3. Review of Literature
REVIEW OF LITERATURE

The rivers of India play an important role in the lives of the Indian people. The river systems provide irrigation, potable water, transportation, electricity, and livelihoods for a large number of people all over the country. This easily explains why nearly all the major cities of India are located on the river banks.

Seven major rivers along with their numerous tributaries, make up the river system of India. Most of the rivers pour their water into the Bay of Bengal. However, some of the rivers, whose courses take them through the western part of the country and towards the east of the state of Himachal Pradesh empty into the Arabian Sea. The parts of Ladakh, northern parts of the Aravalli range and the arid parts of the Thar Desert have inland drainage.

From past 30 years, due to the rapid urbanization and alarming Industrial growth. Our rivers have become carriers of hazardous and heavy metal wastes. More than 4,500 people die every year due to the lack of clean water through out the world. Due to the improper discharge of sewage, industrial effluents and dumping of urban solid waste, our rivers are facing a threat of sever pollution. This indirectly affects the flora and fauna of the riverine eco-system. Due to heavy deposition of the pollutants, the river loses its self purifying capability and accumulation of sludge in the river sediments exceeds It restricts the growth of microbes and intern affects the productivity of the water body.
In India, the ecology of rivers and pollution have been reviewed by Ajmal and Razi-ud-din (1988), Venkateshwarlu (1990), Karthick et al. (2007), Abida begaum et al. (2008) and Prasad and Patil (2008), Rana (1995). The biological profile of riverine system is one of the important aspects of many aquatic systems in the country. Tripati and Adhikary (1990), studied the biological profile of river Nandira, which flourishes various groups of flora and fauna, including, many groups of microbes like bacteria and fungi have been found to occur in various degree. The importance of mycological studies in aquatic habitats has been emphasized by Lund (1934), Harvey (1952), Suzuki (1961,a,b,c), Sparrow (1968) and Park (1972). There are many reports given by Krause (1960), Perrott, (1960), Hughes (1962), Willoughby (1962), Alabi (1971) and Hunter (1975) from different countries on aquatic fungi.

In our country, mycological studies on aquatic system received less attention during early days. However, little work was done earlier by few persons like Dayal and Tandon (1963) and Dayal and Thakur Ji (1966). They merged the information recorded from foreign countries with available references regarding the occurrence, periodicity and environmental factors, involved in the growth of aquatic fungi, prevailing in India. In the first instance, the purpose of this investigation was to determine the composition of the phycomycetes fungal flora in a variety of fresh water habitats, in relation to some of the physico-chemical factors of water, affecting the growth of these fungi in their natural environments.
and to obtain material for proper systematic and morphological studies. These studies may also throw some light on the infrequent collections from India.

Srivastava (1967), Khulbe (1979) and Sati (1997), reported the existence of different communities of zoosporic fungi from the class chytrids and oomycetes, isolated them from different substrates.

Cooke (1961, 1963), divided the fungi encounters in fresh water in to two principal groups, the hydro fungi and geo fungi (typical soil fungi), while former one complete their life cycle with in the water. But, latter one, the typical soil fungi, which are not specifically adopted to aquatic existence, they might present in water, because, adequate supply of nutrients in water. Thus, there are at least four groups of fungi, which are encountered in water. Among them, chytridomycetes and oomycetes are prevalent in aquatic habitat and they are collected by using special techniques given by Emerson, (1958), Sparrow (1960), Fuller and Poyton (1964) and Miller, (1967).


More detailed study on aquatic phycomycetes was done by Dasgupta (1982), who summarized in his book article “Discourse of aquatic phycomycetes in India”. European researchers like Cooke (1926), Blackwell (1937) and
Waterhouse (1940) made significant contribution about ecology, distribution and identification of aquatic phycomycetes. In United States, the studies flourished with studies of Coker (1923, 1937), Johnson (1956) and Seymour (1956).

A similar work was done by Japanese workers like Kobayashi et al. (1954, 1971), who studied the life history, cytology and host parasite relationship of the member of Woroninaceae, Olipidaceae and Lagenidiaceae etc.

In India, studies on water molds was initiated by Butler (1907), who described the genus Pythium. He published a book entitled "An account of genus Pythium and some Chytridiaceae" in which he described 18 species of Pythium, of which five, from India. Out of eleven chytrids, four of them like Nowokowskiella ramose, Pseudolpidium, Aphanomyces, Olidiopsis minor and Olpidiopsis schenkiana were recorded from India. Similarly, the studies made by Chaudhury and Coworkers (1931, 1947) on aquatic phycomycetes, resulted in discovery of seven more genera like Pythiopsis, Isoaclya, Protoachyla, Achyla, Aplanes, Thraustothea and Hamidia. In addition to this, Iyengar, (1935) described two species of Coelomyces.

The existence of distinctive fresh water Ascomycetes has been discovered within past fifty years. Knowledge of this fungi has gained primarily from a few general studies of fungi, colonizing selected submerged woody substrata. Similar studies are also made by Ingold (1951, 1954), Ingold and Chapman (1942), Dudka (1974) and Magnes and Hafellner (1991).
The preliminary studies indicated that, fresh water Ascomycetes are important group of fungi in aquatic habitats were made by Hyde (1988). They exist as parasites, endophytes and saprophytes of submerged aquatic macrophytes. They are decomposers of submerged woody materials (Shearer, 1993; Goh and Hyde, 1996). Clarence and Ingold are the first mycologists who recognized the fresh water Ascomycetes as a distinctive group of aquatic fungi. Ingold (1942) also discovered aquatic hypomycetes, they are now called “Ingoldian hypomycetes” in his honor.

Farida et al. (1990), Arif (1999), Nagdy and Nasser (2000), Laila (2005) and Ali (2007) from Saudi Arabia and Egypt, worked on isolation identification of many zoosporic fungi of several genera from various ponds, rivers and drainage sewers. From all the above reports Pythium and Saprolegnia were found to be dominant genus.

Many researchers in India have carried out studies on aquatic fungi viz., Sati (1997), Paliwal and Sati (2009), Bhargava (1946), Dayal and Tandon (1962), Khulbe (1977), Mer et al. (1980), Manoharachary (1991) and Mishra and Dwivedi (1987). They have isolated identified and reported, many of zoosporic and conidial fungi from aquatic and terrestrial habitats and concluded their morphological characteristics and significance with the environmental conditions.

Marano and Steciow (2009) have made a study on Argentinean streams. In their contribution, the frequency of occurrence and abundance of zoosporic fungi
were quantified in three lotic environments of the Rio de La Plata system, using the baiting technique. Eight genera were recovered viz., Achlya, Aphanomyces, Dictyuchus, Olpidiopsis, Phytophthora, Pythium, Rhizophlyctis and Saprolegnia. Their patterns of frequency, abundance and distribution, show certain similarities with the all streams, which were analyzed.

Voronin (2008), reviewed modern state of knowledge of zoosporic fungi in freshwater plankton and benthos. The effects of abiotic factors upon the distribution and development of these fungi were discussed, along with the role of zoosporic fungi play in lake ecosystems.

Ali (2007), worked on biodiversity of zoosporic fungi in polluted water drainages across Nile delta region, lower Egypt. He has identified thirty four zoosporic fungi and five unidentified fungi belongs to ten genera of zoosporic fungi from eighty four polluted water samples, which were randomly collected from different polluted sites of the water drainages along the Nile delta in lower Egypt. The Saprolegnia delica and Dictyuchus carpophorus, were the most dominant isolated zoosporic fungal species. They were highly occurred, especially at the hyper-polluted water with the heavy metals.

Paliwal and Sati (2009), assessed Kosi river water with reference to watermolds diversity and its influence with physico-chemical parameters of water such as pH, temperature and total organic matter at three study sites viz., Kosi,
Kwarab and Khairma, from November 2000 to October 2001. During their study, they have isolated a total of 16 fungal species, belonging to 7 genera of watermolds. Maximum number of fungal species were recorded during spring and rainy season, while, a minimum number of watermolds were observed during winter season.

Terrestrial fungi are often passively introduced into riverine system, in the form of high loads of fungal propagules via inflowing streams, rainwater, and wind (Smirnov, 1964). However, it is often unclear, whether such fungi, lacking typical morphological adaptations. For example, species of *Aspergillus* and *Penicillium* are among the most common fungal isolates from terrestrial, freshwater and marine environments, even from deep-sea sediments. Some are active and partially adapted to aquatic habitats. Some species from fungal class, such as, Deuteromycetes, Ascomycetes and Pyrenomycetes are also found to be dominant in aquatic eco-system. They are treated as facultative or extra aquatic fungi, these fungi are also found to be present in potable water (Kumar and Saha, 1992).

Along with this diversified mycoflora, which known to degrade organic waste substances, like aquatic phycomycetes and ascomycetes, other group of fungi were also recorded in aquatic system, which are usually pathogenic organisms, known to cause various types of skin diseases (Skin mycosis) in aquatic animals and utilize keratin substances as their food. They usually degrade
keratinous substances in the river sediments. These fungi are called keratinophilic fungi, some times they are recorded as dermatophytes. These are essentially related to diseases of cutinized and keratinized animals and human tissues. Ajello (1953) recorded keratinophilic fungi exist in both soil as well as in water, where the keratinous substances are released. During the past two decades, the diversity in keratinophilic fungi have been investigated in India, Dey and Kakoti (1955), identified some of the important species of keratinophilic fungi which are isolated from various water sources viz., Chyrosorium keratinophilum, Chrysosporium tropicum and Microsporum gypseum.

*Mucor pusillus*, a thermophillic phycomycete, contained hydrolytic enzymes that attacked native cellulose, acid-swollen cellulose, carboxymethylcellulose, and cellobiose. The presence of a multiple cellulolytic enzyme system indicated, that, they may have specific roles in the degradation of cellulose (Somkuti and Babel, 1969).

One of the most important structural polysaccharides of the plant kingdom is cellulose. The degradation of cellulose is often discussed in connection with the action of fungal parasites. The ability of Oomycetes to produce cellulolytic enzymes has been infrequently investigated. In addition to this most of the studies that are reported lack quantitative data Unestam (1966) in his quantitative study, reported no cellulolytic activity of a *Pythium* sp. and *Saprolegnia* sp. incubated in shake and stationary media containing cellulose. Preliminary investigations, of

Generally, majority of aquatic fungi are saprophytes. They lead their life on dead and decaying animal and plant materials, which are usually present in the river sediments. Specific group of aquatic fungi degrade and decompose particular type of organic substances. Garrett (1951) grouped aquatic phycomycetes as "Sugar fungi" probably unable to decompose cellulose and lignin. But, they colonize the substrata because of the presence of simple carbon compounds like hexose sugar etc. Later, it has been reported that, the cellulolitic activity of many Oomycetes (Taylor and Marsh, 1963; Tribe, 1966; Unestam, 1966; Park, 1976; Fisher *et al.*, 1977; Deacon 1979; Thompstone and Dix, 1985) especially, *Saprolegniales*, play an important role in recycling of carbon from cellulose in aquatic system. Based on the available literature, in wood land streams, aquatic hypomycetes are commonly associated with decomposing plant detritus. Studies of aquatic hypomycetes, showed that, hypomycetes grow on leaves in culture indicate, these fungi colonize and degrade leaf litter (Chamier and Dixon, 1982; Suber Kropp and Klug, 1980, Suber Kropp *et al.*, 1983). All these species examined to date, soften and macerate the leaf matrix and cause significant dry
weight loss. Woody substrates were usually degraded by aquatic fungi belongs to various groups viz., aquatic hypomycetes, aero aquatic hypomycetes, chytridomycetes, oomycetes, aquatic ascomycetes and other higher terrestrial geo fungi, like *Fusarium* sp., *Alternaria* sp. etc. This has been reported by various researchers like Clement, Tsui Kevin, Hyde, John, Hodgkiss (2001) recently studied the role of aquatic fungi in the degradation of woody materials in Hong Kong streams. They made detailed study on the above aspect concerned with Chung river in Hong Kong.

In general, all kinds of aquatic fungi are natural bio-degrading agents. They degrade all most all types of organic wastes in the various types of water sources either may be fresh water or marine water or may be lentic or lotic water bodies. Enormous literature is available to indicate the role of fungi in bio-degradation. John Sutherland, (1984) in United States, conducted a study on biodegradation of lignocelluloses from cotton-gin trash by *Pycnoporus cinnabarinus*. It is an white rot fungi, which has proved to be active in degrading lignocellulosic substances, which are released in to the river from cotton-gin.

Reid and Seifert (1982), Hatakka and Uusi Rauva (1983), used to study the lignin degradation. Similarly, to prove the role of aquatic fungi in degradation and decomposition of organic waste in the river sediment, Subber Kropp and Keller (1981), studied degradation, growth and changes in palatability of leaves by six aquatic hypomycetes in wood land streams.
Chytrids, the sub class of aquatic phycomycetes, degrade a variety of substances such as chitin, cellulose and keratin, including, some of recalcitrant materials in the biological world, such as, lignin and sporopollenin (Shearer et al., 2007).

Marano et al. (2009) reported the leaf litter degradation by zoosporic fungi. His study focuses on the communities of zoosporic fungi and straminipiles in a stream, which are involved in the decomposition of leaves of two plant species, Ligustrum lucidum and Pouteria salicifolia, in the presence of other groups of fungi. A characteristic fungal community dominated by Nowakowskiella elegans, Phytophthora sp. and Pythium sp. were found further changes in the fungal community structure over time (succession) was observed.

With this strong literature background, the present work was undertaken to study the Physico-chemical characteristics of Tunga river, distribution and diversity of aquatic fungi and the role of aquatic fungi in biodegradation process in Tunga river.