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Aquatic hyphomycetes communities occur as potential bioindicators of water quality

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Abstract
With a profound knowledge of how physico-chemical parameters affect these communities, microbial communities could be used as indicators for environmental changes and for risk assessment studies. We studied aquatic hyphomycete communities in ponds from sites shaped by intense human activities (namely the "Mansfeld region") and Urmil river, there are no sources of man made effluents in Chhatarpur district. Environmental stress factors such as high concentrations of chloride and calcium as well as low concentrations of oxygen significantly reduced the diversity and biomass of hyphomycetes in the investigated samples. Fungi were negatively correlated with nutrient concentrations. We propose that aquatic hyphomycete communities can be used as sensitive and integrative indicators for freshwater quality.

Key words: Aquatic hyphomycetes; freshwater; community structure; bioindicator

1. Introduction
Aquatic hyphomycetes, an important part of the fresh-water microbial communities, are excellent candidates for bioindicators. They play a vital role in the functioning of aquatic ecosystem and fulfill crucial activities as part of food webs and in nutrient cycling. They initiate the degradation of organic material by e.g. increasing the palatability of litter and wood. In addition, aquatic hyphomycetes can degrade organic compound in harsh habitats such as rivers highly enriched in nutrients (Pascoal *et al*., 2003) [10].
There is a general trend that, independent of its type, pollution usually leads to a decline in the diversity of aquatic hyphomycetes. A drastic decline in diversity and sporulation of aquatic hyphomycetes, accompanied by changes in species dominance (e.g. top conidia produsers) has been reported in habitats highly polluted by heavy metals (Krauss *et al*., 2001) [6]. However, monitoring the relative abundance of individual microbial species within their polluted habitats is of prime importance to detect relevant species that can act as bioindicators in risk assessment monitoring programs.
The objectives of this study were to (1) extract the main environmental factors responsible for constraining the community structure of aquatic hyphomycetes; and (2) investigate whether species assemblages of aquatic hyphomycetes might be used as potential indicators for the detection of minute environmental changes. We focused on fresh-water ponds and river in Chhatarpur district.

2. Material and methods
2.1 Site location
Three water bodies in the Chhatarpur district were selected for the field investigation. Two were the Kishore sagar and Pratap sagar ponds, which was chosen because it represents a pond with a high nutrient load. Indeed, numerous houses and shops are located along its shores. The other water body was Urmil river, which passes through the teak (*Tectona grandis* L.), Salai (*Boswellia serrata* L.), Khair (*Acacia catechu*) and Bamboo (*Dendrocalamus strictus*) forest area. Except for occasional dwellings and small farms along its banks, there are no sources of man-made effluents which might contribute nutrients to the stream.
For mycological analysis, samples of foam, submerged leaves and twigs were collected between 15th and 30th of february and processed as described by Nilsson (1964) [9]. Water samples were also collected for physico-chemical analysis.

2.2 Water chemistry

The physico-chemical parameters of water viz., Temperature, water pH, dissolve oxygen (mg/l), nitrate (mg/l), phosphate (mg/l), chloride (mg/l) and calcium hardness (mg/l) were analyzed following the methods of A.P.H.A. (2005) [1].

Temperature was measured by using a centigrade thermometer by dipping it at a depth of 5-8 cm in water for 5 minutes, at the time of sample collection. pH was recorded on spot with the help of a digital portable pH meter (Hanna) at the time of sample collection. Dissolve oxygen content (mg/l) was determined on the spot by making a composite sampling of water at each month following the Winkler's azide modification method. Nitrate (mg/l), phosphate(mg/l), chloride (mg/l) and calcium hardness (mg/l) were analyzed following the methods of A.P.H.A. (2005) [1].

Table 1: Hydrochemical characteristics of the sampling sites

Chemical characteristics	Urmil river	Kishore sagar pond	Pratap sagar pond
Temperature	19.2	20.3	20.2
pH	7.6	9.4	9.1
Dissolved oxygen (mg/l)	7.3	5.9	4.5
Phosphate (mg/l)	0.00	0.36	0.49
Nitrate (mg/l)	0.09	4.00	1.89
Chloride (mg/l)	29.5	245.9	125.3
Calcium hardness (mg/l)	28.4	62.8	48.2

3. Results

3.1 Fungal diversity

A total of 20 species belonging to 14 genera of water borne conidial fungi viz., *Anguillospora*, *Beltrania, Campylospora, Clavariopsis, Dactylella, Flabellospora, Flagellospora, Isthmotricladia, Lemonniera, Lunulospora, Setosynnema Trichocladium, Tricladium* and *Triscelophorus* were isolated from Urmil river (Table 2). These species were isolated from different decomposed leaf litter of known and unknown species and foam.

Water of Kishore sagar and Pratap sagar pond get polluted by washing of the clothes and bathing by the people. Under these circumstances, aquatic hyphomycetes may be reduced. However, only one fungal species *Lunulospora curvula* was recorded from the Kishore sagar and Pratap sagar pond. According to Manoharchary (1989) [7], aquatic hyphomycetes disappear from such habitats as a result of pollution and anaerobic conditions.

3.2 Abiotic environment

Water temperature at all sites ranges between 19.2 °C to 20.3 °C. The pH value at all sites ranged from slightly basic (7.6) to alkaline (9.4). Concentration of dissolved oxygen at all sites fluctuate between ranged between 5.9-7.3 mg/l. The lower values (5.9 and 4.5 mg/l) were measured in the ponds water. In river water dissolved oxygen concentration was 7.3 mg/l. These fungi require a fresh oxygenated environment for their occurrence (Webster & Towfic, 1972). During study period, two ponds showed the alkaline condition (9.1 and 9.4) but the river water showed the slightly basic condition (7.6). pH greatly affects the decomposition activities of aquatic hyphomycetes in running fresh water bodies. The occurrence and degradative ability of these fungi colonizing on submerged leaf litter is influenced by the hydrogen ion concentration (pH) of water (McKinley & Vestal, 1982) [8]. Species richness of aquatic hyphomycetes declines noticeably at pH ≤ 4.5 and ≥ 8.0 (Barlocher 1987; Chamier 1992) [4, 5].

The nitrate value tended to be higher at Pratap sagar pond (1.89 mg/l) and Kishore sagar pond (4.00 mg/l) whereas lower at river Urmil (0.09 mg/l). Similarly, phosphate value be slightly higher at Pratap sagar pond (0.49 mg/l) and Kishore sagar pond (0.36 mg/l) whereas not found at river Urmil (0.00 mg/l). The concentration of chloride (245.9 mg/l) and calcium (62.8 mg/l) was much higher at Kishore sagar pond.

Table 2: Distribution of aquatic hyphomycetes found in the sampling sites

	Urmil river	Kishore sagar pond	Pratap sagar pond
Anguillospora crassa Ingold	+	_	_
A. longissima (Sacc. and Sydow) Ingold	+	_	_
Beltrania rhombica Penzig,	+	_	_
Campylospora chaetocladia Ranzoni	+	_	_
Clavariopsis aquatica de Wildeman,	+	_	_
Dactylella submersa (Ingold) Nilsson,	+	_	_
Dactylella rhombospora Grove	+	_	_
Flabellospora crassa Alasoadura	+	_	_
Flabellospora verticillata Alasoadura	+	_	_
Flagellospora penicilloides Ingold	+	_	_
Flagellospora penicilloides Ingold	+	_	_
Isthmotricladia gombakiensis Nawawi,	+	_	_
Isthmotricladia laeensis Matsushima	+	_	_
Lemonniera cornuta Ranzoni	+	_	_
Lunulospora curvula Ingold	+	+	+
Lunulospora cymbiformis Miura	+	_	_
Setosynnema indica sp. nov.	+	_	_
Trichocladium angelicum Roldan and Honrubia	+	_	_
Tricladium indicum Sati and Tiwari	+	_	_
Triscelophorus monosporus Ingold	+	_	_
Species richness	20	1	1

The table shows the presence (+) and absence (-) of the individual aquatic hyphomycete species.

4. Discussion

At the investigated sites, the pollution was mainly caused by increased concentration of nitrate and chloride (Table-1). In our study, the maximum concentrations of nutrients measured at Pratap sagar pond and Kishore sagar pond. Consequently fungal biomass and sporulation rate were clearly inhibited in these sites compared to the Urmil river (Table-2) suggesting that the positive role of nutrients on fungal growth might be true up to a certain threshold, beyond which biological activity might be inhibited.

Aquatic hyphomycetes live preferentially in clean and well aerated water habitats (Barlocher, 1992, 2005) [3, 2]. Results of present study showed that growth of aquatic hyphomycetes were generally inhibited with the amount of nutrients in the water. Sridhar *et al*., 2000 [11]; Pascoal *et al*., 2003 [10] also observed same results.

5. Conclusion

Aquatic hyphomycete communities presented in this paper can be used as sensitive and integrative indicators for freshwater quality. Microbial communities are suitable for detection of stress in natural systems because of their ubiquity and rapid response to environmental changes. Present study indicate that variations in water chemistry cause a significant proportion of the change in fungal community. This paper provide a future application of aquatic hyphomycetes as indicators for pollution.

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