Chapter-2

# Review of literature

## 2.1 Riverine ecosystem

Rivers have played a vital role in inspiring minds, they are the cradles of civilizations, and every Indian is made sacred by them. They have a key role in balancing the hydrological cycle and sink of domestic, municipal and industrial waste. Distribution of phytoplankton varies according to the nature of the water bodies and climatic conditions such as temperature, pH, rainfall, humidity, nutrients and amount of suspended matter. A synchronous study of physical, chemical and biological properties of freshwater ecosystem is highly important with the aim of attaining a better understanding of the biological integrity of ecosystem. Deterioration of water quality due to the release of various types of pollutants into rivers makes them unfit for drinking, bathing, fishing and irrigation. The result of these activities converts sacred India into a land of polluted rivers. All the major rivers and their tributaries in India have become polluted due to anthropogenic activities and if this drift is continued, it may lead to serious impacts on human health in the coming years.

Research on phytoplankton composition in Indian river systems dates to the 1950s. Father of Indian limnology (Ganapati 1956; Ganapati and Alikunhi 1950), have made valuable contributions through studies conducted in rivers Cauvery and Godavari. Significant contributions on the study of Phytoplankton ecology of Indian rivers have been rendered by (Roy and Sen 1985; Singh and Sharma 1999; Srivastava et al. 2003; Gurumayum et al. 2001; Mishra and Tripathi 2003). Khan and co-workers (1998) studied variations in the distribution of phytoplankton among the different rivers in India from the river Ganges at Narora, UP. More and Nandan (2003) from the Panzara river, Maharashtra, (Yazdandoost and Kaldare 2000) from different rivers in Pune and (Biswas and Konar 2001) from the river Damodar. Unni and Naik (1997) studied the distribution, diversity and succession of phytoplankton in Indian rivers

like Ganga, Yamuna, Mahanadi, Godavari, Krishna and Cauvery. Varunprasath and Daniel (2010) studied algae and water quality in river Cauvery from Bhavani to Erode. A comprehensive study of the ecology and polluted condition of Indian rivers (Trivedi et al. 1998). Assessment of the water quality of Cauvery river in bhavani region studied (Nagarajan and Sivaraja 2013). The quality of water is vital because it linked with human welfare. Several studies on water quality have been carried out in different parts of India (Sreedevi 2005; Semwal and Akolkar 2006; Thilagavathi et al. 2012).

In Kerala, (Sankaranarayanan et al. 1986) studied the hydrological features of the Periyar River. Kahar (1988) conducted studies on the quality of the Karamana river and the Poonthura backwater. Water quality of Kallada river (Abhisheka and Binoj Kumar 2018), hydro-biological features of Kallada and Neyyar rivers (Madhusoodanan and Dominic 1999). Balachandran et al. (2012) studied the water quality of the Muvattupuzha river and (Abbasi and Abbasi 2011) worked on Punnur Puzha near Kozhikode. Study on the distribution of nutrients and phytoplankton in Thalassery and Valapattanam rivers (Lakshmi 2002). Water quality studies on the Chalakkudy river (Nirmala and Shoba 2003) reported sand as the main component of sediment. Ecology and biodiversity of Nila river (Sushama 2003), diversity of zooplankton of the Shendurni River (Shamsudeen and Mathew 2010) and hydrological analysis of Karuvannur iver (Renjith and Sreekumar 2005). Chattopadhyay et al. (2005) made a case study in the Chalakkudy river basin based on the analysis of 27 water samples during four seasons. Maya (2005) studied the nature and quality of Periyar and Chalakudy rivers. Study on the biodiversity and succession of algae in Periyar river at Aluva (Zacharias and Joy 2007). Prasad et al. (2008) compared the physico chemical parameters and environmental conditions of the

Pamba and Achenkovil rivers. Nikhil Raj and Azeez (2009) examined the spatiotemporal variations in water quality and quantity of the Bharathapuzha river basin using multivariate statistical analytical tools. Nair et al. (2010) worked on the hydrology of Meenachil river, Kottayam. Joseph and Tessy (2010) studied the water quality and pollution status of Chalakkudy river at Kathikudam. Several studies were conducted to address the quality of various rivers of Kerala (Nandan 2007). Rekha et al. (2013) worked on the comparative study of water quality index between Peruvanthanam and Valiyathodu sub-watersheds of Manimala river basin, groundwater study of Karakulam Grama Panchayat (Jaya and Deepthi 2015). Binoj Kumar and Divya (2012) studied Kazhakuttam block of Thiruvananthapuram district and coast of Ernakulam district (Sreekesh et al. 2018). Jalal and Sanal Kumar (2013) analyzed the water quality assessment in environment that affects microbiological studies of the Pamba river. Maya et al. (2013) studied the changes in chemical quality of the Neyyar river basin due to natural and anthropogenic determinants. Anitha et al. (2014) analyzed the water quality of the Periyar, pampa, Neyyar and Chaliyar rivers. Drissia (2019) reviewed the spatial and temporal variation of water stress using water footprint calculated using water stress indicator in Bharathapuzha river basin.

## 2.2 Taxonomy of freshwater algae

Assessment of the diversity of phytoplankton is crucial in the ecological study because it reveals changes in environment affects the species composition and structure. They can exhibit seasonal alterations; some members present throughout the year, but some are found at specific periods and their abundance is limited by periods of relative water scarcity. Monitoring of phytoplankton growth generally useful for evaluation of water quality. Conservation of biodiversity will provide a successful longstanding basis for ecosystem functioning and freshwater management. These are

essential for the conservation of local and global biodiversity (Moss 2000). The succession of Phytoplankton is more seasonal with a series of species throughout the year and their peak abundance may last for a week or two in each year (Sanilkumar and Thomas 2006). Dudgeon (2003) noted that due to a lack of information, knowledge about the freshwater biodiversity of tropical Asia is incomplete. Information on the algal biodiversity and related aspects in water bodies is essential for assessing water quality. Limnological studies mainly in algae have declined markedly over the last three decades, while studies covering other aquatic groups in addition to algae have intensified gradually in recent years (Irfanullah 2006). In 1754, Linnaeus gave the name algae to a group of plants and De Jussieu was the first to separate the algae well known to us today. Monographing the algal flora of India was begun in 1959. Indian algae are represented as 6500 species inhabiting both freshwater and marine environment (Rao and Gupta 1997).

## 2.3 Phycological research in India

Freshwater algae of India have been studied by several workers. M.O.P. Iyengar, K. Biswas, M.S. Randhawa, T.V. Desikachary and F.E. Fritsch made an outstanding contribution to the scientific community and phycology in India. The earliest work on algae in North India is that of (Royle 1970). North Indian Chlorophycean flora have been made by (Kant and Anand 1978; Habib 1995, 1996; Habib and Chaturvedi 2001; Singh and Saha 1982a; Suseela and Dwivedi 2001; Misra et al. 2005, 2009). Fritsch (1907a, 1907b) studied freshwater and terrestrial algae of Ceylon. West and West (1907) systematically described 276 species of freshwater algae belonging to 71 genera from Burma, Bengal and Madras. Biswas (1949) listed the typical fresh and brackish water algal flora of India and Burma. The pioneer works on taxonomy of

freshwater algal groups are accredited to (Venkataraman 1939; Krishnamurthy 1954; Desikachary 1959; Gandhi 1959; Philipose 1967; Kamat (1968) for the first time examined the freshwater flora of some parts of South India and reported several new species. The Indian Council of Agricultural Research (ICAR) published a series of the algal flora of India (Desikachary 1959; Randhawa 1959; Venkataraman 1961; Ramanathan 1964; Philipose 1967; Gonzalves 1981; Iyengar and Desikachary 1981) and these monographs have formed the basis of algal research to all phycologists in India and the world. Seasonal changes and zonation of some intertidal algae at Visakapatanam coast (Umamaheswararao and Sreeramulu 1964). Pandhol and Grover (1976) reported the algal flora of Ludhiana and its adjacent areas. Studies of Eastern Himalayan green algal flora (Das 1961; Santra and Adhya 1973, 1976; Alfred 1978). Sarma and Khan (1980) have listed 4269 algal species from India. Rao and Gupta (1997) reported 390 genera and 4500 species coming under different freshwater algal classes. River ecology is dominated by seasonal flow, mainly due to monsoonal rains. Kant and Gupta (1998) made significant works on different algal genera than any other phycologists and reported 848 taxa from Ladakh, Jammu and Kashmir. Water pollution, salinization and over-harvesting due to anthropogenic activities are critical threats to river biodiversity (Dudgeon 2000). Alterations in the Physico-chemical properties of the aquatic ecosystem due to human interventions can have a direct impact on the biotic structure (Ramachandra et al. 2002). Das and Adhikary (2012) reported 94 species, of which ten species recorded the first time from India. Barhate and Tarar (1981) enumerated 41 algal taxa from Maharashtra. Roy and Sen (1985) from freshwater algae of Chattisgarh, Madhya Pradesh. Mahajan (1987) enumerated 32 algal forms of Madhya Pradesh. Studies on the phytoplankton diversity of Maharashtra (Kamat 1968a, 1975a; Bhosale et al. 2010a, 2010c, 2010d). Jayabhaye et

al. (2007) investigated the phytoplankton diversity in parola dam, Maharashtra and noted maximum phytoplankton population during winter and minimum during the rainy season. Reports on the various studies of algal forms in Bihar (Singh and Saha 1982a; Saha and Choudhary 1984; Patralekh 1991a, 1991b, 1993a, 1994; Kargupta and Ahmad 1991). Investigation on the algal flora of Karnataka (Somashekar 1983a, 1984a; Hegde and Isaacs 1988b)). Basavarajappa et al. (2010) reported 29 algal species from Hadhinaru Lake Karnataka, Bongale and Bharati (1980a) listed 377 species of algae from the cultivated soils of Karnataka. Nafeesa and Narayana (2006) said 85 phytoplankton species from four lentic water bodies around Davangarere, Karnataka. Hegde and Isaacs (1988a, 1988b, 1989) reported freshwater algae from Uttara Kannada district of Karnataka state. The freshwater algae of Davanagere and Raichur of Karnataka state (Bongale and Bharati 1980b). Study on the freshwater algae from Karnataka (Hegde and Bharati 1983a; Hegde and Malammanavar 1988; Hegde and Somanna 1991). Bongale (1981) studied soil algae from the paddy fields of Goa and Karnataka. Assessment of phytoplankton density in relation to environmental variables in Gopalaswamy pond in Chitradurga, Karnataka (Harsha and Malammanavar 2004). Trivedy (1982) listed 62 algal forms from Jaipur, Rajasthan. Makandar and Bhatnagar (2010) from the freshwater bodies of Jodhpur, Rajasthan. Kant and Gupta (1998) reported 848 species of algae from Ladakh, Jammu and Kashmir under nine classes. Study on the algal flora of the freshwater aquatic systems of Orissa (Padhi et al. 2010). Adhikary et al. (2009) reported 307 taxa belonging to 87 genera from Orissa state. Bhakta et al. (2010) described 50 freshwater algal taxa from Sikkim, Sikkim Himalayas (Suseela and Toppo 2004), Simla (Kamat 1968b). In addition, morpho-taxonomic variation in algae was observed in the Sikkim Himalayan algal flora (Kumar and rai 2005). Bharati (1965) reported 46 species of

algae from Kumta, North Kanara. Descriptive study and illustrations on the freshwater algal flora of Andaman and Nicobar Islands (Prasad and Misra 1992, 1984a, 1984b, 1984c, 1985; Prasad and Srivastava 1992). Perumal and Anand (2008a) reported 389 taxa of algae from the freshwater habitats of Tamil Nadu and listed 252 species. Thirugnanamoorthy and Selvaraju (2009) said 14 phytoplankton genera from Tamil Nadu, (Ramadosu and Sivakumar 2010) recently recorded 136 Phytoplankton from the Perumal Lake, Tamil Nadu. Reports on the algal diversity of Tamil Nadu (Suxena 1983; Kavitha and Balasingh 2007; Murugesan and Sivasubramanian 2008a). Diversity of planktonic algae of selected Temple ponds of Mahe, Puducherry (Girish et al. 2014). Meghalaya (Gupta 2002), Orissa (Dey et al. 2008), Pune (Zaware and Pingle 2003; Pingle 2006), Uttaranchal (Khare and Suseela 2004; Suseela 2005), Uttar Pradesh (Misra et al. 2004, 2005, 2008b) and West Bengal (Pal and Santra 1984; Kargupta and Keshri 2006) are also contributions to the algal flora of India. Freshwater studies of Bhagalpur (Nasar and Munshi 1976), Garhwal (Habib 2002), Goa (Shetiya and Kerkar 2004; Geeta and Kerkar 2009), Gujarat (Manohar and Patel 1985, 1988) and Jammu (Anand 1975).

Turner (1892) published a memoir of the East Indian freshwater algae incorporating 22 species of *Myxophyceae*, 542 of desmids and 60 of some green algae. Prasad (1952) identified new species in blue-green algae from the river Varanasi. Reports on the occurrence of *Glaucocystis nostochinearum* (Itzings) Rabenhorst from Alleppey in South India (Prasad and Khanna 1987). Prasad and Saxena (1980) analyzed the ecology of blue-green algae, abundance and physicochemical properties of water in the river Gomathi during the summer season. Blue-green algae from Uttar done by (Prasad and Mehrotra 1978, 1980; Pal 1975; Pandey 1982b; Pandey and Pandey 1982; Misra et al. 2010). Chaporkar and

Gangawane (1984) enumerated 33 forms of blue green algae of cultivated soils from Maharashtra. Study and description of different species of blue green algae from Maharashtra (Barhate and Tarar 1983b; Bhoge and Ragothaman 1986a; Patil and Chaugule 2009; Patil and Deore 2010a, 2010b; Ashtekar and Kamat 1980a; Kumawat and Patil 2010; Kumawat and Jawale 2001; Suryavanshi et al. 2010). Dhingra and Ahluwalia (2007) illustrated thirty-two species of *Phormidium* from various habitats of Punjab. Abdul Majeed (1935) reported diatoms from Punjab. Jha et al. (1986) reported 60 blue green algae from the rice field soils of Pusa and its adjoining areas of Bihar. The occurrence of Chroococcaceae during rice cultivation from north Bihar (Choudhary 2009; Verma et al. 1990). Jain et al. (2011) reported 25 taxa of the order Chroococcales collected from the various habitats of Alwar district, Rajasthan. Rao et al. (2008) enumerated 89 blue green algae from the rice fields of the south Telangana region, Andhra Pradesh. Distribution of Cyanophyceae from the paddy fields of West Bengal (Mukhopadhyay and Chatterjee 1981; Pal and Santra 1982, 1985; Maity and Santra 1985; Sinha and Mukherjee 1975a, 1975b, 1984). Studies on the distribution and succession of blue green algae from rice field soils of Orissa (Padhy et al. 1992; Sahu 2000) and reported the distribution of blue green algae. Misra et al. (2009) studied Chandra Lake, Himachal Pradesh, lists on the 61 species of Chlorococcales belonging to 28 genera (Jha et al. 1985) from Gobindsagar reservoir, Himachal Pradesh. Reports on the occurrence of Cyanophycean flora of southern Himanchal Pradesh (Dwivedi et al. 2008). Prasad and Srivastava (1984a, 1986) reported different taxa on Cyanophyceae from the fresh waters of Andaman and Nicobar Islands. Reports on the distribution of blue green algae from the paddy fields of Tamil Nadu (Anand and Subramanian 1994; Anand and Revathi 1987). Significant studies on the distribution of nitrogen-fixing blue green algae in the paddy fields of India were

reported from West Bengal (Chatterjee and Chatterjee 1983) and Maharashtra (Kolte and Goyal 1985; Patil and Satav 1986; Sardeshpande and Goyal 1981). The freshwater blue green algae were also reported from Goa (Kerkar and Madkaiker 2003), Kanpur (Tripathi and Pandey 1991), Bihar (Saha 1984; Patralekh 1993b), Tamil Nadu (Ramakrishnan and Kannan 1992), Uttar Pradesh (Habib et al. 1992) and Sikkim (Santra 1984) are contributions to the knowledge of Indian blue green algae. The studies on the Cyanobacteria of rice fields of south India have been very much restricted, and they report on the occurrence of a few taxa from selected localities (Anand 1989). Thirty-six species belonging to six genera of Cyanophyceae are enumerated from Bhubaneswar and its adjoining regions (Mohanty (1982). Later he reported fifteen species of blue green algae from Bhubaneswar in 1984.

West & West (1897) described 45 species of desmids from Singapore. Report on desmids in 1902 from Ceylon and 1907 from Bengal and Madras. Descriptive study and illustrations on the freshwater diatoms from Uttar Pradesh (Prasad et al. 1981; Pandey 1982a; Chaturvedi 1985; Srivastava 2010. Misra et al. 2007). Shukla et al. (2008) collected 48 taxa of desmids from the foothills of Western Himalaya, Uttaranchal, Uttar Pradesh and reported 18 taxa of freshwater diatoms. Sarode and Kamat (1978, 1983a, 1983b, 1984) and Barhate and Tarar (1983a, 1985c) described freshwater diatoms from Maharashtra. Study on the distribution of freshwater diatoms in Maharashtra (Suryavanshi et al. 2009; Kumavat 2006; Dhande and Jawale 2008). Narkhede (2006a, 2006b) reported *Nitzschia, Surirella Punnularia, Amphora* and *Cymbella* from Suki dam in Maharashtra. Bacillariophyceae were reported (Singh and Saha 1982b; Saha 1986) from Bihar. Report on the diatom flora of Karnataka (Somashekar 1983b, 1984b; Bongale 1985). Prasad and Jaitly (1985) studied diatoms from Ladakh, Jammu and Kashmir. Saravanakumar et al. (2008) investigated seasonal

variations of phytoplankton in the creak waters of mangroves in Kutch, Gujarat with the dominance of diatom. Das and Santra (1982) listed planktonic diatoms of Senchal Lake, Darjeeling in West Bengal. Jena et al. *(*2006b) reported diatoms from Orissa state and neighboring regions in the eastern part of India. From Andaman and Nicobar Islands (Prasad and Srivastava 1981, 1983,1984b, 1985) reported different taxa of diatoms. Abdul-Majeed (1935) had illustrated 62 freshwater diatoms from Punjab. Later Venkataraman (1939) described diatoms from Madras, Krishnamurthy (1954) reported diatoms from south India. There are reports of diatoms from Rajasthan (Gandhi 1955), Mysore (Gandhi 1957, 1958a, 1959a), Kolhapur (Gandhi 1956, 1958b, 1959b) and Ahmedabad (Gandhi 1960, 1961). Reports of diatoms from Allahabad (Pandey et al. 1983a), Hyderabad (Venkateswarlu 1983), Kashmir (Mam 1995), Tamil Nadu (Rajakumar 2005; Murugesan and Sivasubramanian 2008b), Uttar Pradesh (Suseela and Dwivedi 2002), Nainital (Kamat and Aggarwal 1975) and West Bengal (Pal and Santra 1990; Bhattacharya et al. 2011) are also contributions to the knowledge of Indian freshwater diatom flora. Study on the Cyanophyceae of Meerut (Bendre and Kumar 1975) and from Pathiala (Sarma and Kanta 1978; Sarma et al. 1979). Reddy et al. (1986) reported from northeast India, (Khare and Kumar 2010) from Nainital and from Jharkhand (Sharma 2010).

Freshwater algae belonging to the order Chlorococcales collected from Uttaranchal and Uttar Pradesh (Chadha and Pandey 1977, 1978; Pandey et al. 1983b; Habib et al. 1998; Shukla et al. 2007). Report on the freshwater planktonic Chlorococcales from Bareilly district, UP (Chaturvedi et al. 1987; Habib and Pandey 1990a; Pandey et al. 1987). Prakash et al. (2005) conducted morphotaxonomic studies of freshwater chlorophycean algae belonging to the family desmidiaceae from Sidharth Nagar, U.P. He described ten taxa of freshwater desmids belonging to six

genera namely *Euastrum, Cosmarium, Staurastrum, Micrasterias, Pleurotaenium* and *Desmidium* from UP. Chlorophyceae with 36 taxa represents 18 genera (Kamat and Freitas 1976) from Nagpur, Maharashtra. Barhate and Tarar (1985a) reported 31 algal taxa of Chlorophyceae from Maharashtra. Deshmukh and Pingle (2006) studied Chlorophycean algae of Ahmednagar district, Maharashtra. Jawale et al. (2009) reported 26 taxa of freshwater unicellular Volvocales from Jalgaon district, Maharashtra, Dhande and Jawale (2009) described 23 taxa of *Cosmarium* from Hartala Lake, (Jawale et al. 2010) reported fifteen taxa of Volvocales from Jalgaon and Dhule districts, Maharashtra. Das and Purty (1990) reported 42 taxa of *Cosmarium* from Bihar. Bharati and Hegde (1982a, 1982b, 1983) worked on Desmidiaceae from Karnataka and Goa. Study on the desmids from Karnataka (Gurudeva et al. 1983; Hegde 1986b; Hegde and Isaacs 1988a, 1989; Bongale 1987). Zygospore formation in 24 desmid taxa from the North Kanara district of Karnataka was written by (Hegde and Bharati 1983b, 1986). Suxena and Venkateswarlu (1968) illustrated and described forty two taxa of desmids from Kashmir. Patel and Asokakumar (1979) reported 25 taxa of *staurastrum* from Gujarat. Patel and Daniel (1990) reported 48 taxa of *Cosmarium* and 32 taxa of *Cosmarium* from different freshwater habitats of Gujarat. Isabella and Patel (1985) described Chlorococcales from Gujarat. Study on the distribution of desmids in India (Suxena and Venkateswarlu 1966, 1970) from Pakhal Lake, Andhra Pradesh. Keshri (2009) reported eleven freshwater filamentous green algae belonging to the order Chaetophorales of West Bengal. Keshri (2010a, 2010b) studied and reported thirteen species of Ulotrichales belong to five genera: *Cylindrocapsa*, *Microspora*, *Schizomeris*, *Ulothrix, Coleochaetae, Chaetosphaeridium* and *Uronema* from West Bengal. Agarkar (1969, 1971) studied desmids from Gwalior, Agarkar et al. (1979)

conducted studies on desmids from Bhandhavgarh, M.P. and given an illustrated account of seventy one desmids from perennial stream Bhandhavgarh, one of the important national parks of the country. Toppo and Suseela (2009) described twenty eight species of *Cosmarium* from Chhattisgarh. Diversity of Chlorococcales concerning Physico chemical parameters from selected ponds in Kanyakumari district. Mohan (1987) reported the Chlorophyceae of Osman Sagar and Mir Alam, two major lakes of Hyderabad. Anand and Jitendra (2006) reported ten species of genus *Oedogonium* from Shivalik Himalayas. Tiwari and Chauhan (2004, 2007b) described species diversity and seasonal variation of desmids from the crop fields of Bichpuri, Agra. Tiwari et al. (2001) listed the Chlorococcales from Kitham Lake, Agra. Patel and Isabella (1980) reported sixteen species and one variety of Chlorococcales belonging to fifteen genera from western India. Jena and Adhikary (2007) described and illustrated fifty six taxa of Chlorococcales belonging to twenty-one genera from eastern and north-eastern states of India. They reported chlorococcales from different water bodies of Orissa, West Bengal, Assam, Meghalaya, Nagaland and Manipur. Prasad and Mehrotra (1977a, 1977b) reported desmids from the North Indian paddy fields. Reports of eighty two taxa of desmids from Nagpur (Freitas and Kamat 1979).

Diversity of Euglenineae and reported different species from Uttar Pradesh (Pandey 1985; Prasad and Chaudhary 1986; Habib and Pandey 1990b). Study on the class Euglenophyceae from different localities of Maharashtra and worked on different species like *Phacus, Trachelomonas* and *Euglena* (Ashtekar 1982; Barhate and Tarar 1985b; Bhoge and Ragothaman 1986b). 18 taxa of *Euglena* from Bihar (Gupta and Srivastava 1993) are also contributions to the algal flora of India. The studies of Euglenophyceae and illustrations from Karnataka state (Hegde and Bharati

1983a; Hosmani and Bharati 1983; Hosmani 2008)). Freshwater Euglenoides and Dinophyceae (Chaudhary and Meena 2007) from Udaipur district, Rajasthan. Srivastava and Odhwani (1990a) studied and reported 13 species of the genus *Trachelomonas* from Rajasthan. Patel and Waghodekar (1981) explained and illustrated Euglenophyceae members from other localities of Gujarat. Ratha et al. (2006) described sixty taxa of Euglenophyceae from Orissa.

### 2.4 Algal studies in Kerala

Kerala situated in the southern part of the Western Ghats, one of the biodiversity hotspots, is rich in flora and fauna including several endemics. The systematic study of the algal flora on Indian Algae, especially of Kerala is still far from complete (Easa 2004). According to him algae are one of the least known and less documented groups among lower plants and only 834 species were documented from Kerala. Significant contribution in area of ecology and diversity of freshwater algae in Kerala by MVN Panicker from 1988 onwards. His major works in Chlorophyceae are confined to filamentous green algae especially *Spirogyra*, *Oedogonium*, *Trentenpohlia* and *Chara*. Analysis of different stages of development in Chlorophyceae and many new species also adding to the biodiversity (Panikkar and Ambili 1988, 1992; Panikkar et al. 1997a, 1997b; Panikkar et al. 1989; Ushadevi and Panikkar 1991, 1993a, 1993b; Sindhu and Panikkar 1993, 1994a, 1994b, 1995b; Shaji and Panikkar 1995). Anand and Hopper (1987) made extensive works on blue green algae from the rice field in Kerala. Jose and Patel (1990) contributed new member of Rhodophyta belongs to the family Delesseriaceae from freshwaters of Kerala. Madhusoodanan and Dominic (1996b) reported the epiphytic cyanobacteria on mosses from Western Ghats of Kerala. He tried on the isolation and characterization of the non-symbiotic

cyanobacteria of the paddy fields of Kerala and studied in biodiversity of nitrogen fixing cyanobacteria from different agroclimatic regions of the state.

Radhika and Gangadevi (2005) have investigated the phytoplankton diversity in the Vellayani lake, Thiruvananthapuram and they have observed 36 species representing Cyanophyceae, Chlorophyceae, Bacillariophyceae and Dinophyceae. Seasonal influence of the phytoplankton community in different kinds of eutrophic water bodies from Kerala in two seasons and were observed 297 algal species (Ray et al. 2020). Maya et al. (2000) listed 108 species of algae from the temple tanks of four southern districts of Kerala namely Thiruvananthapuram, Kollam, Ernakulam and Alappuzha. The systematic account of Chlorococcales of Kerala (Jose and Patel 1992) and they reported twenty taxa belonging to seven genera. In 1989 reported new species of *Actinastrum* and *Ecballocystis* from Kerala. They have collected the algae from Athirapilly water falls of Sholayar river in Kerala. Sindhu and Panikkar (1995a) described desmids from various freshwater bodies of Kerala.

Panikkar and Sreeja (2005, 2006) reported the different stages of zygospore formations of desmids collected from paddy fields, ditches and ponds from Kerala. Nasser and Sureshkumar (2012) have conducted a study on the planktonic and periphytic algal flora of Western Ghats, Kerala. Abhijna and Bijukumar (2015) studied the planktonic and periphytic flora of Kerala. Shaji and Panikkar (1994, 1996) described Cyanophyceae gathered from different parts of Kerala. Diversity of algae in Kuttanadu paddy agroecosystem soils (Smitha 2017). Analysis of algal floral characteristics concerning environmental variations in Kuttanadu paddy fields (Dhanya and Ray 2015) and revealed that specific soil and climatic factors, crop growth stages have a significant contribution to algal diversity. They reported sixty four species of blue green algae from Kuttanadu during Virippu and Puncha season.

Study on the ecology and seasonal variation of microalgal community and their effect on eutrophic nature of pond ecosystem (Joseph and Joseph 2002). Zacharias and Joy (2007) studied the seasonal variation and algal diversity in Periyar river. They noticed periphytic algae were dominant throughout the year. Roy and Joy (2007) looked at the algal genera of Periyar River at Aluva, Kerala. Vaheeda (2008) documented microalgal collection from brackish water bodies and their emergence during post-monsoon at the Kodungallur area. Jose and Francis (2007) made an exploratory work on the Algal flora of Thodupuzha thaluk, Idukki district. Joshi (2010) reported 245 species of microalgae in the form of periphytons in the Pokkali fields of Vypeen island of Ernakulam District of kerala.

Jose and Francis (2008) made a systematic study on the freshwater algal flora of the Idukki district and reported four hundred and ninety four taxa and algal diversity in different habitats from the Northern region of the Idukki district. They also reported 52 algal taxa belonging to 37 genera and five classes. Jose and Francis (2010, 2013) documented 19 new taxa belonging to the class Chlorophyceae from the Western Ghats region of the Idukki district during various seasons and thirty three taxa collected from Wetlands of Idukki district, Kerala. Jithesh (2010) identified fifty-nine taxa of Phytoplankton from Mullaperiyar region in Western Ghats. Ecology and biodiversity of Thutha river (Zeenath 2011) and reported high fish diversity and phytoplankton, abundance of all biotic parameters on post-monsoon season. Nasser and Sureshkumar (2013) analyzed the relationship between environmental variables and microalgae in Peringalkuthu Reservoir, Kerala and observed 94 species of algae. Priya et al. (2015) studied the diversity of Phytoplankton belonging to Euglenophyceae in Vellayani Lake, Thiruvananthapuram. The interaction of environmental parameters with the planktonic Chlorophycean members at

Thiruvananthapuram Museum Lake (Anila and Ajit Kumar 2015). Phytoplankton diversity and its environmental implications from Vellayani and Sasthamcottah Lake (Revathy and Krishnakumar 2018). Joseph and Prakasam (2002) identified 39 genera of Phytoplankton from the Sasthamcotta Lake of Kerala.

Chaudhary and Pillai (2010) studied the diversity of Phytoplankton at Sasthamcottah Lake. Subramoni (2007) has studied the algal diversity of Vamanapuram river of south Kerala and reported 107 species belonging to 58 genera and 24 families. Maya (2007) also studied algal diversity and water quality parameters of vamanapuram river of South Kerala and reported 107 species belongs to 58 genera. Shaji and Patel (1990) described 33 taxa of desmids from various freshwater bodies of Quilon district, Kerala. Shaji (2004) told *Pleurotaenium kayei* (Arch.) Rab. var. *major* from a paddy field in Kollam district, Kerala. Descriptive analysis and illustrations of Euglenoids collected from different habitats of the Quilon district (Shaji and Patel 1991b; Shaji et al. 1995). Sheeba and Ramanujan (2005) enumerated 135 species of Phytoplankton from the Ithikkara River, Kerala. Sahib (2004b) analyzed the Phytoplankton diversity and physicochemical characteristics of Kallada river, Kerala and total of 36 genera under the class chlorophyceae as the dominant group were identified.

Tessy and Sreekumar (2009) assessed the biodiversity and seasonal variation in freshwater algae in Trichur Kole wetlands and reported 169 taxa of Phytoplankton with their composition and abundance. The diversity and distribution of algal taxa belongs to xanthophyceae, chrysophyceae and dinophyceae from Kole lands of Thrissur (2011a). Tessy and Sreekumar (2008) listed 33 taxa under Chlorococcales from the Kole lands of Thrissur. Systematic documentation of Volvocales and described four different genera from Vembanad-Kol, Ramsar site (Tessy and

Sreekumar 2012). Tessy and Saritha (2010) enumerated thirty-six algal species belonging to Bacillariophyceae and belonging to Cyanophyceae from Poyya, Thrissur district. Tessy and Shubha (2011) reported eighty two algal taxa from the coconut husk retting area in Thalikulam, Thrissur district. Algal study from Chalakudy river (Rincy and Tessy 2009) and reported one hundred and seventeen species and (Leenamol and Tessy 2009) reported eighty three algal species.

**2.5 Research in rivers of Palakkad district**

The scientific studies of the rivers in Palakkad district, Kerala are still inadequate and there is a scarcity of research data except for some research papers based on water quality and floristic study of fauna. Dinesan et al. (2004) analyzed the water availability and the status of water demands in the Bharathapuzha river basin. Bijukumar and Sushama (2001) recorded 88 species of fishes from Bharathapuzha river and (Sushama et al. 2004; Bijukumar et al. 2013) studied the distribution, distribution and conservation of fishes in Nila river. Brijesh (2006) evaluated the groundwater conditions and made a groundwater model for the basin. Nikhil raj and Azeez (2009, 2012) analysed the spatio temporal variation and trend analysis of rainfall in Bharathapuzha river. Kannan and Sabu (2010) conducted the study on the groundwater quality issues in Palakkad and Chittur taluks of the basin. Raj and Azeez (2010) conducted an attempt to explore the general rainfall pattern of the Bharathapuzha river basin using monthly rainfall data for 34 years collected from 28-gauge stations. Divya and Manomani (2013) described the effects of pollutants on the physicochemical characters, nutrient load and polluted nature of Kalpathy river. Groundwater interaction of a tropical sub-basin Bharathapuzha river (Unnikrishnan and Manjula 2014). Hydrological rainfall pattern and hydrochemical characterization of Thuthapuzha sub basin of Bharathapuzha (Manjula 2015). Drissia (2019) reviewed

the spatial and temporal variation of water stress using water footprint calculated using water stress indicator in Bharathapuzha river basin. Manjula and Unnikrishnan (2019) worked to determine the spatial and temporal variations in Physicochemical properties of the Thuthapuzha subbasin of Bharathapuzha and water utility for drinking and irrigation purposes. Divya et al. (2019) investigated the physicochemical and bacteriological characteristics of Kalpathy river. Lack of specific information is available on the distribution, diversity and species composition of the algal flora.

Sushama (2003) investigated the ecology and biodiversity of Nila river and reported phytoplankton and zooplankton communities and their abundance in relation with hydrological parameters. A morphometric analysis of Bharathapuzha river basin using GIS for the extraction of river basin and its drainage networks has been carried out using GIS (Magesh et al. 2013). Arulmurugan et al. (2010) studied the biodiversity of freshwater algae from temple tanks of Kerala in Palakkad, Kerala. Seena et al. (2019) studied the seasonal influence of phytoplankton community from the tributaries of Bharathapuzha. 81 species of algae with 12 pollution tolerant genus and noted the eutrophic nature of river.