Winter School on

'RECENT ADVANCES IN DIAGNOSIS AND MANAGEMENT OF DISEASES IN MARICULTURE'

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Course Manual

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TOXIC ALGAL BLOOMS

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Incidents of phytoplankton blooms, either harmful or harmless, discolouration of coastal waters, either red, pink, brown and green, has been a regular feature along the Indian coasts, especially in the west coast of India. The red tide or red water phenomena are generally intermingled with changes in chemical properties of coastal waters. Introduction of nutrients during the summer monsoon period through river run off and coastal upwelling are major factors influencing the algal blooms. Most cases of blooms have been harmless, since the aquatic fauna will try to avoid the area and fall in fish catches have been reported every time. However, in recent years, a few cases of fish mortality have been reported in the West Coast, due to algal blooms and effects of PSP and DSP depending on the organisms bloomed. Thus the problem of harmful algal blooms along the Indian coast is more serious than apparent and needs urgent attention to check further escalation due to eutrophication.

There are three different types of algal blooms observed in the Indian Seas. They are:

1. Species which produce basically harmless water discolouration, however, under exceptional conditions in sheltered bays, lagoons and stagnant water bodies, blooms can grow so dense that they cause indiscriminate kills of fish and other invertebrates due to oxygen depletion or asphyxiation.
2. Species, which are non-toxic to human but harmful to fish, and invertebrates especially in aquaculture systems by damaging or clogging their gills. Eg. Diatoms like *Chaetoceros spp.*, *Asterionella sp.*, dinoflagellate *Gymnodinium mikimoti* and species of Coccolithophores.
3. Species, which produce poisonous toxins that, can find their way through the food chain to human, causing a variety of gastrointestinal or neurological illness such as PSP, DSP, ASP, NSP, VSP, CFP etc.

Usually the toxic or non-toxic algal blooms occurring in Indian seas due to sudden multiplication of organisms under favourable conditions like Dinoflagellates (Dinophyceae), members of green algae (Chlorophyceae), blue-green algae (Cyanophyceae) and diatoms (Bacilariophyceae).

Diatom blooms

In many estuaries and inshore areas of the west coast of India, diatom blooms are observed in upwelled waters rich in nutrients during the monsoon and post monsoon months. Report of blooming of *Fragilaria oceanica* coincides with the abundance of oil sardine in the west coast and blooming of *Hemidiscus hardmannianus* with the abundance of choodai fishery (*Hilsa sp.*) in the east coast. So far no ill effects to human health or to the fishery due to the blooming of diatoms has not been reported.

***Trichodesmium* bloom**

The filamentous blue green alga *Trichodesmium spp* is perhaps the most known red tide organisms in the tropical seas. Massive *Trichodesmium* blooms occur in the Arabian Sea during the pre-monsoon season every year. Starting in Feb-March, the bloom

persists till April-May then decline. The blooms are generally confined to 5-25 m patches and occur generally in long bands parallel to the coast. Warming of surface waters (27-32°C) and increase in salinity (30-35%) are thought to be preconditions for the onset of *Trichodesmium* blooms. The nutrient levels have been reported to be generally low during the early phase of the red tide. Phosphate concentrations are very high and nitrate levels are very low during the early bloom period. Ammonia concentrations increase sharply in the water column after every pulse of the bloom.

There are no cases of fish mortality associated with *Trichodesmium* blooms indicating the non-toxic nature of the blue green algae. However, if there is a bloom, aquatic organisms will try to avoid the blooming area.

Dinoflagellate blooms

Members of Dinophyceae cause the maximum harmful effects to the fauna and responsible for the heavy mortalities of fishes in the West Coast. The Dinoflagellates involved the blooms along the Indian coast are *Noctilucus miliaris, Noctiluca scintillans, Gymnodinium breve, Heterodinium sp, Gonyaulax (Alexandrium) spp., Porocentrum micans, Peridinium spp., Ceratocorys sp, Dinophysis sp* and *Ceratium spp.*

The blooming of Dinoflagellates may not cause toxic effects always and the fish mortality reported by the workers earlier, could be due to sudden depletion of oxygen content in the water column, ammonia toxicity or due to the clogging of gills. Most of the shoaling fishes avoid areas of Dinoflagellate blooms. However, the pelagic fishes could not escape these areas and will be trapped and face the consequences.

Dinoflagellate toxins, such as PSP (Paralytic shellfish poisoning) DSP (Diarrehetic shellfish poisoning), NSP (Neurological shellfish poisoning) ASP (Amnesic Shellfish poisoning), CFP (Ciguatera fish poisoning) etc., have been causing great public health concern in several parts of the world.

Paralytic Shellfish Poisoning

PSP is a neurotoxin syndrome resulting primarily from the blockage of neuronal and muscular Na^+ channels. Binding to the Na^+ channel prevents propagation of the action potential, which is essential to the conditions of nerve impulse and muscle contraction. In vertebrates, the peripheral nervous system is particularly affected; typical symptoms of poisoning include tingling and numbness of the extremities, progressing to muscular paralysis leading to death by asphyxiation in extreme cases. The PSP toxins include saxitoxin and approximately two dozen naturally occurring tetrahydropurine derivatives. Eg. *Alexandrium spp., Pyrodinium bahamensei* and *Gymnodinium spp.*

Diarrhoeic Shellfish Poisoning

Several of the components associated with the DSP toxin complex cause severe gastro-intestinal disturbances in mammals when delivered orally. In humans, typical symptoms following the consumption of DSP toxins contaminated shellfish include acute diarrhoea, nausea, vomiting and in some cases abdominal pain. Although no human mortalities from DSP have been reported, the after effects will be prolonged for few more days.

Organisms associated with the DSP are species of *Dinophysis* and *Prorocentrum lima.*

- Since most of the DSP are concentrated in the hepatopancreas, the removal of this organ may reduce the toxicity.
- Commercial canning of shellfish is more effective than cooking in reducing PSP toxicity.
- Awareness programmes to the coastal people, especially fisherman and farm owners about the impact of toxic algal blooms
- Alert the coastal people about the harmful effects of blooming and prevent them for consuming the dead fishes.

Conclusion

The occasional blooming of the toxic or non-toxic forms of phytoplankton occurring in the West Coast are confronted with many reasons. Changes in physical and chemical properties of coastal waters associated with monsoon such as nutrient input through river run off, detrital loading, coastal upwelling, reduction in surface salinity and temperature, influence bloom formation.

Incidents such as outbreak of PSP, detection of DSP, fish and destruction of marine fauna due to toxic algal blooms, indicate the danger to public health and the economic losses caused by some of the blooms. Regular monitoring of shellfish for toxicity would greatly help in avoiding outbreaks of shellfish for toxicity would greatly help in avoiding outbreaks of shellfish poisoning. Experience of other countries has shown that toxicity can suddenly appear after periods of non-toxicity. This calls for vigilance to save valuable human lives. For example, it is known that several dinoflagellates can remain for long periods of time in sediments as ' cysts'. The cysts can act as 'seeds' to initiate blooms when favourable ecological conditions prevail. A study of benthos, especially the sediments in different parts of the Indian coast would help identifying areas prone to toxic algal blooms.

Wastes or effluents from the factories and aquaculture industries, which are rich in nutrients, are being discharged into the sea. The effect of these effluents on phytoplankton ecology needs to be investigated. Survey of aquaculture sites for the presence of potentially toxic species and their cysts would greatly help avoiding problems later.

Table – I

Algal blooms observed during 2001-2002

Sl .No	Month	Location	Algal species	Toxin produced	Harmful effect reported
1	Sep,1998	Poovar/ Vizhinjam	*Alexandrium polygramma*	PSP	Fish mortality and 7 death
2	Sep, 2001	Calicut	*Prorocentrum micas*	DSP	Nil
3	Oct, 2001	Calicut	*Horneillia marina*	Nil	Fish mortality
4	Dec, 2001	Vizhinjam	*Dinophysis caudata*	DSP	Nil
5	Sep. 2 - 23rd 2002	Calicut	*Horneillia marina*	Sulphur oxide radicals	Heavy mortality of fishes
6	Sept, 27, 2002	Calicut	*Noctiluca miliaris* and *Horneillia marina*	Ammonia	Mortality of fishes and molluscs
7	Nov. 2002	Njarackka l, Kochi'	*Gymnodinium* and *Heterodinium*	Nil	Nil

Amnesic Shellfish Poisoning (ASP)

This phenomenon was first recognised in 1987 in Prince Edward Island in Canada, where it caused 3 deaths and 105 cases of acute human poisoning following the consumption of blue mussels. The symptoms include abdominal cramps, vomiting, disorientation and memory loss (amnesia). The memory loss associated with extreme cases of human intoxication from shellfish contaminated by domic acid led to the description of the phycotoxic syndrome known as Amnesic Shellfish poisoning. Most unexpectedly, the causative toxin is produced by a diatom and not by a dinoflagellate. The diatom species are *Pseudo-Nitzschia multiseries, P. pseudodelicatissima, P. australis* etc. To date reports of domic acid in seafood products have been mainly confined to North America and Canada.

Neurological Shellfish Poisoning (NSP)

The toxins implicated in neurological shellfish poisoning known collectively as 'brevetoxins' are considered to be primarily ichthiotoxins. In humans, the symptoms of NSP intoxication include respiratory distress, as well as eye and nasal membrane irritation, caused principally the exposure to sea spray aerosols and by direct contact with toxic blooms while swimming. The brevetoxins are also accumulated in shellfish, which when consumed by humans; cause a toxic syndrome somewhat similar to PSP intoxication. Eg. *Gymnodinium breve.*

Ciguatera Fish Poisoning (CFP)

Ciguatera fish poisoning is a complex syndrome in humans who have consumed certain fish inhabiting or feeding upon coral reef areas, principally in the tropical Pacific and Caribbean region. Symptoms can include gastroenteritis, skin itching, cardiovascular disorders and peripheral neuropathy. The organisms associated with Ciguatoxin fish poisoning are *Gambieroiscus toxicus* and *Prorocentrum sp.*

Venerupin Shellfish Poisoning (VSP)

Venerupin Shellfish Poisoning generally referred to as VSP is also called oyster or asari poisoning. Sporadic or sometimes massive outbreaks of highly lethal food poisoning have followed consumption of oysters and short neck clams (*Tapes japonica*) harvested from certain coastal areas of Japan. Unlike PSP, DSP and NSP, paralytic or neurological symptoms are absent in VSP. Initially gastro intestinal symptoms prevail, followed by damages to liver and kidney. A dinoflagellate belonging to the genus *Prorocentrum* has been suggested to be responsible for the type of poisoning.

Prevention and control of Shellfish Poisoning

Of course, prevention and control and management of toxic algal blooms are not in our hand. However, to some extend, we can avoid the potential blooming conditions in our coastal areas:

- Monitoring of shellfish growing waters for toxic Dinoflagellates as well as assaying these organisms for toxicity are means for preventing shellfish poisoning
- Untreated effluents from factories, industrial areas and other organic wastes should not be discharged into the coastal regions.
- Sewage should not be discharged untreated into the sea since it is full of nutrients.
- Eating of uncooked shellfish from endemic areas, since cooking does not completely destroy PSP and NSP and they are rather heat stable.

Table II

Non-toxic algal blooms observed in the off shore waters of west coast of India (*FORV Sagar sampada*)					
Sl.No	Cruise No.	Date	Time (Hrs)	Depth (m)	Organisms
1	166	24.06.1998	06.00	90	*Trichodesmium sp*
2	168	23.10.1998	16.00	4200	*Noctiluca miliaris*
3	182	13.03.2000	09.00	540	*Noctiluca miliaris*
4	182	22.03.2000	20.00	2440	*Noctiluca miliaris*
5	183	24.04.2000	16.00	75	*Trichodesmium sp*
6	203	22.05.2002	10.30	72	*Trichodesmium sp*

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