CHAPTER-II

Review of Literature

For the first time Carolos Linnaeus used the name “Algae” to a group of plants in 1754 (Gledhil, 2008). Jussieu was the first person who defined the algae as known in the present day scenario in his contribution published in 1789 (Jussieu, 1789). After a break, Link (1820-1833) studied the algal flora of Germany and Agardh (1817-1824) worked on Scandinavian algal flora (Sambamurty, 2005). Kuetzing (1841-1849) described more number of algal genera than any other contemporary phycologists. During the period of 1842-1845, Hassal made an outstanding contribution towards the field of algology (John, 2013). Berger carried out extensive work on freshwater algae of Swede, Australia, South Patagonia, Argentina, Bolivia, Iceland and China and published during 1898-1936 (John, 2013). During 1883-1902, Lagerheim studied the algal flora of Sweden and collections from Equador, India and Abyssinia (Bordoloi, 1973). Lemmerman published his work on the algal flora of Germany and collections received from China and Paraguay during the period of 1891-1910 (Sambamurty, 2005). Nordstedt (1888) described few species of algae from Newzealand and Australia.

Among the pioneer phycologists, contributions of British researchers were also very significant. G.S. West and W. West (1889-1916) made an exclusive study on freshwater algae and discovered a number of new species from Tanganyika, Victoria, Egypt, Southwest Africa, Madagascar, West Indies, Ceylon, Burma, Bengal and Madras. Another remarkable contribution was made by Fritsch and Rich (1907-1937) on the freshwater algae of South Africa. Czurda (1922-1939) worked on morphology, cytology and physiology of Zygnemaceae. Pearsall (1932) studied on phytoplankton of English lakes. Prescott (1938) worked on some noxious algae and their control measures in different fresh water bodies. Damann (1945) investigated plankton population of Lake Michigan for 17 consecutive years.

In the field of diatom, Agardh (1824) was the pioneer worker. He published his work on diatoms including desmids. Schutt (1896) divided diatoms into two groups, *viz.* Centricae and Pennatae. Islam and Haroon (1975) and Islam and Morshed (1985) worked out the taxonomy, systematic and other aspects of the group diatom. Krishnamurthy (1954) and Gandhi (1955) have worked on diatom flora of India.

Agardh (1824) significantly contributed on the algal classification. He divided algae into six well defined orders with twenty genera. Later, Kuetzing (1843-1849), Naegeli (1847) and Robenhorst (1849-1868) were the pioneers in this field (John, 2013). Classification of algae proposed by Fritsch (1935, 1945) is one of the widely accepted and is considered as one the most appropriate one amongst them. Fritsch (1935) classified algae into 11 classes on the basis of type of pigment, nature of reserve food materials and mode of reproduction etc. Smith (1955) divided algae into divisions and further into classes. He classified algae into seven divisions with 14 classes. Chapman and Chapman (1962) had classified algae into 4 different divisions and further into 10 classes considering pigments, morphological characters, biochemical differences and phylogenetic relationships. Prescott (1969) classified algae into nine phyla with different classes based on presence and absence of true nucleus, pigmentation, biochemical nature of cell wall, reserve food material, life history and reproduction.

The invention of electron microscopy enhanced the capacity of viewing fine and detail structures of algae which help in postulation of several advanced schemes of algal classification. The classification proposed by Round (1973) was one of the popular one among them. He divided algae into 12 phyla and further into classes. Some of the advanced classification of algae were put forwarded by Lee (1980), Rosowski and Parker (1982), Corliss (1987) etc. Recently many authors keep Cyanophyceae or blue green algae with bacteria due to its prokaryotic nature rather than keeping it with other groups of algae (Christensen 1962). Komarek (1979, 1983) did extensive taxonomic work on Chlorococcal algae of Cuba.

The study of fresh water algae is the study of algae in many diverse inland habitats ranging from rivers, lakes, ponds, streams, wetlands, ephemerals, snow and ice etc (Wehr and Sheath, 2003). Broadly fresh water algae inhabit all habitats that are at least slightly wet, other than oceans and estuaries (Wehr and Sheath, 2003). There are no exclusively freshwater divisions of algae, but certain groups exhibit greater abundance and diversity within fresh waters, especially Cyanophyta, Chlorophyta, and Charophyta (Smith, 1950). Within the green algae, conjugating greens and desmids (Zygnematales) comprise a group that almost exclusively occupy fresh water bodies (Bourrelly, 1985).

Most of the freshwater algae are cosmopolitan, but some Chrysophytes, Cyanophytes, Chlorophytes , Rhodophytes, and Bacillariophyceae were reported to be endemic (Tyler, 1996; Hoffmann, 1996; Kociolek *et al*. 1998).

Regarding the freshwater ecology of algae remarkable contributions had came from many renowned workers. Coker (1954) studied the ecology of streams, lakes and ponds of United States. Edmondson (1959) published the book “Freshwater biology” which contributes a lot in this field. Lund (1965) described algal productivity in lakes and its related factors. Arnold (1969) studied the ecological status of Lake Erie. Lofflar (1969) studied the ecology of high altitude lakes of Mt. Everest. Bennett (1970) studied the ecology of lakes and ponds of New York. Khan and Siddiqui (1971) studied the role of nitrogen and phosphorus in freshwater planktons. Shehata *et al*. (2008) provided a critical description of distribution pattern of aquatic algae in river Nile with special reference to its treatability in drinking water. Seasonal variations in phytoplankton abundance and their composition were studied of Euphrates River in Al- Hindiya barrage and Kifil City region of Iraq by Hassan *et al*. (2010).

Algae are also used as indicator of environmental quality. Cohn (1853) for the first time focused on the difference in algal community between pure and polluted water bodies. During the early decade of twentieth century, use of algae as indicator of organic pollution was explored by Kolkwitz and Marsson (1908) in European streams and rivers. Storm (1924) assessed water quality using phytoplankton and investigated the ecology and geographical distribution of freshwater algae and plankton in a number of water bodies. Ruth Patrick and C. Mervin Palmer were pioneers in the development of algae based monitoring to assess the ecological health of rivers in North America (Patrick, 1949; Patrick *et al.*, 1954; Palmer, 1969). Several workers used algal indicators of environmental conditions based on the environmental sensitivities and tolerances of individual taxa and species composition of algal community (Butcher, 1947; Zelinka and Marvan, 1961; Sladecek, 1973; Lowe, 1974; Lange- Bertalot, 1979). A number of workers (Nygaard, 1949; Brook, 1965; Cholnoky, 1968; Findenegg, 1971) studied algae as biomonitoring tool of pollution assessment. Rice (1938) found that organic pollution has negative impact on the growth of diatoms. Prescott (1939) reported that oligotrophic lakes are dominated by Chlorophycean flora along with diatoms and that of eutrophics are characterized by dominance of Cyanophycean members. Nygaard (1949) proposed five indices to evaluate the load of organic pollution of water body on the basis of algal groups, assuming that various algal groups have different tolerance level to organic pollution and material enrichment. Kratz and Meyers (1955) found that algae grow extensively in a pH range of 3.8 to 6.5. Prescott (1962), after an extensive study in Michigan and Wisconsin reported that blue green algae are rare or absent in lakes with pH below 5. Brook (1965) reported that some desmids are indicators of oligotrophic water and some others are of eutrophic water. Palmer (1969) for the first time identified and prepared a list of algal genera and species tolerant to organic pollution including 60 genera and 80 species. He gave them some points depending upon their level of tolerance to organic pollution. Friedmann and Ocampo (1976) have reported Chlorooccidiopsis as the most desiccation resistant Cyanobacteria known so far. Presence of algae as disturbance indicator of biological equilibrium in tanks was studied by Fay (1983). Algae as an indicator of salinity of water was reported by Bold and Wynne (1985). Algae as indicators of pesticide residues and chemical fertilizers were studied by MacCann and Cullimore (1979). Recently, algae were widely used to monitor and assess ecological conditions in many types of aquatic ecosystems (e.g., Weber, 1973; Dixit and Smol, 1991; Dixit *et al.*, 1992, 1999; Bahls, 1993; Whitton and Rott, 1996; Biggs *et al.*, 1998; Kelly *et al.*, 1998; Stevenson and Bahls, 1999).

Algae have the capability of reducing pollution in soil and water by removing the toxic compounds and heavy metals (Whitton, 1975; Rai *et al.*, 1981) and acting as an active biodegrading organism (Kuritz and Wolk, 1995). For the first time Oswald *et al.* (1957) discovered the use of algae for removal or biotransformation of pollutants, including nutrients and xenobiotics from contaminated water and soil. John (2000) introduced the term "phycoremediation" for the remediation process carried out by algae. A number of workers used microalgae for removal of nutrients from different wastes (Beneman *et al.*, 1980; De-Bashan *et al.*, 2002; Gantar *et al.*, 1991; Queiroz *et al.*, 2007). Rajamani *et al.* (2007) studied the phycoremediation of heavy metals using transgenic microalgae in Ohio, USA. Murugesan *et al.* (2007) studied the phycoremediation of oil refinery effluent using Cyanobacteria. In a study carried out by Rao *et al.* (2011) revealed that that *Chlorella vulgaris* exhibited appreciable nutrient scavenging properties under both laboratory and field conditions. Sivasubramanian and

Muthukumaran (2012) studied phycoremediation potential of *Chlorococcum humicola* in an oil drilling effluent treatment plant at Kakinada, Andhrapradesh.

Vollenweider (1974) introduced the method of measuring primary productivity of aquatic systems based on phytoplankton productivity in his book "A Manual of Methods of Measuring Primary Production in Aquatic Environments". Riley (1963) illustrated relationship between phytoplankton productivity and trophic chains in marine habitat. Miller *et al.* (1974) studied the algal productivity in 49 lakes by using the method of algal assays. Goldman (1966) studied the primary productivity in aquatic environment based on the photosynthetic production of algae. Roger and Reynaud (1977, 1979) reported that low temperature decrease productivity and favour eukaryotic algae but high temperature favours both phytoplankton productivity and eukaryotic algae (Cyanobacteria).

Oil spill creates surface film on water that prevents gaseous exchange and adversely affects the growth of living organisms including algae (Schramm, 1972). Crude oil contamination generally found to be inhibitor of photosynthesis and growth in algae (Gaur, 1981; González *et al.* 2009). Anderson *et al.* (1974) have emphasized the potential toxicity of water soluble fraction of crude oil on algae. However, Batterton *et al.* (1978) observed no toxic effects of water soluble fractions of test crude oil to three microalgae studied in his experiment. Pulich *et al.* (1974); Soto *et al.* (1975); Kauss and Hutchinson (1975) and Gaur (1981) found significant reduction in algal growth in aqueous oil extract.

Low molecular weight hydrocarbons were found to stimulate or inhibit phytoplankton growth depending upon the species (Dunstan *et al.,* 1975). Stimulation of growth due to low concentration of oil in nature and laboratory condition were reported by Gordon and Prouse (1973). Some of the important studies on the effects of crude oil on algae both in laboratory as well as natural assemblages of crude oil were carried out by Batten *et al.* (1998), Edgar *et al.* (2003), Lee and Page (1997), Suderman and Thistle (2004) and Varela *et al.* (2006). Experimental studies have shown inhibitory effects of crude oil on algae in a wide range of ecosystems (Dahl *et al.,* 1983; Stepaniyan, 2008; Nayar *et al.,* 2005). Although the effects vary with season and location, some studies are found to be reported no significant effect of crude oil on algae (Fabregas *et al*., 1984; Padros *et al.,* 1999). Most of these studies were carried out in marine ecosystem or marine algae. In comparison to marine oil pollution, inland and freshwater oil pollution has received much less attention (Zhu *et al.*, 2001).Information about impact of onshore crude oil pollution on the ecology and seasonal variation of phytoplankton is very less. However, though freshwater spills tend to be of smaller volumes than their marine counterparts (Stalcup *et al.* 2003), they have a greater potential to endanger public health and the environment because they occur within populated areas and may directly contaminate surface water and ground water supplies (Zhu *et al.* 2001).

Both filamentous and membranous green algae have been found to be susceptible to crude oil spill (Baker, 1971). Though they are quickly killed due to oil contamination, populations can recover rapidly by growth and vegetative reproduction through unharmed fragments or spores (Baker, 1971). Such resilience capacity varies from species to species. The species of Chlorophyta have the ability to invade areas from which other species have been eliminated due to crude oil contamination (Cowell, 1971). Cyanophyta show significant growth in different types of habitats polluted by crude oil or crude oil industry effluents (Crosby *et al.*, 1954; Konig, 1968; Spooner, 1970). Several species of BGA, particularly *Oscillatoria* sp. showed luxuriant growth in the presence of oil contaminants (Kauss *et al.*, 1973; Snow and Scott, 1975; Hellebust, *et al.*, 1975; Sholtz and Tebo, 1975). Certain diatoms are found to be not affected by oil spills but reproductive abnormality have been reported in them (Patrick, 1964). Phytoplankton species have been reported to show tolerance to the effects of oil spill (McCauley, 1966). Various species of *Lyngbya*, *Oscillatoria*, *Ankistrodesmus*, *Chlamydomonas*, *Closterium*, *Gonium*, *Scenedesmus*, *Asterionella*, *Cyclotella*, *Fragilaria*, *Meridion*, *Navicula* and *Euglena* have been reported to be tolerant to oil contamination (McCauley, 1966).

Phycology in Indian context was started much later than that of the rest of the world. The algological works by the Indians can be distinctively grouped into three periods-the pioneering works were done by British researchers from 1798 to 1854 on some classical works like description of seaweeds, *Chara* etc. and the second period from 1858 to 1907 some classic and valuable works were done by professional workers (Kant and Gupta, 1998). Wallich (1860) collected and described some fresh water diatoms and desmids from lower Bengal. Lagerheim (1888) described 52 desmids from Bengal. Turner (1883) published an account of “The Freshwater Algae of East India” which included detailed contribution of algal flora recorded so far. West and West (1897) described a large number of algae including desmids, diatoms, several species of blue greens and some red algae in their book. Other algologists worked during that period were Hobson (1863), Martens (1871), Zeller (1873), Dickie (1882), Joshua (1888).

The third and the present phase of algal study started in India from 1919 where Indian researchers started to work on algae. Ghose (1919-1927) studied the blue green algae of Burma and Punjab. Iyengarr (1920-1954) published several works on Volvocales, Chaetophorales, Zygnemales and Blue green algae of India (Sharma, 2003). He has discovered and reported several new species. Because of his enormous contribution, Iyenger is called as "The Father of Modern Algology in India". Bruhl and Biswas (1922-1926) initiated phycological works in Eastern India. Bharadwaja (1933-1940) contributed on BGA of Uttar Pradesh and he established a school of algal research at Banaras Hindu University. Rao (1936-1954) published series of works on Myxophyceae and Zygnemaceae of Uttar Pradesh. Another important contributor to Indian phycology was Randhawa (1959) who carried out investigations on species of Zygnemaceae, Oedogoniales and Vaucheriaceae. His monograph on Zygnemaceae is a valuable ethic. Prasad (1952) described some new forms of Nostocaceae from river of Baranasi. Krishnamurthy (1954) described for the first time the freshwater diatom flora of South India and reported a number of new forms. Gandhi (1959, 1960) presented a detail account of diatoms collected from Sagar and also the diatom flora of temporary ponds of India and reported many new taxa. Desikachary (1959) published his monograph "The Cyanophyta" which was an exclusive document for the workers till today. Vasistha (1960) working on Myxophyceae of India reported two new species and one new variety. The morpho-taxonomic studies of Eastern Himalayan algal flora have contributed by Das (1961), Santra and Adhya (1973, 1976) and Alfred (1978).

Vaidya and Patel (1972), Prasad *et al.* (1976), Prasad and Saxena (1977), Prasad and Melhotra (1977a, 1977b, 1978), Kant and Anand (1978), Prasad and Asthana (1979), Abdus Salam (1979) , Bongale and Bharati (1980), Patel *et al.* (1980), Pandey and Pandey (1980a & 1980b), Barhate and Tarar (1981), Barhate and Tarar (1983a, 1983b), Prasad and Fatma (1981a, 1981b), Prasad and Fatma (1982), Akhtekar (1982), Das and Santra (1982), Goyal (1982), Mohanty (1982), Subramanian (1983), Pandey (1985), Prasad and Srivastava (1984a, 1984 b), Prasad and Mishra (1984), Prasad and Srivastava (1985, 1986, 1992), Jha *et. al*. (1985), Manohar and Patel (1985), Hedge (1986a, 1986b), Prasad and Khanna (1987), Isaacs and Hedge (1989), Habib (1996, 1997), Kant and Gupta (1998), Singh and Gupta (2000), Suseela and Dwivedi (2001), Mishra *et al*. (2002, 2005), Muthukumar *et al.* (2007), Arulmurugan *et al.* (2010) are some valuable contributions in the field of phycological research in India.

Studies on phytoplankton diversity in response to abiotic factors in Veeranam Lake in the Cuddalore district of Tamil Nadu was studied by Senthilkumar and Sivakumar (2008). Seasonal variation of phytoplankton in a freshwater tank of Maharashtra was studied by Milind (2008). Das (1957) studied the ecology of a few fresh water bodies and evaluated interrelations between physical, chemical and biological parameters therein. Das (1970, 1971) studied the ecology of some freshwater lakes of Kashmir. Zutshi and khan (1988), Anand (1988), Bhattacharya *et al.* (1988) did commendable works on ecology of water bodies and concluded that physical and chemical characteristics of water significantly affect the algal population. He also found that pH, total alkalinity and Carbon-di-oxide of water play an important role on phytoplankton succession and finally leading to eutrophication. Ahluwalia *et al.* (1989), Parimala and Ayyappan (1989) stated that chlorine, sulphate and organic carbon play a vital role in the formation of bloom.

The variations of algal composition in pure and polluted water bodies were studied in India by Seenaya (1972), Rama Rao *et al.* (1978). Verma and Dalela (1975) during their study in Kalindi River designated *Oscillatoria*, *Spirogyra* and *Stigeoclonium* as pollution marker. Similar results were also obtained by other workers during their own study in different aquatic systems (Patrick, 1965, Jeeji Bai and Rajendraran, 1980). Zutshi *et al*. (1980) made a comprehensive limnological study on nine lakes of Jammu and Kashmir and concluded that the tropic evolution of lakes occurred due to human interference

Mishra and Saksena (1991) during their studies in Moras river in Madhya Pradesh stated that *Anabaena, Scenedesmus, Closterium, Navicula, Euglena gracilis, Phacus* were pollution indicator algae. Rajkumar *et al.* (1994) with their study on plankton species and environmental relationship in urban aquatic ecosystems stated that in urban areas species association is related to physicochemical aspects of environment but in case of rural areas it is related to nutrient availability. Ragothaman and Patil (1995) made a study in Narmada Estuary and counted the algal number as 60 units/ml to 18000 units/ml which may be due to seasonal variation in the extent of agricultural runoff. Ramakrishnan (2003) illustrated bio-monitoring processes for aquatic bodies and applied this in two water bodies in Tamil Nadu for water quality assessment with a conclusion that water resources can be quantified by bio-monitoring technology more efficiently than conventional chemical methods. Kumar and Singh (1974), Tripathi and Talpasayi (1980) studied the toxic nature of some freshwater blue green algae.

Parvateesam and Gupta (1994) studied the physicochemical characteristics of a lake receiving effluents from textile mills in Rajasthan and concluded that wastes coming from textile mills alter the physicochemical characters of freshwaters and thereby the aquatic lives inhabiting there. Baruah *et al*. (1996) studied the effect of paper mill effluent on the water quality of a wetland (Elenga Beel) in Jagiroad of Assam and found that the water was highly polluted due to the chemical waste of the paper industry. Priyadharsini and Ramachandra (1998) stated that fishy odour, high TSS, alkalinity, hardness, phosphates, coliform population and predominance of *Microcystis* indicating the deterioration water quality. Tessy and Sreekmar (2008) studied the impact of pollution on algae in Thrissurkol wetlands, a Ramsar site of Kerala.

After an extensive physicochemical and biological survey in many water bodies of India, Trivedy *et al*. (1985) came to the conclusion that most of the water bodies in India harbours pollution tolerant Cyanophycean algae. Valecha *et al.* (1987) made an attempt to classify the lakes of Bhopal with regard to its trophic status on the basis of Nygaard index. Khan (1991) reported that the change in water quality correspondingly changes the species diversity. Pal *et al*. (1992) studied the organic pollution level of Hugli River using algae as pollution indicator. Pandey (1993) evaluated the water quality of Nainital lake of Central Himalaya to determine the impact of seasonal variation on physico-chemical and microbial characteristics of the lentic ecosystem. Kaur *et al*. (1996) studied the abiotic and biotic components of a fresh water pond of Punjab. Physicochemical characteristics and their relation with the growth of phytoplankton were studied by Rajan *et al*. (2007) in Birganj.

Kumar *et al.* (1974) observed that Cyanophyceae and Euglenoid flagellates were mostly associated with organically rich water bodies with having low oxygen content. Research regarding the ecology of blue green algae was done by a number of Indian authors (Joshi *et al*., 1981; Rai, 1990). Munawar (1974) performed limnological studies on fresh water ponds of Hyderabad. Alam *et al*. (1996) studied the relationship in the presence of plankton in four heavily polluted freshwater ponds. Algal response to environmental changes and nutrient fluctuation was studied by Frempong (1981), Sudhakar *et al.* (1981).

In India a few works had been done on affect of crude oil pollution on the ecology of fresh water algae. Singh and Gaur (1988) recorded 16 species of epilithic algae in a stream polluted by Digboi oil refinery effluent. Recently, biodegradative capacity is reported in many blue green algae (Subramanian and Uma, 1997). From the observations of several researchers (Shashirekha *et al*., 1997; Joseph and Joseph, 1999, 2001a and b) it was established that some algal species were tolerant to phenol and phenolic effluents generated in oil refineries. Joseph and Joseph (2002) studied ecology and seasonal variation of microalgal community in an oil refinery effluent holding pond in Kochi, Kerala. They found that a resistant microalgal community with distinct seasonal variation inhabited the refinery effluent holding pond. Baruah *et al.* (2009) reported 22 taxa of fresh water algae from three effluent drains of Guwahati Oil Refinery. Rajasulochana *et al*. (2009) collected and identified few algal species belongs to *Chroococcus, Oscillatoria, Lyngbya, Scenedesmus, Scytonema* and *Spirulina* in oil refinery effluent from Ennore (Chennai) India.

The north east region of India is not lagging behind on algal study. Several researchers have been working on algae of this part of India since British era. While working on algal flora of Bengal, Biswas (1922-1950) covered some parts of erstwhile Assam and that was indeed, a pioneering piece of work in the field of Phycology in Assam (Bordoloi, 1973). Bruhl and Biswas (1929) studied on algale of the Loktak lake, Manipur. Biswas (1934) published his works on observations on the algae collections from the Khasi and Jaintial Hills. Bordoloi (1976) studied the algal flora of Ward Lake of Meghalaya with special reference to the seasonal change. Reddy *et al.* (1986) carried out a preliminary survey on blue green algae of North-East region and reported 52 species of BGA under three orders. Alfred (1978) studied the algal flora of Shillong, while Changkakati (1989) gave an account on algal flora of entire Meghalaya. Singh *et al*. (1996, 1997a, 1997b and 1997c) studied the rice field blue green algal flora of Mizoram, Tripura, Arunachal Pradesh and Nagaland respectively. They reported 64 species of BGA from 224 soil samples of rice fields of Nagaland, 79 BGA species from 213 samples from

Tripura and 83 blue green algal species from 450 soil samples of Arunachal Pradesh. Jena and Adhikary (2007) recorded forty six taxa of chlorococcales from different water bodies of North eastern states of India. Yasmin *et al* (2011) conducted an investigation on planktonic desmids of North East India, including Assam. A total of 38 taxa of desmids were reported in their investigation.

Parukutty (1940) was the pioneer of phycological studies in Assam. She collected and described few species of chlorophyceae and cyanophyceae from different places of the state. Bordoloi (1973) collected and described mostly on fresh water algal community in her work on algal flora of Assam. She has also reported few aerial epiphytes, sub-aerials, endophytes, and lithophytes from the state. Devi (1981) had made a detailed account of algae found in Darrang District of Assam. Hazarika and Gogoi (1985) studied algal flora of hot springs in Assam where they reported that cyanophycean algae were the chief constituent of hot spring vegetation. Yadava *et al.* (1987) studied the productivity and limnology of Dighali Beel of Assam.

Baruah and Bordoloi (1988) studied the physicochemical and biological parameters of drains flowing through Guwahati city and recorded a number of organic pollution tolerant algae. Hazarika (1988) studied the distributional pattern of cyanobacterial flora of rice fields of Golaghat district of Assam. Baruah and Bordoloi (1990) studied the pollution status and phytoplankton composition of Deepor beel using Nygaard indices. Bairagi and Goswami (1992) while working on ecology of water blooms in some ponds of North East India reported that higher concentration of nutrients such as dissolved organic matter, Phosphate and total nitrogen favours the abundance of Chlorococcales.

Saikia and Bordoloi (1995) reported 28 species of rice field blue green algae from Assam. Talukder (1997) recorded 64 species of blue green algae from rice fields of Kamrup district. Raut and Dey (1999) made a detailed study on algal flora from rice fields of Barak Valley of Assam.

Nandi and Rout (2000) recorded 66 algal species from different habitats of Silchar, Assam. Ahmed and Kalita (2001) studied the distributional pattern of BGA in Nagaon. Hazarika *et al*. (2002) studied Myxophycean algal biodiversity of Lakhimpur district of Assam. Hazarika and Devi (2003) reported four species of *Spirulina* from stagnant water of beels from Lakhimpur district. Saha *et al*. (2007) during their survey on biodiversity of epilithic cyanobacteria from freshwater aquatic system of Kakoijana reserve forest of Assam reported 29 species under 18 genera and 12 families. Phukan (2008) studied the distributional pattern of phytoplankton in water logged rice fields of Lakhimpur district of Assam. Baruah *et al.* (2009) studied the oil refinery effluent drains of Guwahati city and reported 24 species of algae, where genus *Oscillatoria* (8 species) was recorded as dominant. Das *et al*. (2009) studied diversity of Oscillatoriaceae in Greater Guwahati. Laskar and Gupta (2009) conducted a seasonal study on phytoplankton diversity and dynamics of Chatla Beel, Barak valley, Assam. Saikia *et al.* (2010) worked on algal indices to predict pulp and paper mill pollution load in Elenga Beel of Marigaon district, Assam. Bordoloi and Baruah (2014) assessed water quality of a historical pond of Tinsukia district of Assam using using Palmer's index.

Kakati (2011) enumerate algal diversity in eight historical ponds of undivided Kamrup district of Assam and reported 462 algal species under 125 genera. In a preliminary study on desmid flora of Urpad Beel, Goalpara district of Assam, Deka *et al.* (2011) recorded 91 species of desmids under 14 genera. Deka and Sarma (2011) reported 68 species of cyanophycean algae under the family Oscillatoriaceae from different fresh water bodies of Goalpara district, Assam. Phukan and Bora (2012) studied diatom flora in ponds, lakes and rivers of the Sivasagar district of Assam. Baruah and Kakati (2012) investigated water quality and phytoplankton diversity of Gopeswar temple pond of Kamrup District (undivided) Assam and recorded 45 species of phytoplankton. Gurung (2013) assessed diatom diversity of Deepor Beel-a Ramsar site of Assam and recorded 65 diatom species belongs to 26 genera. Out of the total 65 species 54 were pennate and 11 were centric type. Deka (2014) conducted taxonomic enumeration of BGA of Goalpara District, Assam and recorded a total of 144 BGA species belonging to 14 families and 38 genera. A floral study on freshwater algae of Sivassagar district was done by Phukan (2013). She reported 264 taxa of algae belonging to 6 classes, viz. Cyanophyceae (73 species under 20 genera); Chlorophyceae (148 species under 50 genera); xanthophyaceae (2 species under 1 genera); Baccilariophyceae (28 species under 11 genera); Euglenophyceae (12 species under 3 genera) and Rhodophyceae (2 species under 2 genera). Dihingia (2015) reported 71 species of N_2-fixing BGA belonging to 20 genera and 9 families from different rice fields of Kamrup district, Assam.

Few researchers done prominent works specially on BGA in Assam were Devi and Boissya (1981), Hazarika and Gogoi (1985), Bhuyan (1999), Hazarika *et al*. (2001), Choudhuri (2004), Hazarika (2004) and Hazarika (2007).

A little investigative work has so far been done to understand the effect of crude oil on fresh water algal community in the region. Gaur (1981) studied phycology of Guwahati refinery effluent and reported high abundance of *Lyngbya limnetica*, *Oscillatoria chlorine*, *O. curviceps*, *Phormidium foveolarum* (Cyanophyceae); *Achnanthes minutissima*, *Cymbella ventricosa*, *Gomphonema gracile*, *Nitzschia amphibian*, *N. hungarica*, *N. palea*, *Pinnularia appendiculata* (Bacillariophyceae); *Chlorella vulgaris*, *Chlosterium acerosum* (Chlorophyceae). Singh and Gaur (1988) recorded 16 species of epilithic algae in a stream polluted by Digboi oil refinery effluent. They observed detrimental effects of oil refinery effluent on algae. On the other hand, growth of blue green algae, particularly two species of *Oscillatoria* (*Oscillatoria formosa* and *O. princeps*) were found to be increased. Adhikary (1997) investigated impact of Bongaigaon petroleum refinery effluent on algal flora of Tunia river of Assam. Cyanophyceae, specially the members of the family Oscillatoriaceae were found dominant in his study. Baruah *et al.* (2009) reported 22 taxa of fresh water algae from three effluent drains of Guwahati Oil Refinery. Present worker (Bordoloi and Baruah, 2015 a) studied composition and seasonality of phytoplankton in an crude oil effluent holding pond of Digboi oil field and reported thirty six phytoplankton species under twenty seven genera and the number get increased to 139 species in the Digboi oil refinery effluent stream (Bordoloi and Baruah, 2015 b). Bacillariophyceae was the dominant group with 45 species followed by chlorophyceae with 40 species in that oil contaminated stream. The study also revealed that total oil content along with pH, inorganic phosphorus and nitrate influence the distribution and abundance of phytoplankton in crude contaminated water bodies (Bordoloi and Baruah, 2015b).