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Fungal Diversity of Kshipra River with Relation to Human Health

Abstract

The study of aquatic microbes has been an area of great interest for researchers across the world as aquatic ecosystem serves as ideal home for increased biological activity of diversified microbes. Fungi is one such important group of aquatic microbes whose diversity and distribution in aquatic ecosystem has not attained the degree of prominence. The current study is an attempt to study fungal composition. Diversity, distribution and periodicity for a period of one year. On the basis of anthropogenic activities five sampling sites were selected on banks of river Kshipra from where samples were collected on monthly basis and were subjected to laboratory analysis. Isolation of Fungi was done culturing on Potato Dextrose Agar (PDA) and identification was done by slide preparation and use of standard keys. Total 45 species belonging to seven divisions and eleven families have been recorded during the study period. Among recorded fungal diversity 2 species belong to Dothideomycetes, 7 to Eurotinomyecetes, 6 to Sordariomyecetes, 2 to Basidomycetes, 4 to Uredenomycetes, 5 to Chytridiomycetes, 4 to Hyphomycetes, 2 to Maxomycetes, 5 to Oomycetes, 5 to Mucormycotina and 3 to Trichomycetes. The fungal diversity ranged between 7-45 species where minimum is reported from Kshipra Village in the month of August and maximum fungal diversity has been recorded from Mangalnath study site in the month of May, June and July respectively. A close relation of Fungal diversity with physicochemical parameters has been observed. Cases of water born diseases caused by intake of river water, arising due to pathogenic Fungi have been reported during the present investigation

Keywords: Aquatic Fungi, Physico-Chemical Characters, Water Born Diseases, Kshipra River, Wate Pollution.

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Introduction

Fungi are ubiquitous, achlorophyllous and heterothallic organisms directly influenced by environmental factors. They are cosmopolitan in occurrence and are found in rivers, occurs commonly on decomposing organic matter. Aquatic fungi contribute significantly in aquatic ecosystem as decomposers of animals and plant remains (Sparrow 1968). Freshwater fungi are a diverse and heterogeneous group comprising of many species from different orders. Wurzbacher *et al.,*(2010) has documented that aquatic fungi are common in various aquatic habitats and they play an important role in nutrient and carbon cycling, decomposition, interaction with other organisms thereby influencing food web dynamics.

Water systems are known to be contaminated by both terrestrial and zoosporic fungi, and some terrestrial fungal species are translocated from the soil into water and end up growing in the water just like other aquatic fungal species (Nasser 2005). The movement of some terrestrial fungi into fresh water systems is through animals, plants and soil (Abdel 1990). The other dominant genus is Allomyces, while the abundant species of zoosporic fungi in surface waters such as dams, ponds, rivers are Ditcyuchus and sterile (Khallil 1992).

Aquatic fungi are also considered as a potential indicator of water pollution. These are also associated with utilization, decomposition and degradation of animal and plant remains. The chronically polluted water contains higher number of different filamentous and aquatic (Zoosporic) group of fungi. Amongst filamentous fungi causes many problems to health and leads to severe diseases to human population living along the catchment area of the river and the cities. The diseases due to filamentous fungi can cause of invasive Aspergillosis

(IA), pneumonia and pericardial tamponade, tinea capitis, oculomycosis, abdominal zygomycosis, mycotic keratitis, pericarditis in a patient with acute leukemia, Subcutaneous hyalohyphomycosis, liver necrosis, nephritis and irritation of the gastrointestinal mucosa, nasal mucous membrane ulcers, dermatitis and cancer and induces allergic reactions. Fungi may also cause conjunctivitis, eosinophilic, pneumonitis and a potential human carcinogen resulting into lungs and nasopharyngeal cancers.In addition, fungi growing in water sources are involved in modifying taste and odor of water (Tanver *et al.,* 2001). The present study aims at studying the diversity of Fungi in Kshipra river, analyses its relation with different physicochemical characteristics of river water and correlates the occurrences of fungi with different water born diseases.

Review of Literature

Different workers from India and across the globe have worked on the occurrence, distribution and association of fungi in fresh water. Dayal and Tandon (1962) observed that growth of aquatic fungi reduces with low temperature and organic load. Sparrow (1968) stated about the significance of fungi in aquatic ecosystem. Similarly, Barauh and Bora (1970) and Vishwe and Umalkar (1979) recorded the dominance of fungal species viz. *Cladosporium sps., Mucor sps., Fusarium sps., Tricoderma sps.* from polluted water. Patil (1983) studied occurrence of *Aspergillus* from organic debris. Evans and Reader (2001) and Martinez and Gutierrez (2001) isolated different fungal species form water hyacinth, Wurzbacher *et al.,*(2010) has documented the role of fungi in carbon cycling and decomposition. A number of researchers have recorded higher count of fungi in summer season from different water bodies and reported positive correlation of temperature, pH, BOD and COD with fungal diversity (Bock 1956, Tabak and Cooke 1968, Khulbe and Durgapal 1992, Kuratkowska 2004, Kiziwez and Nalepa 2008, Sakarni *et al.,*2011, Shankar Rao 2013 and Mugilan 2014). Kshirsagar (2013) and Smiley (2014) pointed out that are some fungi species as potential indicators of aquatic pollution. Divya and Chouhan (2014) isolated different fungal species from Irrity river and Pardeshi and Vaidya (2015) isolated some fungal species from Waldhuni river.

Materials and Methods

Study Area

River Kshipra originates from a hill of Vindhya range, one mile south of Kshipra river lying 12 km south-east of Indore city. In the present study Five sites according to environmental condition and high anthropogenic activities on the banks of Kshipra river viz. *Kshipra Village*, Triveni, Ramghat Mangalnath and Mahidpur were selected.

Water Sampling

The present study was carried out from November 2015 to October 2016 where the study of physicochemical parameters and fungal diversity in the river was made on monthly basis at all selected sites. The sampling was done between 6-12 am throughout the study period and samples have been investigated for monthly basis.

Analysis of Physico-chemical Parameters

Samples were collected in 2 liter sterile bottle for analysis of physicochemical parameters, while fungal samples were collected aseptically using sterile bottles and were kept in ice box. Sampling and analysis of various physicochemical parameters was done by using techniques of APHA (2005) and WQI was calculated as per Brown *et al.,* (1972).

Isolation and Identification of Fungi and Data on Water Born Diseases

Fungi was isolated by culturing on Potato dextrose agar and identification was done by slide preparation and by using standard keys (Arx 1981, Vernate and Hunter 1986). Data on water born diseases was obtained by survey from major hospitals of Ujjain and Dewas city by RTI from office of the city Chief Medical Officer (CMO) of Ujjain and Dewas district. A structural interview involving about 500 households randomly selected from all the four quarters in the city of Ujjain and Dewas. Respondents were required to furnish information on their sources of water for domestic use and the occurrence of water born diseases in their respective families.

Resultsa and Discussion

Distribution of Various Fungal Groups at Different Sites of Kshipra River

The qualitative studies on fungi from all the five sites showed a record of 45 species belonging to seven divisions and eleven families during the study period. Among recorded fungal diversity 2 species belong to Dothideomycetes, 7 to Eurotinomyecetes, 6 to Sordariomyecetes, 2 to Basidomycetes, 4 to Uredenomycetes, 5 to Chytridiomycetes, 4 to Hyphomycetes, 2 to Maxomycetes, 5 to Oomycetes, 5 to Mucormycotina and 3 to Trichomycetes. The fungal diversity ranged between 7-23 species at Kshipra Village, 11-42 species at Triveni, 11-39 species at Ramghat, 12-44 species at Mangalnath and 9-26 species at Mahidpur. Minimum fungal diversity is reported from Kshipra Village in the month of August and maximum fungal diversity have been recorded from Mangalnath study site in the month of May, June and July respectively (Table-1).

Ascomycota is represented by 3 families viz. Dothideomyecetes, Eurotiomycetes and Sordariomyecetes. Dothideomycetes family is represented by 2 species and is found to be absent at Kshipra Village and Mahidpur study sites throughout the year. Among Dotheomytecetes *Alternaria* species was dominant. Eurotiomycetes is recorded throughout the year from all five study sites and is observed to be the most dominant family of fungi contributed by 25.39% where most dominant species of the family is Aspergillus niger wheras, among Sordariomyecetes Fusarium oxysporum is the most dominant species.

Division Basidomycota is represented by two families Basidomycetes and Uredenomycetes. Limnoperdon incarnatum is the most dominant species among family Basidomycetes and Rhodotorula mucliaginosa is the most dominant species of Uredenomycetes.

Division Chytridiomycota is represented by single family Chytridiomycetes where the most dominant species is *Batrachochytrium dendrobatidis*. The division Deuteromycota is represented by one family Hypomycetes where dominant species is *Anguillospora filiformis*. The division Myxomycota is represented by single family Maxomycetes where the most dominant species is *Arcyria denudate*. The division is represented by single family Oomycetes where the most dominant species is *Aphanomyces euteiches*. Division Zygomycota is represented by two families Mucormycotina and Trichomyceytes. Mucormycotina is represented by 5 species out of which the most dominant is *Mucor amphibiorum* where as *Smittium hecatie* was the dominant species among Trichomyceytes.

Effect of Climatic Variations on Fungal Distribution

In the present study, total 45 fungal species have been reported, where minimum diversity is reported at Kshipra Village in August and maximum diversity is reported at Mangalnath in June. The fungal diversity ranges between 7-23 species at Kshipra Village, 11-42 at Triveni, 11-39 at Ramghat, 12-44 at Mangalnath and 9-26 at Mahidpur (Fig.1). Lower temperature, low organic load and unfavorable conditions for the growth of most aquatic fungi (Dayal and Tandon, 1962) form an important reason for lower fungal diversity during monsoon whereas, due to floods, water input, agricultural run-off and unsettled ecosystem. However, fungal diversity shows increasing trends from February to June where maximum diversity is exhibited during summer season which may be due to high temperature, high organic load which favors the growth of fungal population. Similar findings were reported by Bock (1956), Dar (2013), Khulbe and Durgapal (1992).

Presence of Various Pollution Indicating Fungal Species in Kshipra River

In the present study the dominant and frequently observed species include Alternaria species Aspergillus niger, Fusarium oxysporum, Limnoperdon incarnatum, Rhodotorula mucliaginosa, Batrachochytrium dendrobatidis, Anguillospora filiformis, Arcyria denudate, Aphanomyces euteiches, Mucor amphibiorum where as Smittium hecatie and Penicillium species were recorded to be dominant among different recorded fungi. Presence of Aspergillus, Penicillium, Fusarium, Tricoderma species indicate water in polluted status. These species were present at Ramghat, Triveni and Mangalnath site throughout the year which indicates organic pollution at these sites. Barauh and Bora (1970) and Vishwe and Umalkar (1979) have recorded dominance of Cladosporium, Mucor, Fusarium and Aspergillus from polluted water. Loudon (1972) has stressed upon the importance of fungi as indicators of pollution and has reported Aspergillus, Fusarium and Trichoderma species to be index organisms for pollution. Divya and Chouhan (2014) isolated Aspergillus, Penicilium, Tricoderma and Fusarium species from Irrity river and Pazhassi Dam, Karnataka and reported Aspergillus, Penicillium, Humcola and Rhizopus to be common in most water bodies in India. Pardeshi and Vaidya (2015) isolated Tricoderma, Aspergillus and Penicillium species from Waldhuni river, Shivajinagar. Patil (1983) reported Aspergillus to be present in any kind of organic debris.

Effect of Anthropogenic Activities on Fungal Diversity

In Kshipra river presence of various species like Aspergillus flavus, Aspergillus fumigates, Aspergillus niger, Fusarium oxysporium, Penicillium citrinium and Tricoderma viridae is registered throughout the investigation period at Triveni, Ramghat and Mangalnath study sites respectively. These sites are rich in organic matter due to performance of worship rituals, high anthropogenic activities, dumping of flower, coconut and body ashes (Bhasin *et al.,* 2015). It is evident that because some species of fungi have capacity to tolerate extreme conditions of organic pollution in aquatic environment and because of their tendency of quick revival at the onset of favorable conditions these fungi have potential as biological indicators in chemically unstable aquatic system with organic pollutants (Kshirsagar 2013, Smiley 2014). At, Managalnath study site particularly higher diversity of fungi is recorded throughout the study period, prime reason for that could be the presence of water hyacinth (*Eichhornia sps*.) in this study site which, indicates high organic pollution and is known to shelter many fungal species like *Alternaria* and *Fusarium* which have been successfully isolated from all habitats of Water hyacinth (Evans and Reeder 2001 and Martinez and Gutierrez 2001).

Impact of Physicochemical Parameters on Diversity of Fungal Diversity

There have been several reports of impact of physicochemical parameters on growth and development of various microorganisms. Temperature of the water is also considered as determining factor for seasonal distribution of fauna and flora. Fungal diversity are naturally occurring and may occur with regularity depending on weather and water conditions of the river. Organic pollution tends to influence fungal flora more than any other factor. As far as the partial distribution is concerned, Mangalnath, Ramghat and Triveni are known to show high fungal diversity which may be attributed to comparatively higher organic load, pollution, pH, oxidisable organic matter, carbonate, bi-carbonate, BOD, COD and low DO. Some species of fungi can survive in low oxygen, high calcium and chloride which have a role to play in life cycle of aquatic fungi (Tabak and Cooke, 1968).

A close relation exists between different physico-chemical parameters and fungal diversity. Dayal and Tandon (1962) suggested that several variable including pH, temperature, DO, BOD and COD influence the occurrence and distribution of fungi. Tripathy (2017) recorded high BOD values with high fungal diversity. A positive correlation between pH, temperature, DO, BOD, COD and fungal diversity has been reported by several workers (Kurzatkowska 2004, Kiziwez and Nalepa, 2008, Sakarmi *et al.* 2011, Rao 2013 and Mugilan 2014). In the present study,

high temperature, pH, BOD, COD and low DO are reported during summer season which account for high fungal diversity during summer season.

Fungi and Health Aspect

In the present study, various pathogenic species of fugi are recorded which includes *Aspergillus fumigates, Aspergillus niger, Chaetomium globosum, Trichoderma longibranchiatum, Mucor amphibiorium* (Fungi). These pathogenic fungi are responsible for causing several water born diseases like allergy, weakness, Aspergellosis, neurological disorders and kidney disorders. Incidence of water born diseases in Ujjain and Dewas districts are recorded as Aspergillosis (0.73%), weakened immune system (0.85%), kidney diseases (0.65%) and allergy (0.8%). The water born diseases are also known to be associated with different anthropogenic activities occurring at a particular site. It has been reported that in freshwater more than 60 fungal species proliferate and many of them cause health disease like kidney and liver disorders, allergy and respiratory disorders (Schwab and Straus 2004, Tanveer *et al.,* 2011) and economic losses for human beings. In addition fungi growing in water sources are involved in modifying taste and odour of water. In the present study, several pathogenic species of fungi are recorded which include *Alternaria species* (hay fever, asthama), *Cladosporodium cladosporoidis* (rot of red wine grapes disease), *Aspergillus clavatus* (hypersensitivity and malt workers lungs disease), *Aspergillus candidus* (ear rot yellow mold peanut disease), *Aspergillus niger (aspergillosis), Chaetomium globosum (neurological infections), Trichoderma longibranchiatum* (neurotrophic allergy), *Batrachochytrium dendrobatis* (chytridiomycoesis), *Aphanomyces euteiches* (pea infection), *Saprolegma ferax* (necrosis of fish), *Mucor amphibiorium* (dental lesion). Fungal diversity of Kshipra river is directly concerned with health aspects which cause different types of disease and has affected several human population.

Conclusion

The present study investigated fungal occurrence, composition and diversity in river Kshipra where 45 fungal species belonging to different genera were isolated. During the current investigation dominant and frequently observed species include Alternaria species Aspergillus niger, Fusarium oxysporum, Limnoperdon incarnatum, Rhodotorula mucliaginosa, Batrachochytrium dendrobatidis, Anguillospora filiformis, Arcyria denudate, Aphanomyces euteiches, Mucor amphibiorum where as Smittium hecatie and Penicillium species. Presence of Aspergillus, Penicillium, Fusarium, Tricoderma species indicate water in polluted status. These species were present at Ramghat, Triveni and Mangalnath site throughout the year which indicates organic pollution at these sites. Fungal diversity was maximum during summer season which may be due to high temperature, high organic load which favors the growth of fungal population and minimum during monsoon due to floods, water input, agricultural run-off and unsettled ecosystem. Fungal diversity is reported to be affected by different physicochemical parameters like pH, temperature, DO, BOD, COD, hardness, chloride and calcium etc. A close relation has been established been between fungal diversity and occurrence of water born diseases. The study provides a baseline data regarding fungal diversity and its relation with physicochemical characteristics and health which will be helpful for the management and conservation of river.

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Table 1 – Qualitative list of Fungi recorded in Kshipra river from Nov 2013 to Oct 2014

S.No.	Organisms	Kshipra Village	Triveni	Ramghat	Mangalnath	Mahidpur
A.	**Ascomycota**					
a)	**Dothideomyecetes**					
1.	Alternaria sps.	-	+	+	+	-
2.	Cladosporoium cladosporoioides	-	+	+	+	-
b)	**Eurotiomyecetes**					
1.	Aspergilus clavatus	-	+	+	+	-
2.	Aspergillus fumigates	-	+	+	+	-
3.	Aspergillus niger	+	+	+	+	+
4.	Chrysosporium keratinophilum	+	+	+	+	+
5.	Chrysosporium/ Emmonsia parvum	+	+	+	+	+
6.	Penicillium citrinum	+	+	+	+	+
7.	Penicillium expansum	+	+	+	+	+
c)	**Sordariomyecetes**					
1.	Chaetomium globosam	+	+	+	+	+
2.	Fusarium oxysporum	+	+	+	+	+

3.	Fusarium solani	+	+	+	+	+
4.	Trichoderma asperellum	-	+	+	+	-
5.	Trichoderma viride	-	+	+	+	-
6.	Trichoderma longibracchiatum	-	+	+	+	-
a)	**Basidomycetes**					
1.	Limnoperdon incarnatum	+	+	+	+	+
2.	Glaciozyma Antarctica	+	+	+	+	+
b)	**Uredenomyctes**					
1.	Rhodotorula glutinis	+	+	+	+	+
2.	Rhodotorula minuta	+	+	+	+	+
3.	Rhodotorula mucliaginosa	+	+	+	+	+
4.	Rhodotorula rubra	+	+	+	+	-
C.	**Chytridiomycota**					
	Chytridiomycetes					
1.	Coralliodiomyces digitatus	+	+	+	+	+
2.	Batrachochytrium dendrobatidis	+	+	+	+	+
3.	Ichthychytrum uvlgare	+	+	+	+	+
4.	Olpidium brassicae	-	+	+	+	-
5.	Rhizophydium globosum	+	+	+	+	+
D.	**Deuteromycota Hyphomycetes**					
1.	Anguillospora filiformis	+	+	+	+	+
2.	Phalangiospora nawawii	-	-	+	+	-
3.	Speiropsis pedatospora	+	+	+	+	+
4.	Triscelophorus acuminatus	-	+	+	+	+
S.No.	**Organisms**	**Kshipra Village**	**Triveni**	**Ramghat**	**Mangalnath**	**Mahidpur**
E.	**Myxomycota**					
	Maxomycetes					
1.	Arcyria denudate	-	+	+	+	+
2.	Lycogala epidendrum	-	-	+	+	-
F.	**Oomycota Oomycetes**					
1.	Aphanomyces euteiches	+	+	+	+	+
2.	Pythium insidiosum	-	+	+	+	-
3.	Saprolegnia ferax	-	+	+	+	-
4.	Saprolegnia hypogyana	-	+	+	+	-
5.	Thraustotheca sps.	+	+	+	+	+
G.	**Zygomycota**					
	Mucormycotina					
1.	Mucor amphibiorum	-	+	+	+	-
2.	Mucor sps.	-	+	+	+	-
3.	Rhizopus arrhizus	+	+	+	+	+
4.	Rhizopus oryzae	+	+	-	+	+
5.	Rhizopus nigricans	-	+	-	+	-
H.	**Trichomycetes**					
1.	Genistellospora sps.	-	+	-	-	_
2.	Smittium hecatie	-	+	-	+	+
3.	Smittium sps.	-	+	-	+	-
	Total No. of species-45	**23**	**42**	**39**	**44**	**26**

Fig.1. Fungal diversity at different sites of Kshipra river