STATUS OF HAB AND POTENTIAL REMOTE SENSING APPLICATION IN DETECTION OF HAB EVENTS IN MALAYSIA WATER

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Introduction
The first report of harmful algal blooms (HABs) and shellfish toxicity in Malaysia was in 1976 when the marine dinoflagellate Pyrodinium bahamense var. compressum bloomed in Brunei Bay on the west coast of Sabah (Roy, 1976). Several people were poisoned during this event. The bloom eventually spread to other parts of Sabah. Over the years many poisoning cases have been reported including fatality.

For many years HABs and shellfish toxicity in Malaysia were considered problems unique to the west coast of Sabah. In 1991, three people were taken ill after consuming green mussel, Perna viridis, cultured at a newly established mussel farm in Sebatu, a small fishing village facing the Strait of Malacca. Symptoms suggested that intoxication was due to algal toxins. Subsequent testing of extracts from mussels collected during the event confirmed the presence of algal toxins. In 1997, the most likely toxins producer was isolated from the area and the clonal cultures were established in the laboratory. The species was successfully identified as Alexandrium tamiyavanichii. Toxin analysis of these cultures confirmed the dinoflagellate produced toxins similar to those in toxic mussels (Usup et al. 2000).

The latest development in HABs took place in September 2001. Six people were taken ill after consuming benthic bivalve, ‘lokan’ (Polymesoda sp.) collected from a coastal lagoon on the east coast of Peninsula Malaysia. One of the victims died (Lim et al. 2002).

Status of harmful algae blooms (HAB)
In Malaysia, the most important seafood inotoxication due to algal toxins is paralytic shellfish poisoning (PSP). At least three species of PSP-toxin producing dinoflagellates are currently known, viz. P. bahamense var. compressum in Sabah, Alexandrium tamiyavanichii in Sebatu, Malacca and A. minutum in Tumpat, Kelantan. More extensive survey may well reveal the presence of other PSP-toxin producing species. The primary vector for PSP toxins are bivalve mollusks, although planktivorous fish such as ‘tamban’, Sardinella sp. can also contain the toxins.

Diarrhetic shellfish poisoning (DSP) is the second important seafood toxicity due to algal toxins. Experiences of several other countries showed that DSP emerged with the establishment of large scale mussel farms (Lembeye et. al. 1993; Gestal-Otero, 2000). The toxin that causes DSP is produced by several species of the cosmopolitan marine dinoflagellates, i.e. Dinophysis caudate, D. fortii, D. acuminata, D. rotundata and Prorocentrum lima. In Malaysia waters, survey carried out in several locations showed that potentially toxic Dinophysis and Prorocentrum are common and can occur
in high densities. It is, however, difficult to prove the toxicity of these species since laboratory cultures have not been established. Furthermore, symptoms of DSP are very similar to gastrointestinal ailments caused by bacteria poisoning and can be easily confused. In addition, it is also likely that DSP would not be reported due to the fact that diarrhea last for only 2 to 3 days. No report of fatality or DSP has been reported so far in Malaysia waters.

Ciguatera fish poisoning (CFP) is one of the most interesting seafood poisoning, in that it is of solely tropical origin. The toxins are produced by benthic epiphytic dinoflagellates, and the vectors are various species of marine fishes. Export of fishes to other countries can result in the occurrence of CFP in places far from where the ciguatoxic fishes originated (Geller et al. 1991). In Malaysia waters, several species of benthic dinoflagellates which may be involved in CFP have been identified, they are Gambierdiscus toxicus, Ostreopsis ovata, O. lenticularis, and Coolia sp. Toxicity screening based on hemolytic assay, antimicrobial and mouse bioassay has proven the existence of biological activities in aqueous and organic phase extract of these cultures. However, the toxins compound are yet need to be determined.

In the late 1980s there were a few suspected cases of CFP in Sabah but these were never confirmed. However, a recent outbreak of CFP in Hong Kong was claimed that the toxic parrot fishes were originated from the Southeast Asia although the country was not specified. Recently, screening carried out using ciguatoxin immunological assay also shown positive results on reef fishes from west coast of Sabah.

Amnesic shellfish poisoning (ASP) is the other group of algal intoxication which remains little studied. Although the existence of the diatom, Pseudo-nitzhia species are common in most plankton samples collected from coastal areas in our waters. This may be due to the fact that difficulty in identification and toxins screening. The occurrence of cyanobacteria blooms and toxins in our freshwater body has never been studied systematically to date. Irregular study on several freshwater ponds, lakes and rivers disclose the existence of known toxic cyanobacterial species, i.e. Anabaena, Nostoc, Oscillatoria and Cylindrospermum. Moreover, there have been quite a number of cattle fatality which we believed may be linked to cyanobacterial blooms that contaminated the freshwater body. Some of these species have been established in laboratory culture for identification and toxicity screening.

Presence of HAB species imposes a severe burden on the affected country. This is compound by wide adoption of the HACCP (Hazard Analysis and Critical Control Point) protocols under FDA (Food and Drug Agency) which require that seafood is certified as safe and wholesome for consumption.

**HAB: Remote sensing as a management tool**

Currently, management of HAB problems and shellfish poisoning were entirely depend on monitoring effort carried out by the related fishery agency. Regular monitoring of plankton and seafood toxins has been carried out to safeguard the public health and meet the export requirement. These procedures required trained personals and extensive effort and it is not cost effective in the long run. However, with the extent of coastline, the unpredictable nature of HABs event, shortage of manpower and facilities make regular and large scale monitoring almost impossible. Thus, monitoring effort currently carried out by Fishery Department has concentrated only in areas where HAB problems exist.
Advancement on satellite technology has directly promotes the utilization of satellite imagery for various observatory purposes. This remote sensing technology provides exciting approaches in management of HAB problems since the past decade. Increased of primary productivity (correlated with increased in cell density) in the water column can be detected with the increase of photosynthetic pigment using passive remote sensing method.

Study carried out by Tester et al (1998) on Karenia brevis (Gymnodinium breve) showed that the detection limit for the species is $10^5$ cell/L. This is true with the assumption K. brevis bloomed uniformly and the entire signal was derived from K. brevis. Remote sensing provided a significant advancement in early detection of K. brevis blooms and also allowed sufficient time to the related agency to react with the events. However, the detection limit might not be acceptable for other HAB species, since the $10^5$ cells per liter has far exceeded the safety limit for Pyrodinium bahemense and Alexandrium sp. to cause shellfish toxicity.

Major drawbacks of this application are that the cell number and chlorophyll pigment is not always proportional. Pigment varies with life stage, physiological status and also species dependent. In addition, plankton patchiness, variable optical properties (DOM, light scattering) of the water and certain background pigment level also influence the observed pigment values.

Currently, this approach is incapable of classifying various plankton taxonomic groups. There is also lack of possible mechanism to differentiate between toxic and non toxic groups when it happened to bloom at the same site. Ground truthing (plankton analysis) is crucial to verifying data from satellite imagery. In this stage, available database of HAB species and information system will assist in determining the risk of occurrence HAB events.

Remote sensing has been implemented in early detection of HAB events with some successful cases, especially in subtropical and temperate regions. However this approaches facing new challenges when applying in the tropical water. Prolong cloud coverage over a great extent deter the passage of the sunlight. Moreover, interferences from land based primary production need to be filter out with certain algorithms. Imagery gap exist due to the non-intersecting swath path also cause loss of imagery data on the portion of tropical regions.

Conclusion

Satellite imagery provide an interesting prospect in the detection of HAB events, however, this technique should be carefully tailor to suit the application need especially in the tropical waters. In addition, verification of data with ground truthing and setting up of HAB database locally is essential in determining the success of the application.

References


Tester, A. P., Stumpf, P. R., Steidinger, K. 1998. Ocean color imagery: what is the minimum detection level for *Gymnodinium breve* blooms?