Review Literature

REVIEW LITERATURE

The work on blue green algae incorporates mostly the botanical description of the forms collected and identified at different locality. The review of initial publications revealed mear identification based on morphology and the ecology of the forms. As the knowledge of these organisms accumulated, the trend in identification went on changing. As these organisms are photosynthetic prokaryotes the microbiologist also paid attention to these organisms and hence the classificatory trend showed application of cultural characteristics.

The middle of 20th century witnessed a voluminous publication by Desikachary, (1959). This volume on cyanophyta is still considered to be the sole hand book for the blue green algal classification and identification. Though voluminous work has been carried out on these photosynthetic prokaryotes, in India the monograph by Desikachary still remains a guideline for the researchers on blue green algae. Desikachary gave a detailed account of morphology, taxonomy, ecology and distribution of the forms occurring throughout the Indian subcontinent. Some comments on evolution and phylogeny have also been made in this monograph. The system of classification followed in this monograph is the modification of Fritsch's classification (1944) with some considerations by Papenfuss (1955). The classification dose not followed Fritsch's but also considerd views of other phycologist eg. the consideration of order Stigonematales is as proposed by Borzi (1914). Desikachary also supported the Fritsch's view regarding the origin of hormogonales and that the Stigonematales are morphologically highly evolved.

Blue green algae are ubiquitous in nature. They occur in a wide variety of environmental conditions and wherever life is possible. Mainly the blue green algae grow luxuriantly in the soil hence the occurrence and distribution is studied by number of phycologist worldwide. The publications appeared during the second half of 20 th century have been confined to the blue green algae occurring within the soil. As blue green algae are productive in their nitrogen fixing ability and the nitrogen is the major requirement of paddy crop the blue green algae are widely associated with this crop. A critical survey of literature on blue green algae reveals that large volume of publication is confined to the occurrence, ecology, systematic, and physiology of blue green algae from paddy field soils.

The pattern of classification followed in the volume cyanophyta is as follow.

Phylum CYANOPHYTA Smith

Class Cyanophyceae Sachs

Order CHROOCOCCALES Wettstein

Fam. Chroococcaceae Nageli

Fam. Entophysalidaceae Geitler

Order CHAMAESIPHONALES Wettstein

Fam. Cyanidiaceae Geitler

Fam. Chamesiphonaceae Borzi

Fam. Dermocarpaceae Geitler

Order PLEUROCAPSALES Geitler

Fam. Pleurocapsaceae Geitler

Fam. Hyellaceae Borzi

Order NOSTOCALES Geitler

Fam. Oscillatoriaceae (S. F. Gray) Dumortier ex Kirchner

Fam. Gomontiellaceae Elenkin

Fam. Nostocaceae Kutzing

Fam. Scytonemataceae Rabenhorst ex Born. and Flah.

Fam. Microchaetaceae Lemmermann

Fam. Rivulariaceae Rabenhorst

Order STIGONEMATALES Geitler

Fam. Capsosiraceae Geitler

Fam. Pulvinulariaceae Geitler

Fam. Nostochopsidaceae Geitler

Fam. Diplonemataceae (Borzi) Elenkin

Fam. Mastigocladaceae Geitler

Fam. Mastigocladopsidaceae Iyengar and Desikachary

Fam. Stigonemataceae Kirchner

While studying seasonal variation in algal flora of sewage Singh *et al* (1970) recorded abundance of *Oscillatoria* and *Phormidium*. Kumar (1970) enumerated twenty two genera and one hundred and six species of cyanophyceae from Saradhana locality. Khan *et al* (1970) recorded forty one different forms of blue green algae from Dehradun. Pot experiments to analyze the effect of algalization on the yield of rice

varieties were carried out by Goyal and Venkatraman in (1970). These authors studied the effect of inoculation of species of *Tolypothrix, Aulosira, Anabaena, Nostoc* etc.

New forms of *Anabaena* such as *A. spinosa, A. vaginicola, A. ambigua*, and *A. variabilis* were reported by Laloraya and Mitra (1971) from the soils around Coimbatore Tamilnadu. Different media were tried to isolate the pure cultures of these forms.

Kamat (1972) studied fifty nine taxa belonging to seven genera of order Oscillatoriales from Mysore state. Khan and Rawat (1972) reported algal flora of Swamps from Golatappar.

A taxonomic enumeration of different algae occurring in Marathwada Maharashtra was made by Kamat (1974). He listed fifty four taxa of Myxophyceae from that area. Thity five taxa belonging to seven genera of Nostocales were reported from nine different places within Mysore state by Kamat (1974). Pal and Yadav in the same year (1974) recorded one hundred and eight forms of blue green algae from Sharangpur district, West Bengal. Effect of inoculation of *Oscillatoria tennuis* and *Nostoc commune* on the early growth period of paddy crop was studied by Rao and Patnaik (1974). This work is considered as a role model in the enrichment of soil fertility and increasing nitrogen level from the soils. Burger (1974) studied the two populations of *A. planktonica* to determine the seasonal changes in cell composition. The relationships of heterocyst to akinetes were studied. This author concluded that heterocyst frequency is inversely related to total combined nitrogen and ammonia suppress heterocyst formation and nitrogen fixation.

Singh (1975) reported the effect of different fertilizers on the heterocyst differentiation from different species of *Nostoc Cylindrospermum* and *Anabaena*. The species were isolated from Iowa State USA. Initially the taxa were maintained in modified Chu-10 medium. However, the effect of concentration of various fertilizers on the growth and differentiation of heterocyst within these species was analyzed by him. Increase in the grain production through application of twenty four taxa of blue green algae from the paddy fields of Bankura district West Bengal was studied by Sinha (1975).

Monthwise distribution and its correlation with various physico-chemical factors in the occurrence of cyanophyceae were studied by Nasar and Munshi (1976) from ponds of Bhagalpur Bihar. The occurrence of blue green algae from barks of various trees from Nagpur Maharashtra was studied by Kamat and Harankhedkar

(1976) they recorded forty six taxa belonging to seventeen genera of blue green algae. Algal flora of Ludhiyana and its adjacent area was studied by Pandol and Grower (1976).

Different species of blue green algae growing in the streams from Miranshav (Jammu) were recorded by Anand (1979). Algae of Rohilkhand division U. P. were studied by Pandey and Chaturvedi (1979), where they recorded thirty seven species of blue green algae. A list of soil algae from Sagar (M. P.) was published by Mishra and Purohit (1979). Sarma *et al* (1979), Studied Algal flora of Patyala. They reported seventy nine species belonging to twenty two genera of cyanophyceae. The fixation of nitrogen by *Gloeocapsa* species was studied by Grover and Puri (1979) under culture condition. They isolated pure culture of the organism and repeated transfer of forms ultimately showed partial acetylene reducing ability.

A comparison between *Nostoc* and *Anabaena* species based on thirty characteristics was made with the standard numerical taxonomic methods by McGuire (1982). The data supported two separate and distinct though similar genera.

Studies on *insitu* nitrogen fixation by *Nostoc commune* Voucher at the West Fold hills Antarctica were carried out by Davey *et al* (1983). They measured the asetylene reduction by *Nostoc* species by twelve month period at the ice free West Fold hills. Their observations showed that substantial nitrogenase activity occured during the summer but ceased when vegetation temperature fell below -7° C.

Effect of lime, N, P, K pesticides and grazing animals on blue green algae was studied by Singh and Bisoyi (1989).

Verma *et al* (1990) reported twenty seven blue green algal forms from paddy fields of districts of Bihar.

Eighty two species of blue green algae were identified by Manab Deka and Bordoloi (1991) from paddy fields of Assam. They also identified heterocystous and non heterocystous forms and gave quantitative estimation of these forms.

Dwivedi *et al* (1992) isolated *Microcystis aeruginosa* in axenic cultures and recommended the improved medium with higher pH supplemented by phosphorous. They recommended the best growth of this alkali tolerance bloom forming alga in their improved media. Composition of soil blue green algae was studied by Padhy *et al* (1992) from Ganjam district Orissa. Correlation of pH and EC with the occurrence of cyanobacterial forms was also studied by them. Extensive collections were made

by Ramkrishnan and Kannan (1992) from Muthupet Tamil Nadu and recorded thirty five species of blue green algae.

Large number of paddy fields were screened for the occurrence of blue green algae from Bangladesh by Begum *et al* (1993). They reported ninety three forms from thirty two genera. Santra (1993) published a detailed account of blue green algae from the paddy field soils. Describing the various aspects of blue green algae he gave taxonomical, cultural, ecological, and agricultural aspects of these blue green algae. Soils from these localities from West Bengal were cultured using different culture media and the organisms growing recorded by Santra. In all two hundred and forty taxa from the rice field soils were described. The seasonal variations in the occurrence of various forms were also described by him. After the Desikachary's volume Santra's volume has also became a guideline in the identification of blue green algae growing in the paddy field soils.

Algal composition of soil samples collected from Assam were studied by Saikia and Bordoloi (1994). They reported sixty five isolates belonging to twelve genera. Shaji and Panikkar (1994) studied cyanophyceae of Kerala. Natural populations of blue green algae in paddy fields of Tamil Nadu were studied by Anand and Subramanian (1994). They reported sixty three taxa.

Anand and Santakumar (1995) reported one hundred and fifty eight taxa of blue green algae belonging to thirty three genera from the rice field soils of Kerala. Maximum species diversity was observed in the paddy field soils of Kerala by Madhusoodanan and Dominic (1995). They investigated occurrence of blue green algae before planting, transplanting, tillering and harvesting period. The examination of nitrogen fixing forms from forty two cyanobacterial isolates was done by Suseela and Goyal (1995).

Life cycle of *N. commune* Voucher collected from soils at Schirmacher Oasis Antarctica was studied by Gupta and Kashyap (1996). Their observations showed that this alga remained predominantly in this stage with conspicuous sheath. However aserriate stage block under cultural conditions. Distribution pattern of blue green algae in different agro climatic zone from paddy field soils of Orissa was studied by Sahu *et al* (1996). They reported one hundred twenty heterocystous and twenty three non heterocystous forms of blue green algae. Simmilarly Nayak *et al* (1996) also reported one hundred twenty forms from different paddy field soils from Orrisa. Sharma and Naik (1996) isolated thirty two blue green algal species of which twenty

eight were non heterocystous and four were heterocystous, from Pithora block of Raipur district Madhya Pradesh. Blue green algae of Mizoram were studied by Irabanta and Singh (1996) from rice fields.

Singh *et al* (1997) studied blue green algae from rice growing areas of Arunachal Pradesh reporting eighty three species belonging to twenty five genera. These species were isolated from four hundred and fifty soil samples. Around seven districts of Arunachal Pradesh were covered under this study. Extensive liminological studies were carried out by Hegde and Sujata (1997) of three freshwater lentic habitalts of Dharwad Karnatak. They reported number of Myxophyceae from these habitalts. Effect of different neem preparation on growth, protein content, nitrogen fixation and extracellular amino acids was studied by Mishra and Adhikary (1997). They concluded that the lower concentrations do not harm the nitrogen fixing ability, while decreasing the protein content and extracellular amino acid secretion. In the same year Kaur *et al* studied the response of diazotrophic cyanobacteria to butachlor. The results showed that lower concentration within the range of 4-5 µg/ml have the algicidal effect. Singh *et al* (1997) studied blue green algae from rice field soils of Nagaland reporting sixty four species belonging to thirty one genera. In another publication Singh *et al* (1997) have reported the cyanobacterial flora from soils of Tripura. Role of blue green algae in determination of soil environment and structure was studied by Goyal (1997). Response towards different fungicides and insecticides by *Nostoc calcicola* was determined by Anand and Subramanyam (1997).

Pandey *et al* (1998) studied the physicochemical characters of Fatehsagar lake of Udaipur Rajasthan. They reported presence of large number of species belonging to cyanophyceae. Diversity and similarity indices of periphytal blue green algae in Kochin backwaters were studied by Sreekumar and Joseph (1998) in which the presence of blue green algae was of considerable importance. Balachandar and Kannaiyan (1998) studied the effect of immobilization on growth and ammonia excretion by nitrogen fixing cyanobacteria. Their observations showed that immobilization of blue green algae on solid matrices improve the ammonia excretion capacity. Twenty four species of genus *Oscillatoria* were reported by Sen and Gupta (1998) from Gangetic plains. Jha *et al* (1998) isolated blue green algae from the different depths of soil and studied their nitrogenase activity. Their conclusions revealed that higher the depth lower the nitrogenase activity.

Cyanobacterial flora of rice field soils of eight districts of Manipur was studied by Amita Devi *et al* (1999). Thirty four genera of blue green algae were isolated from one hundred and three soil samples. Algal flora of rice fields from Irongmara (Barak Valley, Assam) was studied by Raut and Day (1999). They correlated the occurrence of organisms with the pH and alkalinity of soil samples. Ahmed *et al* (1999) surveyed the distribution pattern of blue green algae in rice field soil of Nagaon (Manipur) they reported seventy four algae belonging to sixty four species. Tiwari *et al* (1999) studied the blue green algae of arid zones from Rajasthan reporting seventeen heterocystous and three non heterocystous forms.

Blue green algae of different habitalts such as streams campus, rice fields and plant surfaces from Darga Kona area Silchar (South Assam) were studied by Nandi and Rout (2000). A total of sixty four algal species belonging to forty four genera were recorded by these authors. Effect of inoculation of blue green algae from rice fields in Egypt was studied by Rahman and Soliman (2000). Some biochemical studies were also conducted by these authors. Maya *et al* (2000) studied the freshwater algae from the different temple tanks of Southern Kerala. Uma Maheshwari and Anand (2000) tested the response of *Tolypothrix*, *Scytonemoides* to various concentrations of copper. Cyanobacteria from paddy fields of Durg district of Chattisgarh were recorded by Shrivastava (2000). Utilization of agriculturally important microorganisms on rice crop was investigated by Gulati and Marwaha (2000). It was observed by them that the inoculation of blue green algal mixture sustained the productivity and maintained the soil fertility. Cyanobacterial flora and properties of paddy field soils from Jabalpur and Katni district of Madhya Pradesh were studied by Singh *et al* (2000).

Cyanobacterial abundance and their relative distribution from rice field soils at different crop growth stages was studied by Nayak *et al* (2001). Mishra *et al* (2001) studied the cyanobacterial diversity in Terai belt (Uttar predesh). They also studied the nitrogen fixing potential of local heterocystous isolates. Distribution pattern of blue green algae in rice field soils of Hojai subdivision Assam was studied by Ahmed (2001). Algal periphytons of the river Pandu were studied by Tiwari and Kaur (2001). They reported nine cyanophycean genera in their report. Tiwari *et al* (2001) studied algal dynamics of Ganga River at Kanpur. This flora showed presence of thirty seven blue green algae. Nitrogen fixing potential of cyanobacterial isolates of rice field soils of Nagaon subdivision Assam was studied by Ahmed (2001). Physiological

characterization of some Rivularian isolates from paddy field soils of Uttar Pradesh was done by Mishra and Dikshit (2001). The characters studied in these experiments were, biomass production, growth rate, generation time, nitrogen fixation and pigment composition. Singh (2001) made a note on cyanobacterial flora of Rampur and its adjoining area of Uttar Pradesh. They reported twenty four taxa from five families. Singh *et al* (2001) studied the soil samples from twenty four Parganas of West Bengal. Cultures were raised to analyse the blue green algal composition and the dominant species were recorded. Study was conducted by Mishra *et al* (2001) to analyse rice field algal flora of different regions in Tarai belt Uttar Pradesh. Thirty heterocystous strains were isolated from the samples. Cyanobacteria of rice fields from Lakhimpur were studied by Hazarika *et al.* (2001). Eight taxa of *Spirulina* were reported from the fishpond at Anjale by Kumawat and Jawale (2001). Association and succession of blue green algae at different growth stages of rice crop were studied by Sen (2001). Selvakumar *et al* (2001) isolated and characterized the cyanobacterial isolates from herbicide applied rice fields. Acid tolerance cyanobacteria from the rice field soils of Tamil Nadu were isolated by Tamilselvam *et al* (2001). They studied five forms and their characteristics. Application of some potential blue green algal strains in rice cultivation in unsterilised soil condition in pot cultures were studied by Ahmed (2001). Uma Maheshwari *et al* (2001) studied differential response of cyanobacteria to copper. They concluded that increased concentration of copper decreases pigment composition.

Cyanobacterial diversity in agroecosystems of Kashmir was studied by Ara *et al* (2002). Soil cyanobacteria of southern Rajasthan were studied by Pandey (2002). She sampled two hundred forty soil samples from six different areas recording fifteen nitrogen fixing forms. The dominance of *Oscillatoria* was the prominent feature. Studies were conducted by Hazarika *et al* (2002) from Ranganadi and its adjoining area of Lakhimpur District of Assam Seventeen species of *Oscillatoria* were encountered in this study. Nitrogen fixing potential of blue green algae isolated from rice field soils if Hojai subdivision Naga Assam was studied by Ahmed and Kalita (2002). Kaur *et al* (2002) studied the effect of bimetalic combinations of heavy metals on growth and development of cyanobacterium *Anabaena doliolum*. Various concentrations of nickel, cobalt, zink and cadmium were tried in their experiments. Sharma and Srivastava (2002) performed comparative electrophoretic protein profile of *Spirulina fusiformis*. These experiments revealed that there are twelve polypeptide

bands including two major, five moderate and five feeble ones. Cyanobacterial diversity in rice field soil of Sambalpur Orissa was studied by Das (2002). He reported thirty five species of thirteen genera.

While describing the morphology and taxonomy of cyanobacteria Ramakant *et al* (2004) described the genus *Aphanothece.* The same authors (2004) performed database and physiological characterization of agriculturally important unicellular cyanobacteria of Uttar Pradesh.

Bigeya Th *et al* (2005) made biodiversity documentation of agriculturally important cyanobacteria of rice fields of Aurangabad Maharashtra.

Balamurugan *et al* (2007) worked on *Spirulina platensis.* They showed that these blue green alga increases the weight of chicks when used as poultry feed.

Growth features and the cultural characteristics of the newly reported *Symphynemopsis* were studied and its evolutionary aspects have been discussed by Kant *et al* (2008). They considered the "v" shaped branching as a connecting link between *Symphynema* and *Mastigocladus*. Further they have concluded that the genus could be reasonabally placed in Nostocales and not in Stigionematales as was done by earlier phycologist. Narkhede P. N. (2008) described eight species of *Spirulina* from Katnur Dam, Jalgaon and Maharashtra which are to North Maharashtra. Naskar N. M. and Naskar K. R. (2008) describe nine taxa of *Anabaena* Bory from bheris of North 24-Parganad District, West Bengal.

Tiwari *et al* (2009) describe the morpho-taxonomy of coccoid Cyanobacteria. In their article they have classified the coccoid cyanobacteria based on various concepts of different workers. A list of Indian contribution on cyanobacteria after Deikachary has also been added in this article.