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Review on blue green algal habitat distribution

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Abstract
Moderate temperature, high light, nutrients availability, presence of water appears to be better conditions for Blue green algae growth in different habitat. Blue green algae are found, in all kinds of natural habitat that include marine, freshwater, soil, Biological soil crust, estuaries, surface of stone, paddy field, mangroves, roots etc. Numerous species characteristically inhabit and can occasionally dominate both near surface epilimnic and deep eutrophic hypolimnic waters of lakes. Many species are capable of growing on the soil and other terrestrial habitats where they take an important role in the ecosystem with regard to nutrient cycling. They flourish in the environment. The Successful growth of Blue green algae in different habitat includes extremes is due to the possession of certain properties related to this structure and metabolism. Blue green algae also protect themselves from growth inhibiting light intensities, with a variety of pigments that absorb harmful radiation (eg: Scytonemin in the sheath, Carotenoids and Xanthophylls) In this review study we Observe various habitat in which blue green algae grow and the various strategies they adopt to survive.

Keywords: blue green algae, epilimnic, habitat, hypolimnic, survive

Introduction
The Blue green algae have a long history on earth. The oldest Blue green algae fossils are 3.5-billion-year-old, blue green algae are common component of the periphyton forming crusts and films over rocks (epilithon), plants, sand, sediments and other substrates. In many environments these Blue green algae accumulate from millimeters to centimeters in thickness as vertically structured, microbial that form a benthic layer at the bottom of the water column, or that detach and float at the surface (WF. Vincent *et al*, 2009) [19] Blue green algae occur frequently in freshwater bodies as phytoplankton. However, they are found in the most diverse habitat like the upper part of the marine intertidal zone, Blackish horizontal band on rocks and cliffs is formed by epilithic blue green algae. There is an instance where Blue green algae live as endolithic as well as some Blue green algae live as symbiotic with other plants. They occur in lichens, in the roots of plants, leaves, water fern and even in fungus.
Modern day Blue green algae include some 2000 species in 50 genera and 5 orders, with a great variety of shapes and size. Ecologically, there are major groups in the aquatic environment, In Kerala Blue green algae are not only widespread in Freshwater, Marine and terrestrial ecosystems but also found in rhizosphere, mangroves, hypersaline localities, estuaries etc.
Diverse species having different ecological demands exhibit differential adaptations to the conditions at their source locality. The massive communities of Prochlorococcus in the oligotrophic deep oceans that live in close association with Cyanophages enabling rapid lateral transfer of genomic material opens new areas on biological adaptation and evolution (Johnson *et al*, 2006) [5].

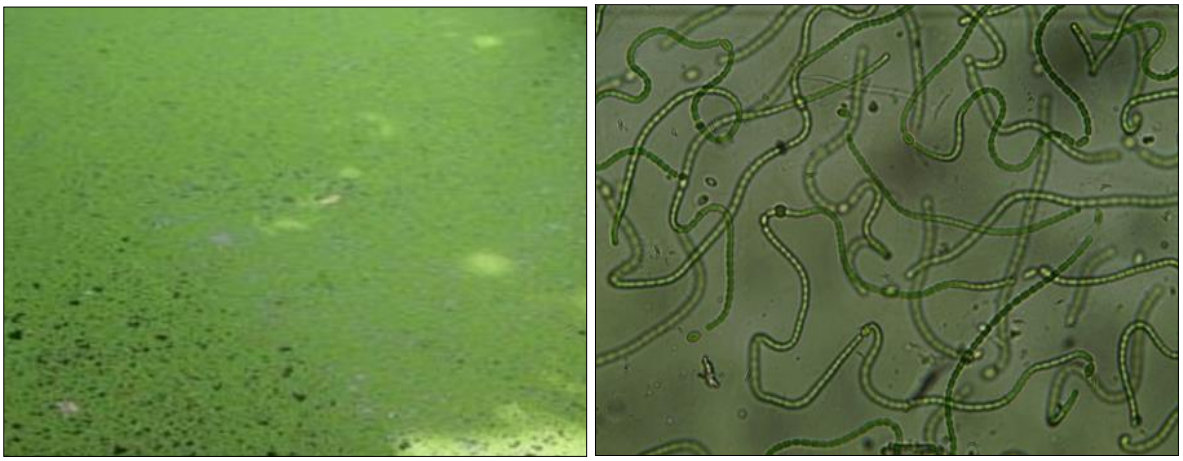
Marine blue green algae
Marine ecosystem is the major backbone of life on earth and constitute the largest source of habitat and biodiversity (Anderson *et al*., 2012) [1]. Blue green algae are of widespread distribution in and around the oceans and may form an important element of the vegetation of some marine habitats, like the intertidal zone of temperature and tropical seas and in estuarine areas. In the open ocean the Coccoid Blue green algae like *Synechoccus*, *Synechocystis* and Prochlorococcus occur as Picophytoplankton. The marine strain of Synechoccus WH8012 has a gene encoding a transporter for glycine betaine that is absent in freshwater, Planktonic populations of the marine *Trichodesmium* frequently form extensive orange brown surface blooms in the Red sea, the Indian ocean and in the equatorial regions in the Pacific and Atlantic oceans. Reddish floating cells of marine *Wynechococcus* were recently found to be a universal component of the marine phytoplankton. Hyella species are cyanobacterial endoliths that bore into and live in ooids. Ooids are spherical, concentrically laminated carbonate grains that form by carbonate accretion in agitated shallow tropical marine environment (Samit ray, 2015) [15].

Blue green algae in estuaries

A total number of 75 species of Blue green algae from 2 genera belonging to 7 families and 4 orders of the class Cyanophycea in cochin estuaries were recorded of which 31 were unicellular colonial forms.43 non heterocystous filamentous forms and two were heterocystous filamentous forms (Sincy Joseph *et al*.,2016) [6].

Freshwater blue green algae

Microcystis aeruginosa bloom in fresh water ponds of central Kerala was monitored with the changes in the water quality, bloom characteristics and toxic effects. The species is known to produce potent toxin Microcystin that has an adverse effect on various aquatic organisms (Renju Mohan *et al*., 2020) [10]. The distribution and diversity of Blue green algae taxa in temple ponds of Kollam districts recorded *Spirulina princeps, Scytonema stuposum, Oscillatoria agardhii, Oscillatoria amoena, Aphanocapsa pulchea were* recorded from class Cyanophyceae (Sreeja Krishnan, 2016). The filamentous forms such as various Anabaena species, *Aphanizomenon flosaquae* and *Gloeotrichia,* develop first soon after the onset stratification in the spring, while the unicellular colonial forms like Microcystis species typically bloom in autumn. Oscillatoria with green unicellular alga Scenedesmus can grow faster in optimum conditions (figure1)



A

B

C

D

Fig 1: Showing different habitat with Blue green algae association (A- Fern, B-Higher plants, C-Freshwater, D-Mangroves).

Terrestrial blue green algae

It is a fact that the Blue green algae are more prevalent in aquatic habitats, but they are also found growing on the surface of moist soil (*Nostoc* species, *Lyngbya* species) and also beneath the soil surface Blue green algae are almost universal components of the flora in tropical soils. *Schizothrix, Scytonema, Phormidium, Nostoc* and *Microcoleus* are of worldwide distribution in the microflora of subtropical and tropical arid soils. Nostoc commune is a cosmopolitan terrestrial Blue green alga can tolerate acute water stress (Rinta *et al*., 2003) [14].

Members of the genera *Pleurocapsa, Gloeocapsa* and *Phormidium* are well adapted to these habitats and often dominate the dark blue, black community of the spray zone. Tolypothrix and Calothrix species are more typical components of the surface littoral community. Species of the genera *Nostoc, Lynbya, Chamarsiphon* and Gloeotrichia have been found encrusting submerged plants. Aphanothece and Nostoc particularly in the more eutrophic lakes. Benthic Blue green algae growing over the littoral sediments on submerged plants. *Chamaesiphon,Nostoc, Rivularia, Phormidium, Pleurocapsa* species are among the more common Blue green algae inhabitants of this environment (El-Shehavy, 2003).

Intertidal blue green algae

Blue green algae population in the intertidal zone is characterized by adaptability to grow both in freshwater and marine environment. Blue green algae grow as epiths at the littoral fringe both in temperate and tropical seas. Genera like Calothrix, Gloeocapsa, Phormidium, Nodularia grow as black encrusting sheath or thick cushions on rocks. Filamentous Blue green algae all abundant in the intertidal regions of coral reefs. They are responsible for the high productivity of reef and tropical lagoon communities. They are also the primary food for the herbivores. A transition from freshwater to marine habitats is found in salt marshes. Algal community in salt marshes from definite zones and various genera of various genera of Blue green algae also form part of this from the intertidal Blue green algae genera occur in the following sequence Oscillatoria, Phormidium, Lynbya, Calothrix, Rivularia, Nostoc etc.

Blue green algae in paddy field

Altogether 64 species of Blue green algae belongs 22 genera and 6 orders have been found out from Kuttanadu, Alappuzha paddy fields, The genus Oscillatoria with 12 species dominated the soils, followed by Anabaena (9 species) and Nostoc (7 species). Phormidium and Leptolynbya with 5 species each were also found out from fresh soil samples and Leptolynbya was the only species in fresh soil, The six orders of algae observed were Chroccales (5 genera, 9 species) synechocystales (3 genera, 4 species) Nostocales (9 genera,18 species) Stignematales (3 genera,4species) pseudoanabeanales (1 genera,5 species) and Oscillatoriales (5 genera,24 species) were observed in Kuttanadu paddy field Kerala (Dhanya *et al*.,2015) [15].

Blue green algae in symbiotic association

Some Blue green algae live as symbionts with or even within other plants. They occur in many lichens, in the roots of Cycas, in the leaf cavities of the water fern, Azolla and in unicellular fungus Geosiphon, in the higher plants, in the mangroves, in the Bryophytes etc.

Blue green algae associated with higher plants

The Survival of Cycads in such habitats is strongly associated with their ability to form symbiosis with Nitrogen fixing Blue green algae (Geheinger *et al*., 2010). All the Known cycads associate with Blue green algae and they are the only gymnosperms to form a facultative symbiosis with blue green algae (Rai *et al*., 2000). The Gunnera Blue green algae symbioses are an excellent model to understand and devise the possible routes of introducing

the Blue green algae to the crop plants. Blue green algae are Ubiquitos on the earth from soil to water bodies and from roots to plant leaves (Rai *et al*.,2000). Nitrogen fixation in Nostoc, the dominant species symbiotic to Cycads coralloid roots (Geheinger *et al*., 2010).Cycads maintain complete photosynthetic apparatus, thylakoids, phycobilisomes, phycobiliproteins and carboxysomes, associated with pigments and enzyme levels comparable with free-living Blue green algae (Lindblad etal.,1985). Blue green algae found in cycads are predominantly species of Nostoc, but in some studies, species of calothrix, Scytonema and richelia were also identified (Grobbelaar *et al*., 2001).

Multiple strains of Blue green algae can be housed in a single cycads host (Zheng *et al*.,2002, Thajuddin *et al*.,2010). Single symbiotic Nostoc strain was found the coralloid roots of the genus Macrozamia (Yamada *et al*.,2012). Inside the Gunnera cells heterocyst differentiation rapidly increase as compared to the regular distribution of heterocyst in the filament. Genus Nostoc is very successful in forming symbiotic associations with different groups of plants because of its extreme and fluctional plasticity (figure1)

Blue green algae associated with Mangroves

Mangroves are the most productive ecosystems and the algae attached to the roots of mangroves contribute to the mangrove ecosystem as principal primary producer (Selvaraj, 2000). Avicennia officinalis pneumatophores support the greatest number of epiphytic algae, mangrove wetlands such as Cherukkunu, Valapattanam and Vellikkeel identified about 19 algal members among these Chroococcus, Lynbya, Oscillatoria and Scytonema from Cyanophyceae (P. Silsha *et al*.,2019) [17]

A Survey on the Blue green algal biodiversity of 7 mangrove *viz*. Vallikunnu, Kadalundi, Kallayi, Mangalavanam, Kumbalam, Kumarakam and Mekkara mangroves of Kerala was undertaken in total 31 species of Blue green algae coming under 10 genera and 4 families were recorded in all mangrove environments, Maximum species (13 species) of Blue green algae were recorded from Kadalundi, whereas the minimum was recorded from Mangalavanam (2 species). The genus Oscillatoria was observed with maximum distribution (13 species) followed by Nostoc (5 species) and Lynbya (3 species).The genus Aphanocapsa, Microcoleus and Scytonema and Chroococus, Aphanothece, Merismopedia and Phormidium (1 species each) shows equal distribution (Arun T Ram *et al*., 2017).

Blue green algae associated with fern

Nostoc, a genus of filamentous, heterocystous, Blue green algae, is widely distributed in the free-living state.a Pteridophyte genus Azolla while the symbiont is reffered to as Anabeana azollae, One of the most symbiotic association is that between a water fern Azolla and Blue green algae Anabeana they grow together at the surface quiet streams and ponds of the tropical and temperate regions. The hormogonia of Anabeana azolla often survive under the indusicum cap on top of the germinating megaspore.Although Azolla can absorb nitrates from water,it can also absorb ammonia secreated by Anabeana within the leaf cavities (figure 1).

The Anabeana-Azolla association is one of the most efficient Nitrogen fixing systems. The Azolla plays a very important role in rice production. Azolla and its Nitrogen fixing partner, Anabeana have been used as'green manure' in many Asian countries to fertilize rice fields to increase production. (Samit., 2006)

Blue green algae associated with invertebrates

Blue green algae were reported in worms like *Ikedosoma gogoshimense* and *Bonellia fuliginosa.* occur in the sub epidermal connective tissue of these worms (Samit, 2006)

Blue green algae associated with bryophytes

Blue green algae (*Nostoc*) have been found to grow in symbiotic association with Bryophytes like *Blasia cavicularia* and 4-6 genera of hornworts like Anthoceros. In Anthoceros Blue green algae inhabit a mucilage filled intercellular cavities within the gametophyte thalli. The hornwort gets nitrogen from Blue green algae and Blue green algae gets its carbon from hornworts. The vegetative cells of liverworts and hornworts associated with Blue green algae became enlarged, Nostoc colonies when released from Anthoceros or Blasia liberate small amount of ammonia and fix carbon dioxide (Samit, 2006).

Blue green algae associated with fungi

An integrated system of lichen thallus where an interaction between the fungal partner (Mycobiont) and the Blue green algal partner (Phycobiont) results in the formation of a morphological entity. Nostoc is the common Blue green algae in lichens but genera like Calothrix, Dichothrix, Stigonema and Scytonema are also found. In lichens with a Blue green algae as the only Phycobiont, the relative number of heterocyst is similar to that observed in free-living forms. A direct relationship is also established between nitrogen fixing capacity of Nostoc and the proximity of Coccomyxa.

Conclusion

Blue green algae are an enormously diverse group of prokaryotes whose adaptive capacity along with the ability to tolerate extreme conditions, Blue green algae are present in wide range of habitats *viz*. Marine, freshwater, terrestrial, Soil, further found in association with different host. In this review the diversity of Blue green algae from different habitats and enlist the dominant group inhabiting these habitats. The diversity of Blue green algae

from different parts have been reviewed and reported in this study. The ranges of survival strategies adapted and chemical diversity in these organisms have made them most unique and promising organism on earth.

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