CHAPTER 2. REVIEW OF LITERATURE

River ecosystems have been studied in detail by many scientists and a thorough knowledge on the same has become wide spread over the last three decades (Frissell et. al., 1986; Johnson et. al., 1995; Ward, 1998; Tockner and Stanford, 2002). The ecological condition of a river is affected by stressors that exist at multiple spatial scales. Natural drivers such as climate, geology, rainfall, geography, etc shape the river, control the substrate and provide organic material and thus rivers change their pattern in the direction of downstream in response to the natural forces (Lubinski, 1993; Lorenz et. al., 1997; Naiman, 1998; Ward et. al., 2001; Fausch et. al., 2002; Mertes, 2002). A riverine system provides several attractive distinctive microhabitats to diverse group of fauna and flora throughout its drainage. As river changes its pattern of drainage and discharge while advancing downstream, its physico-chemical characteristics also change resulting in the wide changes of microhabitat associations. Distribution pattern, assemblage and diversity of flora and fauna of a river are greatly determined by its physical, chemical and hydrological conditions (Stalnaker et. al., 1989; Galat et. al., 1998; Knutson and Klass, 1998; Montgomery and Buffington, 1998; Reash, 1999).

Freshwater ecosystem has a contribution of less than 1% on earth’s surface. But this coverage alone provides space for around 10% of the world’s described species (Strayer and Dudgeon, 2010). The ecosystem serve man in terms of providing fish for food or water purification for drinking, nutrient cycling, etc. Biodiversity of freshwater ecosystems have been assessed by several studies and found out that species richness in these ecosystems is relatively higher than that in terrestrial and marine ecosystems (Gleick, 1996). Order Odonata under Class Insecta, alone includes 6500 described species in freshwater systems and 50% of all the fishes presently described are exclusively freshwater inhabitants (Pauly and Froese,
2006; Trueman and Rowe, 2009). Threats to freshwater biodiversity are due to water pollution, flow modification, destruction of habitat, invasion of exotic species, over-exploitation and global environmental changes (Dudgeon et. al., 2006; Vorosmarty et.al., 2010).

Aquatic ecosystems continue to be recipients of contaminants from industries, agriculture and human settlements, despite of intensive research on water pollution and suggestions by ecologists, for centuries. Recent surveys on the inland water ecosystems show that Indian subcontinent has the most threatened river catchments on the globe (WCMC, 2000). Many studies have reported the physico-chemical aspects of major rivers and reservoirs of India in relation to alterations due to increased perturbation. Studies related to alterations in physico-chemical parameters of rivers like Adyar (Chacko and Ganapati, 1949), Malampuzha (Chacko et. al., 1953), Kali (George et. al., 1966), Ganga (Ray et. al., 1966; Ageawal et. al., 1966; Pandey, 1985; Singh and Rai, 1999; Sahu et.al., 2000; Rao et.al., 2000), Sabarmati (Venkateswarlu and Jayanti, 1968), Alakananda (Badola and Singh, 1981; Nautiyal, 1986; Tiwari et.al., 1991), Tungabhadra (Mitra, 1982; Reddy and Venkateswarlu, 1985), Jhelum (Raina et. al., 1984), Ambika (Zingde et. al., 1986), Periyar (Sankaranarayanan et. al., 1986), Brahmanani (Panda et.al., 1991; Mitra, 1997), Godavari (Rao, 1993; Raifeeq and Khan, 2002), Cauvery (Batcha, 1998; Abida and Harikrishna, 2008) and Yamuna (Meenakshi and Garg, 2002; Anand et.al., 2006) have received good attention on the basis of pollution aspects.

Studies on rivers originating from Western Ghats showed that the threats to the forests cause depletion of freshwater habitat, biodiversity, water resources, clean environment and potable water (Daniels, 1997). Growing human population have even resulted in such a figure that swaying of 350 individuals per square kilometre occurs in the Western Ghats hotspot which is the highest density of humans within any of the global biodiversity hotspots.
(Cincotta et al., 2000). Consequent deforestation, soil erosion, water extraction, pollution and over-exploitation of freshwater ecosystems would be the prime factors for biodiversity depletion (Gadgil and Meher-Homji, 1986; Rai and Proctor, 1986; Menon and Bawa, 1997; Jha et al., 2000; Myers et al., 2000; Smakhtin and Anputhas, 2006; Nihara et al., 2007). The rivers and streams of Western Ghat Hotspot has been investigated for aquatic insects and found that the region has a high diversity and endemism of Odonates (Fraser, 1936; Peters, 1981; Rao and Lahiri, 1982; Davis and Tobin, 1985; Prasad and Varshney, 1995; Emiliyamma and Radhakrishnan, 2002; Jaffer et al., 2002; Palot et al., 2002; Subramanian and Sivaramakrishnan, 2002; Radhakrishnan and Emiliyamma, 2003; Subramanian, 2009). At the same time, studies have proved that anthropogenic interventions like agricultural activity and associated habitat modifications, pesticides and chemical fertilizers, stream flow regulations, and sediment runoff pose high threats to the odonate diversity of Western Ghats. There have been reports on total absence of endemic odonates in streams running through tea, coffee, cardamom and rubber plantations in the proximity of Western Ghats, indicating serious damage to the fauna caused by chemical pesticides (Molur et al., 2011).

Kapoor and Bamniya (2001) studied the effect of pollutants in eutrophication and algal bloom in standing waters and found that pollutants especially organic pollutants increase the rate of algal blooms. An inverse correlation of nitrogen nutrients, sulphate and silicate with the coliform bacteria has been reported in lake ecosystem (Badge and Varma, 1991). The nutrients increased only during filling phase in rainy season but decreased continuously during winter and summer while coliforms increased during summer and decreased during rainy season and winter.

Nitrogen appeared to be the primary major nutrient limiting primary production in fresh water system (Edmondson, 1970). Rai and Kumar (1970) studied algae of some habitats polluted with nitrogen and chloride rich effluents of a fertilizer factory. The most dominant
alga *Oscillatoria*, confirmed the view of other workers that blue-green algae were highly tolerant to pollution (Palmer, 1969).

Studies on environmental indicators and biomonitoring of ecosystems using indicator organisms have been in existence since 1900’s (Kolkwitz and Marsson, 1908). But it took nearly eighty years to establish biomonitoring as a valuable assessment programme through implementation of Rapid Bioassessment Protocol which gained popularity throughout the world for many of the ecosystems since the medieval of 1980’s (Plafkin *et. al.*, 1989; Barbour *et. al.*, 1995, 1996; Gibson *et. al.*, 1996). Organisms of a particular taxon that responds in a predicted way to alterations in the environment can be termed the best candidate species for use in bioassessment. Biological community including plankton, periphyton, microphytobenthos, macrozoobenthos, aquatic macrophytes and fish has been in use for biomonitoring of aquatic ecosystems (Mohanty, 1983; Reddy and Venkateswarlu, 1986; Tripathy, 1989; Batiuk *et. al.*, 1992; Depauw *et. al.*, 1992; Mitchell and Stapp, 1992; Mohapatra and Mohanty, 1992; Philips and Rainbow, 1993; De Lange, 1994). Benthic macroinvertebrates have also gained attention of several ecologists as excellent indicator organisms for health assessment of aquatic environment. They comprise aquatic insects, crustaceans, annelids, molluscs, nematodes, planarians, bryozoans, cnidarians such as Hydra, and nemerteans which can be retained by a mesh size of 500 μm. They are considered as the most popular faunal assemblage for river health assessment (Rosenberg and Resh, 1993; Johnson *et.al.*, 1995; Hauer and Resh, 1996; Barbour *et. al.*, 1999; Lazorchak *et. al.*, 2000; Carter and Resh 2001; USEPA, 2002; Klemm *et. al.*, 2003)

Meyer *et. al.* (1979) studied interactions between microbiological and chemical parameters and found inverse relationship between microbiological and organic chemical parameters. Goldman and Wetzel (1963) has studied the effect of temperature on the primary productivity of lotic ecosystem and found that temperature is important in determining
seasonal productivity. Jayangoudar (1964) studied interrelationship between the physicochemical variables and biological conditions in Nuggikari lake and found that blue-green bacteria became abundant in summer. Pearsall (1932) also have reported that blue-green bacteria were abundant in summer when nutrient salts of biological significance such as phosphate and nitrate showed their presence. Total solids and total suspended solids are composed mainly of carbonate, bicarbonate, chlorides, sulphate and nitrates of calcium, magnesium, potassium and manganese and organic matter silts and other particles (Bilotta and Brazier, 2008). In polluted waters the concentration of solids increases depending on the type of pollution, while direct relationship between oxidisable organic matter on one hand and albuminoid ammonia, free and saline ammonia and carbon dioxide on the other has been reported. At the same time an inverse relationship has been established between oxidisable matter and oxygen (Rao, 1954; Meybeck et. al., 2003). Qureshi and Dutka (1979) made microbiological studies on the quality of urban storm water runoff in Southern Ontario, Canada and found that there appeared to be little relationship between the duration, intensity and amount of rainfall and the occurrence of peak microbial population.

Depauw-Gillet and Remacle (1978) studied relationship between environmental parameters, pH and temperature and the control of microbial growth characteristics and noted that slight changes in temperature and pH affected growth of aquatic strain of achromobacter to a great extent. Temperature endured considerable impact on the life process of microorganisms when it exceeded maximum tolerance limiting level and resulting in even death due to irreversible damage suffered by cytoplasm of microorganisms (Hutchinson, 1975; Rheinheimer, 1977). Moore (1979) studied influence of several environmental factors on the planktons in 21 rivers and reported that temperature was the main factor influencing the diversity of flora and fauna. The pH gives an idea to the type and intensity of pollution (Verma et. al., 1984; Mishra and Seksena, 1991). An inverse relationship between Coliform
count and dissolved oxygen in water was established. High coliform were reportedly coincided with low dissolved oxygen whereas low coliform counts coincided with high dissolved oxygen (Badge and Varma, 1991). Dissolved oxygen is positively correlated with pH and temperature (Saran and Adoni, 1984; Hussain and Ahmed, 2002). High amount of chloride indicated the source of sewage drains (George et. al, 1986; Upadhyay and Rana, 1991). Hardness is an important parameter in the detection of water pollution. Hardness is chiefly due to the presence of Ca and Mg ions. Direct correlation between Ca, Mg hardness and coliform bacteria was reported (Badge and Varma, 1991). Brooks and Cech (1979) observed that all rivers with elevated nitrates showed positive faecal bacteria count in agreement to other workers (Waring, 1949). The data regarding physico-chemical parameters and pollution status of Achencovil river is scanty when compared to other high altitude originating rivers of Southern Western Ghats. The results of the present study will be of great significance in connection with the healthy status of not only river Achencovil, but also status of downstream segment of Pamba River and Vembanad ecosystem, as river Achencovil merges with Vembanad lake through Pamba River at its end.