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1 Phytoplankton

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ABSTRACT

Investigations on phytoplankton of the Indian Seas has assumed great significance during the last 5 decades. As these microscopic organisms fluctuated in response to climatic changes, water movements, seasonal variations, nutrient content of the water etc. they form an important and convenient link in the assessment of the stock of potential resources. The shelf and oceanic waters of the Indian seas show fluctuations in the standing crop of phytoplankton due to the effect of two monsoons. Available data indicated that the waters along the west coast of India are more fertile than that along the east coast mainly due to upwelling and other favourable factors conducive to phytoplankton growth. Some of the ecological factors contributing to the pattern of production of phytoplankton are also briefly discussed.

Introduction

The floating microscopic plant components of the seawater are the phytoplankton or micro-algae which constitute the primary producers synthesizing the basic food. Their importance lies in the fact that they are photosynthetic organisms and serve as first link in the food chain. Most phytoplankton organisms are unicellular; some are filamentous and colonial in habit. The important components of phytoplankton in the seawater are the diatoms (Bacillariophyceae), dinoflagellates (Dinophyceae), green micro-algae (Chlorophyceae), blue-green algae (Cyanophyceae), silicoflagellates, Coccolithophores and very minute forms called the nannoplankters.

Just as on land, in the sea also, animal life is not possible without plants. Plants form the food of herbivores and the herbivores inturn, nourish the carnivores. No life including fish can exist in water without phytoplankton.

In the inland waters, lakes, ponds, reservoirs and so on, it is common to notice members of green, blue-green algae and diatoms, chiefly in the order mentioned, but in the seas, the diatoms account for the bulk of floating vegetation. They are the 'grass' of the sea and are the most important among the prime synthesizers of food in the vast masses of water all over.

Collection of phytoplankton

Special devices are employed to collect the standing crop of phytoplankton. Usually a conical net made of thin finest bolting silk (mesh size 20-40 microns) is towed through the water and the plankton is collected and centrifuged at high speed to concentrate these organisms in it. A high powered microscope is required to examine them. Collections have to be made at frequent intervals at different places, for which a well equipped research vessel is needed. It may be of interest to mention here that CMFRI is engaged in this work since 50 years and much work was done in the inshore and offshore waters with the help of *R.V. Varuna, Rastrelliger, Sardinella, Skipjack, Cadalmin* series and recently on board FORV *Sagar Sampada.*

Link in the food chain

As already mentioned, the phytoplankton constitute the food for the smallest of animals, viz. zooplankton which in turn form the food of the largest mammal, the Antarcitic whale *(Balanoptera)* which feeds on small shrimp like zooplankton known as krill (*Euphausia superba*). The krill is wholly dependent on the bloom of phytoplankton for its survival and growth. The largest of the fishes, the basking shark, is also a planktonic feeder, mainly feeding on the copepod *Calanus* which in turn survives on the phytoplankton. The fishery for oil sardine and mackerel are entirely dependent on the bloom of phytoplankton along the west coast of India. There are several other fishes and mammals in the sea whose life is linked with phytoplankton, only the number of links in the food chain vary in each instance. Each species has its own period of growth and growth intensity depends on many external factors such as temperature, salinity, nutrients and the physiological state of the species itself and these in turn are influenced by seasons and climatic factors.

Peak periods of production

The peak periods of production in the temperate and artic regions occur during the spring and summer. At other times the temperature being very low, limits growth or the depletion of nutrients from the surface layers of water brings in a check on growth as it happens during the late summer. In the autumn, due to rough weather, the nutrients at sub-surface levels are brought to the surface (upwelling) resulting in a bloom of phytoplankton.

Along the west coast of India, maximum production of phytoplankton occurs during the south west monsoon season (June-September) after which there is a decline in the standing crop. Later during the north east monsoon season also another peak of production takes place, may be anytime between November and February, though of a much less magnitude compared with the former. The south west monsoon bloom can be compared to spring bloom and the north east monsoon bloom can be compared to the autumn bloom of temperate waters. The magnitude of the south west bloom on the west coast is of a high order, surpassing those known from some of the most fertile regions in the world. (Subrahmanyan, 1959).

On the east coast also, generally the maximum production occurs during the south west monson season, followed by one or two peaks of production of lesser magnitude during the north east monsoon season. The peaks of production are mainly due to the multiplication of diatoms, dinoflagellates and nannoplankters. The blue-green algae chiefly composed of filamentous bundle like structures called *Trichodesmium* occur generally during the warmer months. Investigations on the factors responsible for the production of phytoplankton have shown that during the monsoon months, optimum conditions such as abundance of nutrients due to upwelling and river discharge, fall in temperature and salinity are common features of these waters. At no time is there a complete depletion of nutrients as in the temperate waters to act as a limiting factor. It is seen that the limiting factor here is the physiological state of the plankton elements themselves.

The nature of phytoplankton flora changes frequently and each species appears to have its own peak periods of occurance and associations. The species which contribute to the bulk during periods of maxima also vary from year to year, though a few appears to be common. A total of 365 species of phytoplankton have been recorded (Subrahmanyan, 1958) apart from a systematic description of 2 genera of dinoflagellates (Subrahmanyan, 1958, 1971), totalling more than 700 species from the Indian Seas. In subsequent years, some new distributional records of diatoms and dinoflagellates have been added to the total number of species of phytoplankton (Gopinathan, 1975, 1984, Gopinathan and Pillai, 1975).

Euphotic zone and production

In the shallow coastal regions, the waters are mixed upto the bottom and the phytoplankton have access to the nutrients in the water column and also what is generated at the bottom. But in the offshore waters, the euphotic zone and the depth of the mixed layer determines the rate of phytoplankton production. The depth of the mixed layer during the pre-monsoon period is about 60 m which becomes less than 20 m during monsoon period and during the post-monsoon period, it deepens to 40 m (Nair *et al.* 1973). In the pre monsoon period, as there is no further addition of nutrient rich waters, the rate of production is maintained at a lower level till the commencement of upwelling. During the post monsoon period when the mixed layer deepens, the nutrients are not depeleted and hence moderately high production is continued during this period. Thus the lower rate phytoplankton production during the pre monsoon and higher rates during monsoon and post monsoon as well as the lower values observed seaward can be attributed directly to the availability of nutrients (Nair and Gopinathan, 1981).

Phytoplankton bloom

Sometimes the seawater becomes discoloured owing to the intense bloom of a single species, the colour of the water depend on the pigmentation of the organisms concerned. Thus, the dinoflagellate *Noctiluca milaris* on certain occasions, particularly during the south west monsoon period, bloom so intensively as to colour the water into pink or red (red tide)or greenish pink; *Hornielia marina* discolours the water into green and blooming of *Trichodesmium* spp. causes brown colour on the surface of waters. Besides, toxic dinoflagellates like *Gymnodinium, Gauniaulax* and *Peridinium* species also causes discolouration and bad smell during the blooming time.

Factors favouring phytoplankton production

Phytoplankton production in the Indian Seas are controlled by various physico-chemical and climatic factors and vertical mixing process like upwelling. Among the chemical factors, salinity variations affect the rate of photosynthesis and thereby the production of phytoplankton . It was observed that phytoplankton grow well in salinities of 20 to 30 ppt and diatoms prefer salinity greater than 35 ppt. In the inshore marine environment sudden fall in temperture and salinity associated with high nutrients favour the phytoplankton production.

The nutrient concentrations in the water, over the shelf on the west coast of India follows a pronounced seasonal rhythm, reaching the maximum during the south west monsoon months. The regional and seasonal variations in the nutrient content of the upper layers follow the same trend of production of phytoplankton. During the period of south west monsoon, the nutrient concentrations show an increase in the central region. The entire continental shelf waters are rich in phytoplankton and a gradual increase in standing crop from south to north is observed. During the post monsoon period, though there is a fall in the values of nutrients, the concentrations are enough to maintain moderate rates of phytoplankton production.

Among the phenomena governing the distribution of phytoplankton in the sea, the divergence and convergence play a significant role. Regions of divergence are generally rich in nutrients and have high density of phytoplankton while in regions of convergence, there is great accumulation of zooplankton.

The phenomenon of upwelling on the west coast of India has a pronounced effect on the replenishment of nutrients and in turn phytoplankton production. On the west coast the bloom of phytoplankton observed in the south west monsoon, noticed off Trivandrum coast from January onwards, reaches a peak in May at Cochin and Calicut and northwards, the maximum peak is observed in July-August. This would indicate the commencement of upwelling much earlier. From September onwards, the phytoplankton abundance showed a decline indicating the cessation of upwelling and initiation of the reversal process. Thus the positive corelation of phytoplankton production and the phenomenon of upwelling fully support the views of Sharma (1966). However, this will not happen suddenly, for the algae in the water have to grow and multiply and usually the bloom occurs after some lapse of time and away from the place where upwelled water reached surface levels. Upwelling brings about ideal condition for the growth of phytoplankton during which period the aquatic environment is conditioned like a culture medium for growth (a fall in temperature to optimum levels from 29-31°C to 23-25° C, slight lowering of salinity from 34-35 ppt to 30-32 ppt and plentiful supply of essential nutrients) (Subrahmanyan, 1959).

Usually one would expect a very high oxygen content, even super saturation, during heavy phytoplankton blooms. On the west coast, though oxygen values rise, they never reach super saturation until the bloom has waned in November. This would indicate that the oxygen level is being kept up by the phytoplankton during photosynthesis in the upwelled water which is poor in oxygen content. It is known that in the Arabian Sea, there is an oxygen minimum layer as a result of consumption of oxygen by disintegrating organic matter in the lower layers. This layer rises during upwelling and sometimes breaks surface resulting in the mass mortality of marine organisms. Another reason for oxygen content not reaching saturation values is due to consumption by diatoms for building their cell walls.

The most significant difference between east coast and west coast waters are - while the blooms on the west coast is very extensive, throughout the region during the south west monsoon, this is not so on the east coast where the blooms are localised apparently due to local favourable factors. The intensity of the bloom and the standing crop on the west coast are almost 3 times that on the east coast. Numerous species may occur, but only a few, always by their quantity, contribute to the bulk on the west coast whereas the same is not true for east coast where no single species could be stated to dominate the crop. There is cyclical change in the species constituting the bulk from year to year though generawise not much change is noticeable. (Subrahmanyan, *et al.* 1975).

Phyto-zooplankton relationship

The relationship between phytoplankton and zooplankton has been described by Subrahmanayan (1959). On the west coast of India, there is a predominantly phytoplankton period succeeded by a predominantly zooplankton period; however zooplankton tend to increase gradually with the increase of phytoplankton from the beginning of the south west monsoon season and the zooplankton attain their peak immediately following the peak of phytoplankton production. The trend showed a direct relationship. During the north east monsoon season, both direct and inverse relationships were observed; however, the bulk of the plankton was of animal matter, which had obviously increased at the expense of phytoplankton.

Phytoplankton and fisheries

The objective of fishery research is mainly to devise a method for the forecasting and controlling of future fish supplies; in other words, a rational exploitation of the available resources. As the phytoplankters, the main synthesisers of all food in the sea, fluctuate in relation to definite environmental factors, they form an important and convenient base for assessing the stock of fishery resources. Studies on the west coast of India showed that there are some intimate relationship between plankton production and fish production.

The magnitude of phytoplankton production has been assessed in several parts of the world using methods such as depletion of nutrients, oxygen released during photosynthesis, standing crop and in recent years by using C14 technique. There have been fewer attempts to relate this to actual landings of fish. Perhaps the first of such an attempt was by Cooper (1933) for the North Sea region and next by Subrahmanyan (1959) for the west coast of India. Comparing a highly exploited area with the west coast of India, Subrahmanyam concluded that there is vast scope to exploit this region further at least by 3-4 times the present level. Subsequent assessments based on the use of C14 have confirmed the views of Subrahmanyan (Prasad *et al.* 1970).

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