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'RED TIDE' and its Deliterious Effects on Fishery

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The colour of the sea is generally deep blue, but certain circumstances green, brown or pink colour can also be observed. The blue colour is characteristic of the open seas, whereas the green water is more common in coastal areas, and the brown or red water is observed in nearshore waters only. The blue colour of the open sea is the result of the scattering effect of the light against the water molecules or scattering against suspended minute particles or even due to the radiation and colour changes of the clouds. The colour of the larger suspended particles or organic particles, if, present in abundance, can also give colour to the sea and then the water is appropriately called 'discoloured'. Discolouration can also be observed when large quantities of finely suspended mineral particles are carried into the sea by land drainage, by low and high tide-effects, erosion of land due to high wave action or when large populations of certain species of planktonic algae are present very near the surface.

'RED TIDE' – what is it?

Red water phenomenon or 'red tide' is the popular name given to the discolouration of water, either fresh, brackish or marine, caused by large number of microscopic organisms which may hamper the life of acquatic organisms. The discolouration of water which owes its origin mainly to a high concentration of marine phytoplankton, the floating plant components, has been reported in various parts of the world. Such discolouration may be in the form of pink, red, yellow, brown or dark green depending upon the causative organisms present in the water. The deeply coloured water sometimes has an oily appearance. Although the usage 'red tide' is often used rather indiscriminately, the discolouration need not necessarily be 'red' and may not be biologically originated. However, the causative organisms and characteristic features reported everywhere due to a group of diversified organisms called dinoflagellates. Various genera coming under this group which are responsible for bringing out this

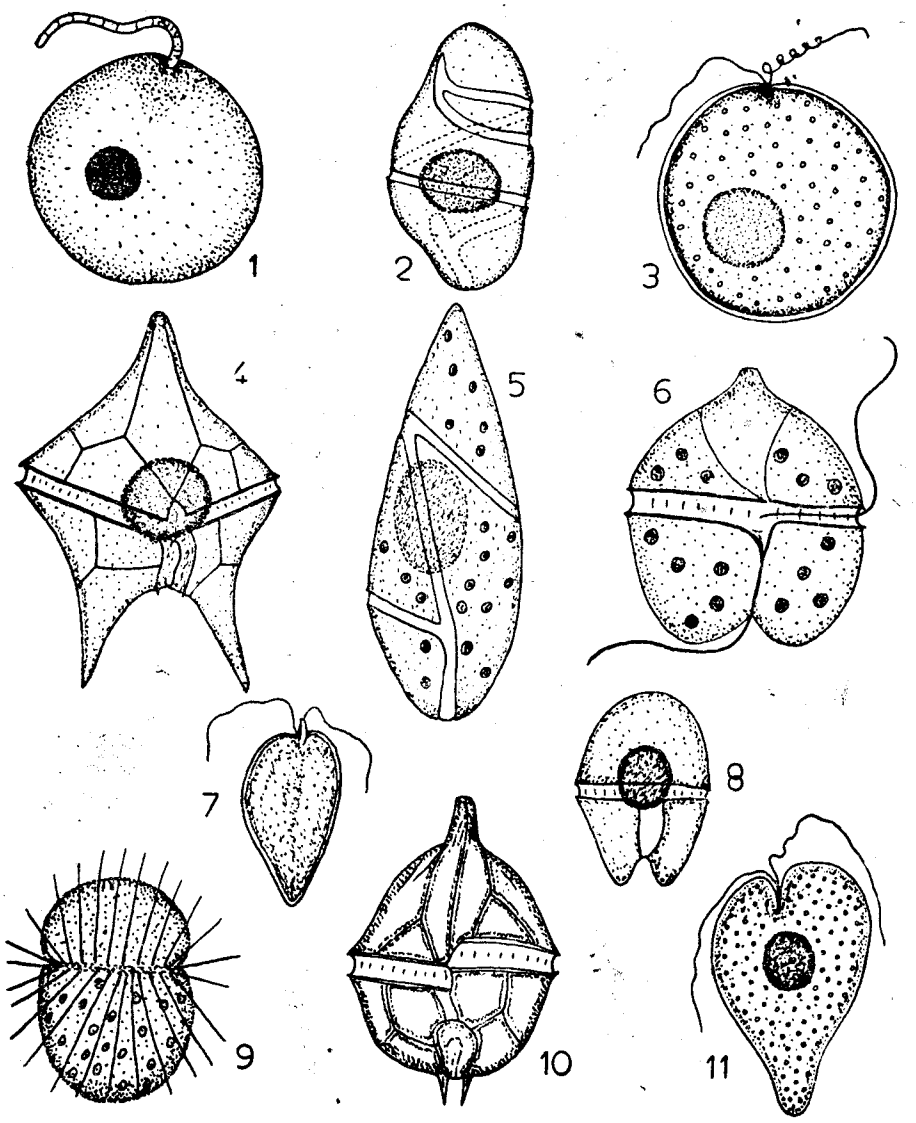
phenomenon are the species of the dinoflagellates, *Gymnodinium, Noctiluca, Peridinium, Cochlodinium, Goniaulax* and *Haplodinium.* Besides, some chrysophycean members such as *Hornellia marina* and a blue-green alga called *Trichodesmium* spp. are also responsible for the discolouration phenomenon.

The study of the 'red tide' phenomenon is of considerable interest, not only from the biological stand point, but also due to economic reasons, since mass mortalities of commercially important fishes have been reported to be due to the 'red water' outbreaks in various fishing grounds. In the coastal waters of India, the dinoflagellates associated with the discolouration of water have been identified as either due to *Noctiluca miliaris, Gymnodinium breve, Goniaulax polygramma* or species belonging to *Cochlodinium.*

Causative Factors

Large outbreaks occur particularly in the tropical and subtropical regions of the world oceans where the rate of the overturn of the organic matter is high. Generally, it occurs in very fertile parts of the sea, often during or after unusually warm weather, since plenty of sunshine is another requirement for the red water outbreaks. It was usually observed towards the end of a phytoplankton bloom in areas where upwelling is seasonal in nature. Inflow of river water also contribute towards such outbreaks, especially dense concentrations of a single species of phytoplankton or zooplankton are population explosions known as swarms, or blooms. They are seasonal in occurrence or occur at irregular intervals when environmental conditions are exceptionally favourable for the growth and reproduction of a particular species. During the blooming period, if we examine a small quantity of the water, say one litre of water, we can detect the presence of more than a million cells in it. Depending upon the organisms forming the bloom, the colour of the water also will vary. In Florida coast, during the period of such a bloom, the quantitative estimate of the dinoflagellate, *Gymnodinium breve* was more than 13 million cells/litre of seawater. Similarly, such a phenomenon was observed earlier at about 8 miles off Cochin, and the organisms constituting the abundance was found to be *Goniaulax polygramma* which was counted upto 11 million cells in one litre of water.

There are different views put forwarded by scientists for the cause of such 'red tide'. According to one view, upwelling and rainfall may be the primary causative factors of red tide outbreaks. Subrahmanyan in 1959 stated that the bottom mud of the Arabian Sea probably contain growth-promoting substances, essential for the production of phytoplankton. Recently it has been shown by experimental culture study, that marine microorganisms produce growth-promoting substances containing vitamin B_{12}. Very recently again by experimental cultures, it was proved that red tide outbreaks may be due to some growth promoting substances, rather than upwelling and rainfall, at least in the tropics. However, the exact mechanism which triggers sudden outbursts of a phytoplankton causing discolouration is not fully understood. We could not single out a particular factor favouring the monospecific bloom, probably a number of factors are involved in this matter.



Common organisms which cause the **'Red Tide'** or red water phenomenon.

1. *Noctiluca miliaris*
2. *Cochlodinium* sp.
3. *Haplodinium* sp.
4. *Peridinium* sp.
5. *Gymnodinium contortum*
6. *Gymnodinium breve*
7. *Prorocentrum micans*
8. *Gymnodinium splendens*
9. *Mesodinium rubrum*
10. *Goniaulax polygramma*
11. *Hornellia marina.*

Impacts

Red tide appears first as coloured patches of water in varying dimensions. The affected water masses then become soupy or cloudy as the number of organisms increase. The colour of the water progressively changes from light green to a deep amber, sometimes with a distinct reddish tinge. At the same time the water becomes more and more viscous or slimy until when taken up in hand, it runs through the fingers thickly like a syrup. At this stage the greatest mortality of marine life usually occurs. As the red colour disappears a scum and patches of debris often remain at the surface of the water. If conditions are optimal, there is a possibility that the outbreaks may be self-perpetuating. As various marine organisms die, they decompose thus releasing additional nutrients which may be utilized by red tide plankton.

There are two types of red tides noticed with reference to their effects on other marine organisms. They are the toxic and non-toxic red tides. Toxic red tides are caused by the various dinoflagellates and non-toxic red tide by the blue green alga *Trichodesmium* spp.

There have been many views about the noxious effect of red water. Several authors attribute the mortalities in red water areas as due to putrefaction and pollution caused by the dead plankton. In some of the regions where red water occurs there is certainly shortage of oxygen and development of the foul gas, hydrogen sulphide. But the direct cause of these mortalities during water bloom in lakes and in the sea probably is the strong poison produced by the living plankton of dinoflagellates or blue green algae. Water bloom may be very noxious not only to fishes and invertebrates, but also to air breathing animals for which lack of oxygen in the water is of no importance. Thus, harmful effects of red tide are not confined to fishes alone, but barnacles, oysters, shrimps, crabs, purpoises and turtles have also been reported to be killed due to this phenomenon.

Experiments conducted on two species of dinoflagellates namely, *Gymnodinium breve* by Gunter *et al.*, in 1948 and *Prymnesium parvum* by Otterstron and Steemann Nielsen in 1940, collected from the area of fish mortality at Florida and Danish Lake respectively have shown that these organisms may kill fish in well aerated aquaria. Reich and Aschner in 1951 have shown that *Prymnesium parvum* secretes a toxin which acts directly upon the fishes, killing them within hours.

Some of the dinoflagellates can produce certain secretions which are highly poisonous to other organisms. The important dinoflagellates coming under this category are : *Gymnodinium breve, G. mikimotoi, Cochlodinium catenatum, Exuviella baltica* and *Pyrodinium phoneus.* With the death of these organisms the poisonous secretions present in the body dissolves in water which causes harmful effects to other organisms.

Records

As already stated, the blooming of the dinoflagellates cause harmful effects to higher organisms especially fishes. In such cases mortality of fishes is common. For example, in the Bay of Mexico, it is a regular feature to observe the dead fishes floating on the water when red tide phenomenon occurs. The red tide occurred in the Gulf of Mexico at

least 20 times since its first recorded appearance in 1844. Along the coastal waters of South Africa, west coast of India and in the Bay of Valvive such mortality of fishes were reported.

Along the California coast, *Prorocentrum micans, Goniaulax polydora* and *G. catenella* are the organisms causing harmful effects to the marine organisms. Near Florida in U.S.A., during 1946–47, blooming of dinoflagellate *Gymnodinium breve,* caused disastrous results to higher organisms and fishes. *Coccolithus huxley* has been found to cause discolouration of water along the Norwegian coast. Similarly *Goniaulax splendens* along Washington coast, *Conchodinium* sp. in Japanese waters and *Noctiluca* sp, along the African and Indian coasts were reported to cause harmful effects to local fisheries.

The species of *Goniaulax* are not only harmful to aquatic life, but also to the human beings. In 1799, the incident of 'shell fish poisoning' in Alaska, due mainly to the blooming of two species of *Goniaulax (G. catenella* and *G. tamarensis)* and this involved in the death of several hundred people by consuming the affected shell fish. Sea-gull and cuttle-fishes were also affected by the poisoning due to the 'bloom'. Nishikawa in 1901, reported that 'red tide' caused by *Goniaulax polygramma* 'bloom' in the Bay of Agu in Japan was responsible for considerable destruction of oysters and was generally toxic to other organisms. Mass mortality of fish and various other organisms near Cape Town in South Africa have been attributed to the 'red water' phenomenon by *G. polygramma* by Grindley and Taylor in 1962.

Prakash and Sharma in 1964 observed the red water phenomenon about 8 miles off Cochin and identified it as due to *Gonlaulax polygtamma*. After a series of tests in the laboratory, they concluded that there was no toxic effect on the fishes by its blooming. However, reports from different sources state that the fishes avoid the areas of 'bloom' and they reappear after the red water had drifted away or finally settled down.

Although there is no report about the harmful effects of the blooming of the two dinoflagellates, namely *Goniaulax tamaronsis* and *G. catenella,* there were incidents of harmful effects on the human beings who consumes the fishes poisoned by these organisms. One flagellate called *Hornellia marina* has been reported to cause harmful effects along the Malabar coast on the west coast of India and in the Japanese waters. Similarly, another dinoflagellate called *Prymnesium parvum* caused serious trouble to the fishery in the inland waters and fish ponds in Israel and Denmark. Red sea and Vermillion sea are known for the frequent occurrence of such blooms; and the names of these seas were derived from the discolouration of the water, mainly due to *Trichodesmium* spp.

Although there are reports of red tides in various parts of the world, the exact reason and the factors responsible for the blooming and the controlling measures are yet to be satisfactorily answered by scientists. Since red water blooms are largely a surface phenomenon and winds and currents are the primary factors governing their distribution, the use of aircrafts in locating and regularly observing such discolouration over a wide area suggest an interesting possibility for estimating the rate and direction of the surface water drift. Of course, for a more authentic estimation, the growth potential or the generation time of the causative organisms must be taken into account. Briefly, a study of the physiological ecology of the causative organisms in relation to physical and chemical aspects of the coastal waters would be a right step towards understanding the phenomenon of blooms causing 'red tide'.