Review Literature

Charophyte study in India started long back in nineteenth century when Alexander Braun described charophytes from Indian subcontinent. About eleven species of charophytes were described by Braun (1873). The oldest record of algal collection shows that the first algal species reported from Bombay presidency was that of *Nitella*. Two species of *Nitella* namely *N. accuminata* and *N. dispresa* were described in the report. This report was made by Stroke (1847). Never the less, actual work on charophytes from India was initiated during the first decade of the twentieth century. It was Hate (1909) who reported two species of *Chara* viz. *C. verriculata* and *C. flaccida* from Bombay island. Two volumes on British Charophyta were published by Groves and Webster (1920). It was first attempt of classical work on charophytes. Addition to this was made by Groves (1922 – 24) by reporting *Nitellopsis* from northern India. Allen (1925) also made important contribution to the knowledge of charophytes from Utter Pradesh. Nuclear and cell division in *Nitella* and *Chara* was observed by Karling (1926). J. Groves (1928) published notes on charophytes collected by Mr. Thomas Blow. This collection contained three hundred eighty four dried specimens.

Karling (1928) found basis of cytological observations in charophytes when he knew that antheridial filaments were usually favorable for the study. He studied series of nuclear and cell division stages in growing tissues. According to him the number of filaments in an antheridium may be as high as 200 and each filament consisted of average 75 cells. Thus single antheridium would contain as many as 15000 – 20000 cells in separate linear series. The cells of these filaments are free from chloroplast, other pigment bodies and stored food material. In Characeae, antheridial filaments show a high degree of synchronization of division of nuclei. In *Chara zeylanica* quadriscutate and octoscutate nature of antheridium was recorded by Groves J. (1931)

Pal (1932) studied various aspects of charophytes such as distribution, ecology, economic importance and systematic account on Burmese charophyta. He suggested that distribution of charophytes was abundant in hilly regions rather the plains. Kundu (1934) observed algal specimens collected by Dr. Agharkar from Nepal and found some fruiting plants of *Chara canescens*.

Zaneveld (1940) did an extensive work on charophytes of Malaysia and adjacent countries. He gave taxonomic account of twelve species of *Nitella*, eleven species of

Sunderlingam and Francis (1958) studied two species of *Chara, C. zeylanica and C. corallina,* in order to elaborate study of nature of shield cell in antheridia. The algal collections of Prof. M.O.P. Iyengar (1958) are the memorial things in the history of phycology of India. In his studies Prof. Iyenger reported a new species of *Nitella* viz *N. terrestris* sp. *nova.* This was first record of terrestrial charophytes though it closely resembled to *N. tenuissima* and *N. batrachosperma,* which differed from them in having quadriscutate antheridia and gametengia on special axillary branches. Sunderlingam (1959) gave a systematic account of South Indian charophytes. He described nine species of *Nitella* and ten species of *Chara* from South India. A new species of *Chara* was described by Sunderlingam viz. *Chara vandularansis.* For the first time Sunderlingam provided a taxonomical key for identification of charophytes. Contempory to the South Indian work Allen (1961) published series of notes on charophytes from Banaras, United provinces in Northern India. In his notes he decribed a new species of *Nitella, N. saharanpurensis* sp *nova* similarly he described sixteen species of *Nitella* and thirteen species of *Chara* in his report.

Phylogenetic study and interrelationships of charophytes were discussed by Desikachary and Sunderlingam (1962) with a definite phylogenetic scheme. They considered two distinct lines of evolution among the charophytes such as *Nitelloideae* and *Charoideae.* According to them *Nitella* being more advanced than *Chara* and within *Chara* ecorticated forms were considered to be derived from corticated ones. These authors also commented on origin of charophytes from chaetophorelian algae. Sunderlingam (1962 – 1963) studied the developmental morphology of some species of *Nitella* and *Chara.* In *Chara, C.corallina* and *C. wallichi* were studied for their developmental aspect.

The first voluminous work on Indian charophytes was published in the form of monograph by Pal et al (1962). Eighty six species belonging to seven genera have been dealt in this monograph. Each species has been described in detail with its ecology and distribution in India. Till today this is the sole monographic work on Indian charophytes, and serves as the first hand information to the phycologist working on charophytes.

The seventh decade of last century showed flourished development in the work of charophytes throughout the India from North to South. Western Indian region was also studied by Vaidya and Gonzalves (1963). They reported thirty one species of charophytes belonging to two genera, *Chara* and *Nitella* from Western Maharashtra. In addition to

Chara and one species of *Nitellopsis*. In addition, distribution pattern of charophytes was also given in his account.

Our knowledge of charophytes especially from then Bombay Presidency has been enriched by Prof. S.C.Dixit (1931, 1935, 1940a, 1940b, 1942) who reported about seven species of charophytes from Salsette near Bombay. Dixit also reported nine more species from and around Pune (1940). During the first quarter of twentieth century no reports on charophytes found either from north or from south India is known to us. Biswas (1949) made reports on algal studies in India. He divided the algal study period in India into three parts viz. Early period (1798 – 1860), middle period (1861 – 1900), and recent period (1900 – onward). However, thorough search of literature during the past century shows that till the beginning of twentieth century the work on charophytes was restricted to some patches like Bombay Presidency, Uttar Pradesh, and Madras presidency.

Extensive work on charophytes was undertaken by Wood, who for the first time published an index of *Characeae* (1950). He published a revised list of species belonging to *Characeae* world over in 1952. According to him there were one hundred sixteen species of *Chara*, one hundred fifty-three of *Nitella*, thirteen of *Tolypella*, four of *Lamprothamnium*, three of *Nitellopsis*, two of *Protochara* and one of *Lychnothamnus*. In addition to this list of charophytes, a list of useful taxonomic literature world over was also provided by the author. Imahori published a list of charophytes in Micronesia in 1952. Wood (1952) made a detailed ecological analysis of charophytes. A survey of twenty-six water bodies in Woods Hole region, Massachusetts, was made to determine the occurrence of Characeae with respect to major environmental conditions. Imahori (1954) studied ecology, phytogeography and taxonomy of Japanese charophyta.

As an interesting group of algae charophytes drew attention of many phycologists. It was Sunderlingam (1954) who studied the structure and development of the stem, branchlets, and the reproductive structure, cortex, stipulodes, antheridia and oogonia in *Chara zeylanica*. He also studied germination of oospores and its further development in the species. These developments were confirmed later in other species of charophytes. Till this time (beginning of second half of last century) the work on charophytes was largely restricted to mear taxonomy and some developmental aspects. However, phylogeny of charophytes was made a point of discussion by Prof. Desikachary (1958) in his article 'Taxonomy of Algae'. He gave importance to minor character such as the quadriscutate and octoscutate nature of antheridia in taxonomy of charophytes.

that they also studied ecological factors governing the growth of charophytes from various region of Western Maharashtra.

In the northern part of country Sarma and Khan (1964) extensively studied the chromosome complement from different species of charophytes. They also reported the chromosome number in *Lychnothamnus* for the first time. According to them haplostephanous species largely showed chromosome number n = 14 while diplostephanous species showed n = 28 and higher chromosomes. They also verified the theory put forth by Proctor and Griffin. Sunderlingam (1965) studied the developmental morphology of three species of *Nitella*. Kamat (1965) gave an account of ecological observations on algae of Kolhapur, Maharashtra, in which he reported species of *Chara* and *Nitella*. Kamat (1967) also studied endozoic dispersal of charophytes by pintails. Ecological factors controlling the growth of charophytes were studied from about thirty five localities from western India by Vaidya (1967). It was first attempt to correlate the physico- chemical factors of water such as pH, hardness alkalinity, carbonates, chlorides, etc. In 1968 Sinha and Chaudhari compared occurrence of charophytes from India and south eastern United States. Sarma (1968) made a survey of cytology and cytotaxonomy of Indian charophytes. A new records of chromosome number were made by Noor (1968), Sarma and Ramjee (1969). The first report of occurrence of charophytes from Chittor district of Andhra Pradesh was made by Rao (1969), while Chatterjee (1970) reported chromosome number in *Lychnothamnus barbatus* (n = 14) from West Bengal. Based on their extensive study of taxonomy, morphology and cytotaxonomy Sarma et al (1970) discussed the phylogeny, interrelationship and evolutionary aspects within the charophytes. They hypothesized that *Characeae* are more evolved than *Nitellae*. Sinha and Verma (1970) worked out cytology of fifteen species of *Chara* and three species of *Nitella* from Bihar.

Kanahort (1971) analysed karyotype of section *Nitellae* of the genus *Nitella* in his voluminous publication –"Cytotaxonomical Rasearch on *Chara*ceae". Ramjee and Sarma (1971), and Sinha and Noor (1971) worked out chromosome number of different species of charophytes from Bihar. The question of basic chromosome number in *Nitella* was discussed based on their extensive studies by Mukharjee and Noor (1973).

In the year 1974, Chennaveeraiah and Bharati studied the cytotaxomomy of four varieties of *Chara gymnopitys*. The separation of species *gymnopitys* was justified by these authors based on their observations. Noor and Mukharjee (1975) reported a new

chromosome number in *Chara hydropitys*. Chatterjee (1976) investigated cytologicaly three forms of *Chara braunii* from West Bengal viz. *C. braunii* f. *schweinitzii* (n = 14), *C. braunii* f. *coromondelina* (n = 14) and *C. braunii* f. *kurzii* (n = 28). He concluded from the analysis of the karyotype of these species, that it is not only the polyploidy but also structural alterations in the chromosomes which are responsible for evolution within the intraspecific complexes in *Chara braunii*. He also made detailed investigation on cytotaxonomy of *Chara socotrensis* f. *nuda* and recorded the chromosome number (n = 28) which was in contrast to the previous report n = 14

Effects of chemicals like colchicines, methyl hydrazine, caffeine, 2, 4 – D, G. A. was studied on different species of *Chara* and *Nitella* by Sarma and Tripathi (1976a, b). They revealed that all these chemicals brought about mitotic inhibition in the species of *Chara* and *Nitella*. Effect of X-rays and gamma rays on behavior of chromosomes of selected taxa was observed by Sarma and Singh (1977). Sunderlingam and Bharathan (1978) first time reported *Lychnothamnus barbatus* from Chennai (then Madras). Charophytes from Rohilkhind, Bihar were studied by Ramjee and Bhatanagar (1978). The ploypoid nature of *Nitella* was studied by Mukharjee (1978). Chatterjee (1979) reported the occurrence of new species of *Chara* viz. *C. fibrosa* for the first in India which was considered to be endemic to Japan. The fossil Charophyte flora of Goandwana region was studied by Bhatia (1979). Cytotaxonomical studies on *Chara zeylanica* complex from Karnataka were carried out by Bharati and Chennaveraiah (1980).

An extensive review of charophytes from various parts of world and India was made by Khan and Sarma (1981). They correlated the occurrence of common species in India and other continents. They classified the charophytes as Indo – pacific, Indo – American, endemic etc. In their detailed account they have also given list of species in individual groups.

Bhatanagar (1983) prepared a hypothetical scheme of the origin of three charophyte genera viz. *Chara*, *Nitella* and *Tolypella*. For the first time charophytes from Gujarat were reported by Patel and Jawale (1984). In the next year they reported new form of *Lychnothamnus barbatus* f. *gigantea* f. nova from Gujarat. They confirmed the previous record of chromosome number (n = 28) in *Lychnothamnus barbatus*.

Our knowledge of ecology of Indian charophytes was enriched by Ramakant and Pandey (1985) who studied occurrence of charophytes from various water bodies with the limiting factors. Cytotaxonomy and phylogeny of *Tolypella* was studied

by Bhatanagar and Johari (1985). The occurrence of *Chara globularis* var. *globularis* f. *capensis* was reported by Jawale and Patel from Gujarat (1986). Bhatanagar and Johari studied the radiomimetic efficacies of synthetic bioregulants on chromosome of charophytes. They detected twenty three types of nuclear aberrations in *Chara*, *Nitella* and *Tollypella*. To the revision of world charophyceae the first amendment was made by Bhatanagar (1988) and added third tribe *Tolypella* apart from tribe *Charae* and *Nitellae*. Effects of antibiotics on spermatocysts of *Chara braunii* was studied by Noor and Poorak (1989). In the same year Pal and Chatterjee observed cytological effects of two common algicides like $CuSO_4$ and diuron. The revision of *Chara globularis* complex was made by Bhatanagar (1989) confirming range of chromosome number n = 14 to n = 42. Similar chemical studies such as effect of chloramphinicol on growth and cytological behavior in *C. corallina* were made by Poorak and Noor (1991). Singh and Amin analysed the cytoplasmic streaming behaviour at various pH levels in charophytes. Cytotaxonomical studies in two taxa of *Chara* viz *C.vulgaris* and *C. zeylanica* and *Nitella heterodactyla* were made by Subramanyan and Chowdary (1992). Pal and Chatterjee (1992) treated four species of *Chara* viz. *C. zeylanica, C.vulgaris, C. fibrosa* and *C. corallina* to gamma rays and noted the induced cytological aberrations which led to male sterility. Chaugule B. B. and Patil S. R. (1992) made list of the charophytes from the State of Maharashtra. Mukharjee and Ray (1993) studied the charophyte oospores under electron microscope and observed the ornamentation on oospore wall.

The first report on chromosome number in *Nitella hyalina* var. *hyalina* f. *indica* was made on the basis of morophological, cytological and cytotaxonomical observations by Pundhir et al (1993). Pundhir and Vidyavati (1994) made observations of charophytes from Uttar Pradesh and analysed fourteen taxa of *Chara* and six of *Nitella*. The first time record of chromosome number of *Chara fibrosa* f. *longicorolata* (n = 14) was made by same authors. Charophytes from Alighar District were studied by Pundhir and Gautum (1994). In the same year Inderjeet and Dakshine studied algal allelopathy confirming observations made earlier by Crawford (1979) by suppression of phytoplanktonic blooms in ponds by the introduction of *Chara*. Chau and Bissan (1994) reported distribution of chromosomes in *Chara* along with cytological and physiological features of banding pattern. The control of *Chara* at paddy field was studied by Guha (1995). Modern technique in cytology became more popular by the end of twentieth century. The banding pattern in charophytes chromosome was studied by Bhatanagar et al. (1996). Pundhir and

Chauhan (1997) discussed cytotaxonomic status of *Chara longifolia* and criticized its inclusion in *Chara hornmanii* by Wood (1965). Effect of orange G on chromosome of *Chara vulgaris* was observed by Bhalla and Yadav (1997). In the same year the aquatic vegetation of Himalayan region was screened by Lal in which he reported some species of *Chara* and *Nitella*. Morphotaxonomy and cytotaxonomy of charophytes from Indian subcontinent was studied by Verma (1998).

Karande V.C. and Chaugule (1998) for the first time recorded details of chromosome and karyotype of the endemic species *Chara socotrensis* f. *pashani* from Western Ghats of Maharashtra. They observed haploid chromosome number n = 14. Karande C T and Vanita Karande (1999) reported some noteworthy charophytes from Satara District, Maharashtra.

For the determination of chromosome number in charophytes Dilip Kumar Mandal and Samit Ray (1999) applied feulgen staining in the revealation of chromosome morophylogy. Langangen (2001) reported some charophytes from Pakistan and also gave a short history of the charophyte studies in Finland in 2002. Ray Samit and Mukhopadhyay Arpita (2003) studied the chromosome morphology of two populations of *Chara setosa* f. *setosa* from Murshidabad and Purulia districts of west Bengal.

Hidetoshi Sakayama et al (2004) investigated using light and SEM for the oospores and sequencing of the gene encoding the large subunit of RuBisco. Soulie Marsche (2004) studied ecology and life cycle of *Chara braunii* in a Mediterranean habitat. Approximately thirty seven taxa of *Chara* have been described on the basis of Australian collections by Casanova (2005). Prado-Joao-Femando (2005) reported new records of Characeae for Brazil.In the same year Qiu – Li- chuan reported charohyte flora in China .*Chara corallina*-a new record from Andaman and Nicobar Islands, India was studied by Gupta R. K (2005).

Abrol Deepika (2006) studied biodiversity of few Indian charophyte taxa based on molecular characterization and construction of phylogenetic tree. In this study, molecular characterization such as band frequency, RAPD polymorphism, genetic identity index, band shearing frequency and genetic distance within and in between *Chara* and *Nitella* were evaluated. Zarina A (2007) first time described the occurrence of *C. aspera* and *C. globularis* in Sheikhupura district of Pakistan.

In order to improve our understanding of charophyceae, their taxonomic status and chromosome number of some charophytes from our area, this problem was taken for the present study.