. The account given by Minden (1915) about lower primary aquatic group of Phycomycetes in "Kryptogamen flora der Mark Brandenburg" is considered as the first significant published research work in the field of aquatic mycology. Later Coker (1923), Coker and Matthews (1937) and Seymour (1970), had given valuable systematic account of Saprolegniales, Blastocladiales and Monoblepharidales. Couch (1924) observed the spore formation and discharge in *Leptolegnia*, *Achlya and Aphanomyces* and (1939 a) studied techniques for collection, isolation and culture of Chytrids.

Sparrow (1927, 1930, 1979). Sparrow *et. al.*, (1965), Sparrow and Morison (1961), Sparrow and Dogma (1973), Wolf and Wolf (1941), published a list of water moulds of Cypress Swamp in California. Sparrow (1960) has provided an invaluable aid to the study of aquatic fungi by writing a book, "Aquatic Phycomycetes". Nagai (1931); Crooks (1937); Indoh (1937) and Kono (1968) studied the aquatic Phycomycetes of Australia, Japan and China. Forbes (1935 a, b) observed some British water moulds in Manchester district. Karling (1928, 1931) has done considerable work on Chytrids. He gave a taxonomic account of many fungi belonging to Chytridiales, Blastocladiales and Monoblepharidales in his book entitled, "*Chytridiomycetarum Iconographia*" (1977). There is also Karling's monograph on "The Plasmodiophorales" (1942b).Canter (1971), Canter and Willoughby (1964), Canter and Lund (1969) have concentrated their association with the fresh water algae. Extensive monographic studies on genus *Achyla*, *Aphanomyces* and *Saprolegnia* have made by Johnson (1956), Scott (1961) and Seymour (1970). Fott (1951) reported new Chytrid parasitic on algae. Emerson

(1938, 1939) observed the life cycle of *Allomyces* and Blastocladiales, Emerson (1950), worked on aquatic Phycomycetes. Shanor (1940) studied in the genus *Olpidiopsis* and its host range of certain species. The contribution made by Shanor (1942,), Benek (1948a, b), Beneke and Schmitt (1961), Beneke and Rogers (1970), Barr (1968, 1969) Booth (1971a, b, c), Miller (1961), Miller and Bosiljkan (1969), Johns (1959), Willoughby (1959) and Townley (1961a, b), Jeffrey and Willoughby (1964), Dick (1960a, b, c, 1997a), Unestam and Gleason (1968), and others in the field of taxonomy, physiology and morphology of aquatic Phycomycetes are of much importance. Middleton (1943) observed the taxonomy host range and geographical distribution of the genus *Pythium* in Argentina. Hanson (1944) reported new Chytrid parasitizing *Volvox*. Hunycutt (1948, 1952) studied the keratinophilic Phycomycetes. Johnson (1949, 1977a, b,) and Johnson and Howard (1968, 1972), Johnson *et. al.*, (1973), Johnson and Miller (1974). Johnson *et. al.*, (1975) and Seymour and Johnson (1973a), Hughes (1962) have studied the taxonomy of various groups of aquatic Phycomycetes from Iceland and United states. Kobayashi and Ookubo (1952, 1953a, b) studied on the aquatic fungi of the Ozegahara Moor. Wiffen (1945), Cantino (1950), Cantino and Hornstein (1956), Cantino and Turian (1959), Goldstein (1960a, b) and Murray and Lovett (1966) have reviewed the various nutritional studies of Phycomycetes in the laboratory. Paterson (1956, 1967) studied Phycomycetes flora of the Donglas lake region II and Benthic and Planktonic Phycomycetes from Northern Michigan. Sparrow and Koch (1959); Suzuki (1960a, b, 1962) studied the distribution and ecology of aquatic Phycomycetes in some inorganic acidotrophic lakes of Japan. Roberts (1963) studied the distribution of Saprolegniales during 1956-57. Scott (1964) studied the fungi associated with fish diseases. Alabi (1971a, b), studied seasonal periodicity and factors affecting seasonal occurrence of Saprolegniaceae at Ibden Nigeria. Rooney and Mc Knight (1972) studied the aquatic Phycomycetes of Lily Lake. Knox and Paterson (1973) studied the occurrence and distribution of some aquatic Phycomycetes on Ross Island and the dry valleys of Victoria Land Antarctica. Padgett (1976, 1978), Pedgett and Seymour (1974) studied the Phycomycetes of Australia. Cooke (1954a, b), Cooke and Matsura (1963a), Cooke and Bartsch (1959, 1960); Willoughby and Collins (1966) and others have given considerable information on the occurrence of fungi inducing zoosporic Phycomycetes and fungi imperfecti in streams, river etc with effluent. Rattan *et. al.*, (1980) carried out ecological studies of Saprolegniaceae in Shatt-al-Arab River in Iraq. Okane (1978) studied the seasonal variations of aquatic Phycomycetes in the Yokata river system. He in (1981) studied the distribution of aquatic Phycomycetes and amount of their zoospores in two strong acid rivers The Tamagava and The Takanatugava. Chamier *et. al.*, (1984) studied on the

spatial distribution of fungi on decomposing older leaves in the fresh water stream. Zeiglar, (1958) have extensively studied morphology, taxonomy and physiology of aquatic fungi of USA, Cuba, Seychelles island and Hispaniola. Dick and Newby (1961); Cantrell and Dowler (1971); Liu Chin Hui and Paul Voltz (1976); Klinch and Tiffney (1985) worked on members on Oomycetes. Batko *et. al.,* (1975) studied the mineralization of organic matter in aquatic systems. El-Nagdy (1985) has worked on aquatic fungi recovered from the various water habitats in Upper Egypt. Hawksworth (1991) estimated fungal diversity to be 1.5 million species that prompted much discussion as to the numbers of fungi that may be present on earth. Published estimates of the extent of fugal diversity range from 0.5 to 9.9 million species (Hawksworth, 2001). Gessner *et. al.,* (1997) studied the fungal biomass, production and sporulation associated with particulate organic matter in streams. Kiziewicz (2004) studied aquatic fungi growing on Seeds of Plants in various types of water bodies of Podlasie province. Kiziewicz & Alicja (2004) investigated on aquatic fungi and fungus-like organisms isolated from surface waters situated near Białystok in Podlasie Province of Poland using the insect *Notonecta glauca* as bait. Shearer *et. al.,* (2006) worked on fungal biodiversity in freshwater, brackish and marine habitats. Wurzbacher *et. al.,* (2010) studied on fungi in lake ecosystems. Krauss *et. al.,* (2011) has seen the ecology, physiology and biochemical potential of fresh water fungi. Czeczuga *et. al.,* (2015) had studied Ecological diversity and economical importance of species from *Aphanomyces* genus of north-eastern Poland**.** Tisthammer *et. al.,* (2015) studied on Global biogeography of marine fungi is shaped by the environment and analyzed marine fungal community structure at a global scale using the International Census of Marine Microbes dataset.

WORK DONE IN INDIA

Inspite of great importance attached with the researches on the microbiology of water in India. There is general opinion that significant attention and time has not been paid to the distribution, occurrence and potential importance to fungi in aquatic environment. It was E.J. Butler (1907) who has given the account of genus *Pythium* and *Chytrids* for the first time and in (1911) he worked on Allomyces. After that various forms have been reported by various workers from the country (Butler and Bisby, 1931; Chaudhary, 1931; Chaudhary and Kocher, 1935; Mitra, 1935; Chaudhary and Lotus, 1936; Mundkar, 1938; Chaudhary and Banerjee, 1942; Hamid, 1942; Mundkar and Ahmad, 1946; Chaudhary *et. al*., 1947). Chaudhary (1942) added new genus *Hamidia* to the Saprolegniaceae. Saksena and Bhargaya (1944) described *Isoachyla anispora* as a new variety. Balakrishnan (1948a) isolated *Pythium periplocum* var.

coimbatorensis. Lacy (1949) from Patna discovered *Aphanomyces apophysii sp*. and made several new records for India. Talukdar and Baruch (1952) studied for the first time the occurrence and distribution of aquatic fungi at Guwahati. Bhattacharya and Baruch (1953) reported *Saprolegnia ferax* from Gauhati. Das-Gupta and John (1953) have reported six species of aquatic fungi from Lucknow belonging to Blastocladiales, Monoblepharidales and Lagenidiales. John Rachel (1955) studied the occurrence of two species of *Ancylistes* in *Closterium*. Dayal (1958) had reported seven species of aquatic fungi belonging to Saprolegniaceae from Allahabad. Lacy (1955) made several new records for India. Adyantheya and Subramanian (1955) and Rajgopalan and Ramakrishnan (1967-68) worked on Pythiaceous fungi of Madras, South India. Karling (1963, 1964a, b, c, d) made extensive survey of various water bodies situated in Kerala, West Bengal, Punjab and Rajasthan. He described altogether seventy one species of aquatic Phycomycetes belonging to different orders. Most of his identified species belonged to Chytridiales and Hypochytriales (Anisochytridiales). John (1959) reported *Catenaria sphaerocarpa* on *Spirogyra* sp. for the first time in India. In the field of taxonomy Shrivastava and Bhargava (1963), Bhargava and singh (1965), Dayal and Tandon (1962), Dayal and Thakurji, (1965, 1966, 1968), Thakurji and Dayal (1971), Thakurji (1967, 1970a, b), Singh and Pavgi (1971), Kiran and Diyal (1978, 1980, 1982, 1983, 1992), Sarkar and Dayal (1983), Mishra and Gupta (1983), Mishra (1984), Mishra and Dwivedi (1986, 1987) described several new records from India. Bhargava and Shrivastava (1966), described *Isoachyla luxurians.* Shrivastava, (1975, 1979) described *Catenaria indica* and *Aphanomyces pisci*. Rai and Mishra (1976, 1978) reported *Achyla hypogyna* for the first time from India and added a new species of the genus *Dictyuchus* to the mycoflora i.e. *D. lucknowensis* sp. nov. Mishra (1982a) added *Brevilegnia bispora* and *Dictyuchus pseudodictyon* to the list of Indian aquatic fungi. Chaturvedi and Dayal (1988) studied influence of fungi on palatability of leaves. Patil and Kapadnis (1977), reported *Catenochytrium carolinianum* and *Sommerstorffia spinosa* from Maharashtra. Vaidya (1988) for the first time recorded two genera of Chytrids from India viz., *Polyphagus parasiticus* and *Hypochytrium infestans*. Khare (1992) had done Taxo-ecological studies on water moluds. Ghosh and Bhatt (2000) studied keratinophilic fungi from Chilka Lake side soil. Manoharachary carried out extensive researches on several aspects of aquatic and soil fungi. He and his co-workers made significant contribution on taxonomy and ecology of zoosporic fungi, Manoharachary and Rama Rao (1978) studied the effect of various physico-chemical characters of water on the growth and distribution of aquatic fungi of Hyderabad. Khulbe and Bhargava (1979), studied parasitic watermoulds of Kumaun Himalayas. In India very little

work has been done on the aquatic fungi of the rivers, Iyenger *et. al.*,(1955), isolated *Sapromyces indicus* sp. nov. from dead leaves in water streams at Kambak Kam Hills. Khulbe carried out extensive researches on several aspects of aquatic fungi (Khulbe 1980a, b, c, 2001). Chidambaram (1942) initiated studies of fungi associated with fish diseases. He observed red patches on the body of *Osphronemus gouramy* due to *Saprolegnia* species. Later Gopalakrishnan (1964) observed fish mycoses caused by *Saprolegnia parasitica* in inland waters. The above work has been followed by Gopalakrishanan and Jhingran (1972); Srivastava and Srivastava (1976a, b,); Khulbe and Sati (1979, 1983); Srivastava and Mekrani (1980); Prabhuji and Srivastava (1981); Sati and Khulbe (1981a, b); Mitra and Patra (1993); Khulbe *et. at*., (1995). Chowdhary and Agrawal (1980a, b,) studied the taxonomy and seasonal variation of aquatic fungi from Delhi and distribution of some aquatic fungi in India. Chowdhary (1985) isolated 34 different species of aquatic fungi from Delhi. Das-Gupta and John (1988) worked on genus Blastocladia. Sree K. Nair (2001) studied on diversity, ecology and biology of aquatic fungi of some fresh water streams of western Ghat forests in Goa state. Manoharachary *et. al*., (2005) had studied Fungal biodiversity: Distribution, conservation and prospecting of fungi from India. Fungi around some aquatic bodies in Andhra Pradesh, India written by Rao *et. al*., (2004). Kshirsagar and Gunale (2013) worked on diversity of Aquatic fungi from Mula River at Pune City. Gawai (2015) has studied the diversity of zoosporic fungi from Godavari river of Nanded. Maini and Shukla (2015) worked on Freshwater Fungal Richness, their Assessment and impact on Human Welfare. Biswal and Agrawal (2016) investigated bioaccumulation of toxic metals through aquatic fungi. Saksena and Rajgopalan (1958) were the pioneers in the field of aquatic Mycology. Chaudhary (1976); Hasija and Batra, (1978); Dubey, (1980); Hasija and Khan, (1982a, b), in the field of taxonomy have made their contribution. Mishra (1982) studied the occurrence, distribution and seasonality of aquatic fungi as affected by chemical factors in six alkaline ponds of India. Singh, (1987) Studied the Mycoflora of Effluent of Gelatine Factory at Jabalpur. Indra, *et. al*., (1988) studied Some fungi from the Suptal lake at Jabulpur. Shukla and Tiwari (1988) studied the aquatic fungi in role of leaf litter decomposition in lotic and lentic environment at Jabalpur. Agrawal *et. al*., (1989) had studied on aquatic fungi from Jabalpur. Mishra *et. al*., (1990) studied on aquatic fungi from Ganga Sagar Lake at Jabalpur. Saksena, (1990) have done considerable work on aquatic fungi. At Hoshangabad Chauhan and Pathak (1991) have studied aquatic fungi of river Narmada. Singh, and Pathak (2002) had Studied on fungal flora of the River Narmada at Hoshangabad M.P. India. Banerjee (2007). Studied on biodiversity conservation in Madhya Pradesh policies and strategies. Awasthi *et. al.*, (2011) studied on

the Diversity of fungi in effluents of sugar industries of Madhya Pradesh and studied a total number of 15 species belonging to 9 genera of fungi capable to degrade the organic matter which is present in effluent. Dubey (1982) carried out the ecological study of aquatic fungi in upper and lower lakes of Bhopal they found 35 species of aquatic fungi. Chauhan (1990) worked on ecological study of aquatic fungi of the river Narmada at Hoshangabad, they found 30 genera and 50 species. In which 17 species belongs to Mastigomycotina, 1 to Zygomycotins, 2 to Ascomycotina, 33 to Deuteromycotina. Qureshi and Prasad, (1992); Chauhan and Qureshi, (1994); Qureshi *et. al.*, (1995); Chauhan (1997) studied fungi associated with fish diseases. Panday and Singh (2006) firstly reported *Allomyces* from upper Lake of Bhopal. Singh, (2008) studied the biodiversity of aquatic fungi at species level of Lower Lake of Bhopal.

CONCLUSION

Overall it seems that fungi are most significant and essential components of aquatic ecosystem. They also exhibit great degree of biodiversity with respect to aquatic environment. Present estimations suggest that global fungal diversity greatly exceeds that of any other group of microbes. But assessment of aquatic fungal biodiversity is still not complete. In this paper maximum work related to zoosporic fungi has been covered so that it will be helpful for the students and researchers working on these types of fungi.

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