REVIEW OF LITERATURE
CHAPTER - 2
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Limnological study:

Limnology is related to the study of various aspects of fresh water ecosystem, within continental boundaries. Water is the most vital resources for all kind of life and basic inevitable element for human civilization. It is the most important component of aquatic ecosystem. Aquatic ecosystem or wetland, which includes river, lakes, reservoirs etc. are the precious life sustaining water resources. There exist a complex inter-relationship between the physico-chemical environment and the organism in a water body. A seasonal variations in ecological parameters exerts profound effects on the distribution and population density of aquatic organism. Algal community is directly or indirectly influenced by the interaction of a number of physico-chemical factors. Several physical, chemical, and biological circumstances acting simultaneously, must be taken into consideration in understanding the fluctuation of planktonic population. Prasad (1916) was one of the earliest pioneer Indian workers in the field of limnology who observed the seasonal condition governing the pond life in Punjab. This was followed by the valuable contribution of Pruthi (1933) who worked on plankton in relation to water chemistry in the Indian Museum Tank at Calcutta. Most of the limnological information pertains to temperate waters of America and Europe. Little is known about the limnology and hydrobiology of tropical waters. Though progress of limnology was rather slow in the initial period it gets momentum from 1960 onward. The main aim of early workers, was to obtain baseline information of plankton and water chemistry to be used in pisciculture. Prasad and Singh (1980) have reviewed the algal hydrobiology in India. According to Gulati and Wurtz-Schulz (1980) in developing country like India, with pressing problem of population growth and threatened environment, limnological studies should be on problem related to utilization of water resources for food production, pollution control, public health, water supplies and environmental education programmes.
Studies of physico-chemical characteristics are essential and fundamental to know the diversity and complexity of an aquatic ecosystem. Any two fresh water resources may neither be identical in physico-chemical characteristics nor be static in biological sense (Elder, 1965). Besides this the seasonal fluctuation brings rapid change in the physico-chemical and biological characteristics of water particularly in smaller fresh water bodies. To understand the relationship between the distribution and the productivity of an aquatic ecosystem, it is necessary to study its physico-chemical properties. Relationship of physico-chemical characteristics of water and quality and quantity of aquatic biota have been extensively studied by various workers (Welch, 1952; Hutchinson, 1957; Needham and Needham, 1962; Ruttner, 1963; Edmondson, 1965; George, 1966; Kaul and Zutshi, 1967; Venkateshwarlu, 1969; Zafar, 1964, 1967, 1968; Unni, 1969; Seenaya, 1972; Kant and Kachroo, 1975; Munawar, 1974; Adoni, 1975; Wetzel, 1975; Zutshi and Vass, 1977; Trisal, 1977; Tyagi, 1979; Cole, 1979; Khatri, 1984; Munshi and Munshi, 1995; Singh and Roy, 1995; Tiwari, 1999; Sahat et al., 2001; Mariappan and Vasudevan, 2002; Das et al., 2002; Dutta Gupta et al., 2004; Fasihuddin and Puttaiah, 2004; Rajgopal et al., 2010; Singh et al., 2013). Ravi and Sivakumar (2012) made significant study on seasonal variation of phytoplanktons population and physico-chemical characteristics in three perennial pond of Chidambaram, Tamil Nadu. A comparative assessment of physico-chemical conditions and plankton diversity of river Tons and Asan in Dehradun was done by Isaq and Khan (2013).

Tropical reservoirs are generally characterized by rich population of phytoplankton (Srinivasan, 1964). In spite of the fact that a good amount of work has been done on fresh water ecology of lentic and lotic ecosystem in India, a relatively less information are available with respect to the state of Rajasthan. Limnological study in different parts of Rajasthan has been carried by Ratnam and Joshi (1952), Sarup (1958), Vyas and Kumar (1968), Bohra and Bhargava (1976), Bohra (1978), Mishra et al., (1976), Sharma (1980), Kulshreshtha and Gopal (1981), Goel et al., (1981), Mahajan et al., (1981) etc.
Temperature is an important factor in controlling the fluctuation of plantation and functioning of any water body (Dwivedi and Pandey, 2002; Singh and Mathur, 2005). The development of algae is directly depend upon temperature in association with inorganic nutrients and light (Singh, 1960; Hutchinson, 1967; Rai and Kumar, 1979). Vyas and Kumar (1968) also found a close correlation of phytoplankton production with temperature. Transparency is a physical variable significant to primary production. The maximum transparency was recorded in winter season attributed to the sedimentation of suspended matter (Kadam et al, 2007; Shah and Pandit, 2012).

pH is considered as an important ecological factors and is the result of the interaction of various substances in solution in the water. It is the scale of intensity of acidity and alkalinity of water and measure the concentration of hydrogen ions. In natural water, pH remained in slightly alkaline range. Higher value of pH is directly proportion with the water productivity (Khan and Khan, 1985). Generally, it shows a significant positive correlation with carbon dioxide (Marimuthu and Krishnamurthy, 1985). The conductivity of a sample is a numerical expression of its ability to carry an electric current which in turn depend on the ionic strength. Unni (1985) suggested that lower value of electrical conductivity in the larger water bodies and higher value of it in smaller water bodies, are mainly due to large quantity of water and lesser quantity of water, respectively.

Hardness of water is principally due to salts of calcium and magnesium salts and generally a significant positive correlation is present among hardness, calcium and magnesium (George, 1966; Saran and Adoni, 1984; Adoni and Joshi, 1985). Hutchinson (1967) summarized that the hard water with high alkalinity generally exhibit greater phytoplankton population as compared to soft water. Hard water contains large concentration of alkaline earths derived from drainage of calcareous deposits. Kataria et al. (1996) suggested that
higher values of total hardness in summer are mainly due to higher temperature which increases the concentration of salts by excessive evaporation.

Dissolved oxygen levels are considered as the most important and commonly employed measurement of water quality and indicator of a water body's ability to support desirable aquatic life. The occurrence of dissolved oxygen in water is mainly due to physical and biological process. It has been found that dissolved oxygen and carbon dioxide showed an inverse relationship (Gonzalves and Joshi, 1946; George, 1966; Munawar, 1970; Patel and Nandan, 1984; Adoni and Joshi, 1985; Patil et al., 1985). A reciprocal relationship between oxygen and organic matters has been noticed by various workers (Zafar, 1964; Singh, 1960; Munawar, 1970; Rao, 1972). The concentration of dissolved oxygen may vary during different season and it has been studied that the lower value of it during summer season may be attributed to the higher temperature and activity of microorganism and higher value during winter due to lower temperature which enhanced the oxygen dissolving capacity (Agarwal et al., 1976; Rai, 1978; Sikandar and Tripathi, 1984; Salve and Hiware, 2006).

Carbon dioxide is added to aquatic ecosystem by rainwater inflowing groundwater and respiration of aquatic organisms. It dissolves more readily in water than oxygen and its dissolution depends on temperature, pressure and mineral content of water. It shows inverse correlation with dissolved oxygen (Singh, 1965; Vyas and Kumar, 1968; Sankhla, 1981). Free carbon dioxide displayed positive correlation with water temperature, phosphate and total alkalinity and negative correlation with other parameters (Vikal and Tyagi, 2006).

Calcium and magnesium is an important constituent in natural water and plays a significant role in the biological production of the lakes and ponds. In fresh water, chlorides are generally present as salts of sodium, calcium and magnesium (Ganapati, 1956). It imparts salty taste to water (Sohani et al., 2001). Generally, organic pollution influences the chloride concentration in
water bodies (Singh, 1960; Adoni, 1975). Verma (1967) stated that higher value of chloride in water may be attributed to pollution of animal origin. Shukla et al. (1989) observed maximum value of chloride during summer and minimum during rainy season and suggested that the latter may be due to dilution of water by precipitation. Nitrate content is excellent parameters to judge organic pollution and it represents the highest oxidized form of nitrogen. Similar finding were observed by Kedar et al. (2007) and Sahni and Yadav (2012). Unni (1985) detected nitrate in trace from major reservoirs of India. Ganapati (1960) suggested that unpolluted tropical water is deficient in nitrates. Nitrate and phosphate have been accepted as the main causal factor for eutrophication by many workers including Munawar, 1970; Zdanowski, 1982; Patil and Goudar, 1985; Forsberg and Ryding, 1980; Rathore et al., 2006. Vyas (1968) observed lower concentration of phosphate throughout winter and summer and higher in rainy season and suggested that the latter may be due to addition of phosphate through drainage and sewage. Harney et al. (2013) observed higher value of phosphate during summer and suggested that it may be due to rapid evaporation and mineralization of decomposed material in pond water.

Floristic:

A floristic study on the fresh water algal flora reveals the species composition and taxonomic diversity of biological communities in an ecosystem. In addition, it reflects the seasonal variation, evolutionary processes, ecological functions and stability of aquatic ecosystem. Floristic study on algae has attracted a much attention from different regions and habitats. Belanger et al. (1836) seem to be one of the pioneer on Indian algological researchers. Wallich (1860) was the first to contribute to the study of desmids. He described seven genera and eight species of Desmidiaceae. Grunow (1865) was the pioneer worker in the field of Diatom flora of the Indian region. Carter (1858) was the first to pay attention to the study of
phytoplanktonic forms. He also collected a few Volvocales from some puddles in Bombay. Martens (1870a, 1870b) made a contribution to the Bengal algae. Dickie (1882) described twenty-eight species of diatoms from the Himalayas. Lagerheim (1888) described fifty-two species and varieties of desmids from Bengal. Turner (1892) made a contribution to the fresh water algae of East India. He described 22 species of Myxophyceae, 60 species of Chlorophyceae and 542 species of desmids.

West and West (1907) recorded fifty-nine species of diatoms, one hundred forty-eight species of desmids and fifty-three species of other green algae. Ghose (1919, 1923) made an outstanding contribution of algological researches in India. He described the Myxophyceae of Lahore and Simla. Iyengar (1925) described a new species of Hydrodictyon and two species of Botrydium. In 1932, he discovered the genus Fritschiella. The discovery of this genus is of great significance. Bruhl and Biswas (1922, 1922a, 1926) have contributed greatly to our knowledge of Indian algae, many papers and monographs containing description of many new species and observation on their habitat, periodicity, ecology and distribution. Biswas (1924, 1925, 1926, 1930, 1934, 1949) made an outstanding contribution to the knowledge of the algae of Eastern India. He studied the algae Manipur, Assam, of the salt lakes of Calcutta, Chilka Lake and Khass and Jaitia hills. Randhawa (1936a, 1936b, 1939a, 1948, 1958a) has made tremendous work on Indian Zygnemaceae and extensively studied the fresh water algae of North India.

Bharadwaj (1933, 1934, 1935, 1963) and Rao (1936, 1937a, 1937b) made a great contribution to the knowledge of blue green algae of United Provinces. Banerji (1935, 1936, 1938) made systematic studies of the blue green algae of lower Bengal. Algal flora of paddy field soil and Myxophyceae of the United Provinces was described by Singh (1939a, 1939b). Gonzalves and Gangla (1949) made observation on the algae of paddy field soil near Bombay and have described many species which are new record for the country. Mitra (1947, 1950, 1951) studied the algal flora of Indian soil. Venkataraman (1957)
has studied the algal flora of the ponds and puddles inside the Banaras University. Singh (1941, 1960) explored the Chlorophyceae of Banaras and made phytoplanktonic study of Uttar Pradesh.


A significant study on algae has also been carried out by various workers in the different region of the world. Crow (1923) described fresh water algae from Ceylon. Peterson (1935) had studied the biology and taxonomy of soil algae. Fritsch (1935, 1942) made a significant study on the physiology and described the interrelations and classification of Myxophyceae and also authorized a manual “Structure and Reproduction of Algae” in which he has
described all classes of algae. Drouet (1942, 1951) had contributed for algae in a series and also made a significant study on Myxophyceae. Prescott (1951) extensively described the algae of the Western Great Lake in which he accounted all group of algae along with physico-chemical condition. Forest (1965) described the soil algae community of Soviet. Chapman (1962) extensively described the algae entitled as “The Algae”. Hock (1963, 1964) made a significant study regarding taxonomy of algae. Sahin (2007) reported two new records for the fresh water Algae of Turkey. Sevindik et al. (2010) observed 24 new records for the fresh water algae of Turkey. Shin et al. (2013) studies the nine newly reported species of Chlorococcales from Hongcheon river, Korea. Sovran et al. (2013) worked on the desmids flora of Serbian peat bogs and reported 220 desmids of 22 genera.

Desert algae have also received much attention by various workers. Bolyshev and Manucharova (1947) studied the distribution of desert algae. Shield and Drought (1962) recorded the distribution of terrestrial algae of Nevada test site. Shtina and Bolyshev (1963) have described the soil algae of arid Steppes. Friedmann (1964, 1968) studied the endolithic and xerolithic algae of Negev Desert. Ocampo-Pous and Friedmann (1966) have described the Chlorococcalean desert algae. Forest and Wetson (1966) described the Atacama Desert algae and proposed the line of modern algal taxonomy.

**Algal groups: Distribution and Diversity**

Algae play an important role in maintaining the aquatic ecosystem and form the base of food chain and food web. It may be observed in every water supply exposed to sun light. A number of factors have been attributed to influence the diversity of algae. Except a few soil algae, the majorities of them are aquatic and develop in the water of ponds, lakes, reservoir, stream and oceans.

Blue green algal taxa have very wide range of distribution which often occurs in a variety of habitats. Gonzalves and Joshi (1943a, 1943b, 1946)


Wallich (1860) reported Chlorococcales from Bengal, first time. Bruhl and Biswas (1922) described the Chlorococcales of Bengal and recorded twenty nine taxa of this order. Dixit (1937) studied the Chlorococcales of Bombay presidency. Iyengar and Venkataraman (1951) have done work on the Chlorococcales of Madras state. Philipose (1967) described 208 species and 110 varieties of Chlorococcales from India in his monograph. Jha et al., (1985) describe the Chlorococcales of Gobindsagar Reservoir (H.P.). Dhande (2013) described the 19 taxa of Chlorococcales from Hartala tank, Jalgaon in which two taxa were reported first time from Maharashtra.

A significant study on Volvocales of India was carried out by Iyengar (1920, 1933). Carter (1858) reported some Volvocales from some puddles in Bombay and made observations on the fertilization process in Eudorina elegans. Iyengar and Desikachary (1981) have described the Volvocalean taxa from unicellular to colonial form in their monograph.

Suxena (1955) studied the Euglenophyceae from Hyderabad. Philipose (1988) described seventy taxa of Trachelomonas from different region of India. Hedge and Sujata (1997) recorded 77 taxa belonging to 35 taxa of Euglenophyceae from rain water pools of Dharwad, Karnataka state. Narkhede (2006) described the eleven taxa of Euglenophyceae from Hatnur dam in which seven taxa were reported first time from North Maharashtra.

different aquatic habitats of Lalkuna, Kathgodam and Pantnagar areas of Uttarakhand State and Pilibheet District of Uttar Pradesh, which are region of foothills of Western Himalaya. Mishra et.al. (2008) collected 42 taxa belonging to 7 genera of desmids from Garhwal region of Uttarakhand (Western Himalaya). Dwivedi et al. (2009) described the desmids of Southern Himachal Pradesh of Indo-Western Himalayas. Deka, et. al. (2011) studied the desmids flora of Goalpara District of Assam. They observed 91 species of 14 genera of desmids. Das and Keshri (2012) made systemic investigation on the 12 taxa belonging to 5 genera of desmids and its biodiversity of Manmecho Lake, Sikkim, Eastern Himalaya.

A number of factors have been attributed to influence the diversity of phytoplanktons in any aquatic ecosystem. So, the Phytoplanktonic diversity of Rajasthan Desert area is very interesting due to its extreme climatic conditions and has been studied by many workers. Anantani and Marathe (1947a, 1947b) studied the soil algae of arid and semi-arid regions of Rajasthan. Singh (1949) studied the sub aerial algae along with ecological factors from Mount Abu. Bhandari (1951, 1952) reported Characiosiphon rivulais and 30 other taxa of blue green algae from Jodhpur. Goyal (1964) also reported some blue green algae from Jodhpur. Vyas (1968) described the phytoplanktons and the ecology of the famous “Pichhola Lake” Udaipur. Gupta and Kumar (1968) described the blue green algal flora of Udaipur and its neighborhood. Kumar and Singh (1977) studied the algae of certain habitats endemic to the Rajasthan. Srivastava and Nigam (1979) studied soil algae of arid and semi arid region of Rajasthan. Yadav and Bhardwaj (1979) studied the fresh water algae of Rajasthan especially from Ajmer and Kishangarh. Srivastava and Nigham (1980) reported the soil algae from arid region meanwhile from the same habitat. Srivastava and Dwivedi (1983) described some chlorococcalean taxa. Dwivedi (1984) described the algae of arid region of Rajasthan. Soni and Bhardwaj (1980, 1988) studied the blue green and chlorophyceae in temporary and permanent ponds of Bikaner. Srivastava and Odhwani (1991) described twenty one algal forms belonging to eleven genera of the order volvocales from

Algal periodicity:

Quality and quantity of algae varies from season to season. Seasonal periodicity of algal forms in lakes and ponds has been presented by many researchers. Fritsch and Rich (1913) and Flint (1938) reported the maximum density of desmids during the rainy season occurred due to dilution of water. Vyas (1968) reported the maximum numbers of phytoplanktonic species during winter season while the maximum quantity occurred during the summer season and also found the dominance of blue green algae during the summer season and Diatoms during the rainy season. Patil (1990) studied the seasonal variations in distribution and abundance of blue green algae in relation to physico-chemical characteristics of water for two years at Bhopal. Parvateesam and Mishra (1993) reported total 88 forms belong to Chlorophyceae, Chrysophyceae and found definite correlation between the change in various
physico-chemical parameter and number and kinds of these groups of algae. Khanum (1997) observed the ecology of Cyanobacteria and found that they persisted throughout the year but showed a tendency to develop two peaks—one in summer or early monsoon and another at the end of monsoon season, and concluded that the pattern of rainfall and regimes of temperature were apparently responsible for their periodicity. Tiwari and Chauhan (2006) reported the abundance of Cyanophyceae during summer months. Gehlot and Barupal (2010) reported the maximum numbers of phytoplanktonic species as well as maximum density during winter season. They also reported the dominance of Chlorophyceae and Euglenophyceae during the winter season and Cyanophyceae during the summer season. Sharma et al (2011) observed the dominance of Chlorophyceae during winter as well as rainy season. Summarwar (2012) observed the highest density of phytoplanktons in summers.