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# Prevalence, Toxicology and Chemistry of Marine Toxins

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## Abstract

Marine toxins are produced by a large number of marine algae. They are the chemicals with varying degree of chemistry and altered symptoms. The potent chemicals are the source of food poisoning followed by different types of physiological disorders when consumed by victims such as sea birds, marine mammals and human in large quantities. They are also responsible for sea food contamination across the globe. Sea food intoxication incidents have been occurred at shores of Europe, US, Canada, Japan, Africa, Australia and New Zealand by the consumption of contaminated shell fish. Shell fish can further categorize into mussels, oysters, scallops and clams. Marine toxins cause various types of food poisoning such as Amnesic Shellfish Poisoning (ASP), Paralytic Shellfish Poisoning (PSP), Neurologic Shellfish Poisoning (NSP) worldwide, Diarrheic Shellfish Poisoning (DSP) and Azaspir acid Shellfish Poisoning (AZP). The prevalence, toxicology and chemistry of marine toxins have been discussed in the present study.

***Keywords:*** *Marine toxins; Marine algae; Toxicology; Seafood; Intoxication*

## Introduction

The microscopic marine algae are essential food for filter-feeding bivalve shellfish. There are 5,000 identified species of phytoplankton, 300 out of them are known for harmful algal blooms (HABs) depending on their high density and proliferation rate [1-3]. Conversely, from these, 40 species are known to yield marine toxins. Various studies have suggested that these species produce marine toxins to compete other species in their vicinity for food and space. These toxins accumulate in the digestive glands of bivalve shellfish [4-8]. Toxins transmit via food chain to other ocean dwelling higher organisms such as mammals, marine birds and eventually to the human (Figure 1). They also yield greater economic losses to seafood industry annually [9,10]. This review extends the understanding of poisoning disorders caused by various toxin producing marine algae in diverse oceanic extents. There are commonly five types of marine toxins which are produced by marine algae (Table 1).

## Domoic acid

Domoic acid (DA) is produced by diatom *Pseudo-nitzschia*. It is a happen with a number of DA isomers, and a potent neurotoxin which causes ASP (Figure 2) [11]. DA targets hippocampus which is responsible for memory [12]. It binds to glutamate receptors which in turn open membrane channels leading to up surge of sodium influx thus creating membrane depolarization.

### Symptoms, prevalence and toxicology

ASP is followed by short-term memory loss; other symptoms include various gastrointestinal disorders [13,14]. The permissible level of DA is 20 mg/kg of shellfish. DA incidents have been reported globally in many coastal regions of US, Canada, France, UK, Spain, Ireland

and Portugal [15-20]. The first intoxication incident was occurred in 1987 on Prince Edward Island, Canada by the consumption of blue mussels (*Mytilusedulis*) contaminated with higher proportion of DA [14,15,21].

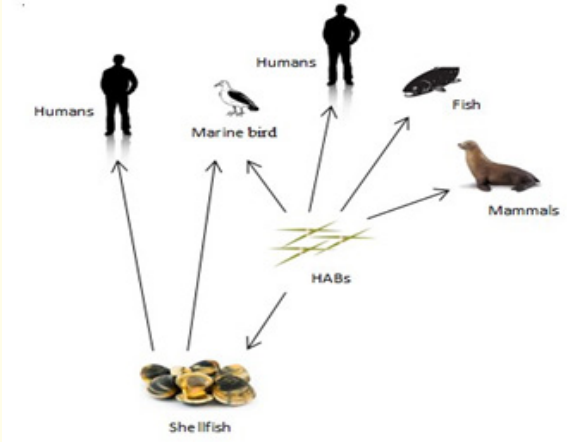


***Figure 1:*** *The exposure routes of marine toxins by harmful algal blooms (HABs).*

| Toxin group | Syndrome | Genus | Reference |
|---|---|---|---|
| Domoic acid | ASP | *Pseudo nitzschia* | [22] |
| Saxitoxins | PSP | *Alexandrium* | [23-25] |
| Brevetoxins | NSP | *Karenia* | [7,26] |
| Okadaic acid | DSP | *Phalacroma* | [27] |
| Azaspiracids | AZP | *Azadinium* | [28] |

***Table 1:*** *Classification of toxin groups and their related algae.*

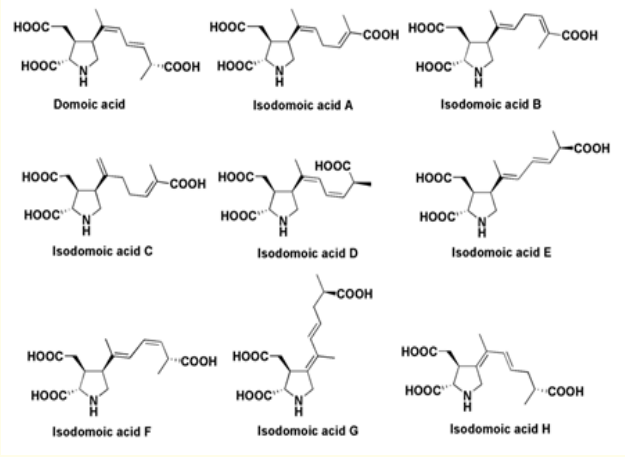


**Figure 2:** Chemicalstructures of domoic acid (DA)and its isomers.

**Saxitoxins**

Saxitoxins are produced by the genus of Alexandrium (Figure3); this group of toxins is responsible for PSP and consists of 57 different analogues, they are natural neurotoxic alkaloids called paralytic shellfish toxins (PSTs) [29,30].

**Symptoms, prevalenceand toxicology**

Saxitoxinsalter the physiology of voltage-gated sodium channels in the membrane causing decreased action potential. Its intoxication results in short-term blindness, insensitivity of the lips, neck and face with some few other related gastrointestinal and respiratory disorder disorders ultimately lead to the death [30-34].

Saxitoxins were identified in 1920 at California with reports of six deaths. The permissible level is 800 µg/kg of shellfish. The toxins are detected in Europe, US, Canada, Japan, Africa, Australia and other countries [35-38].

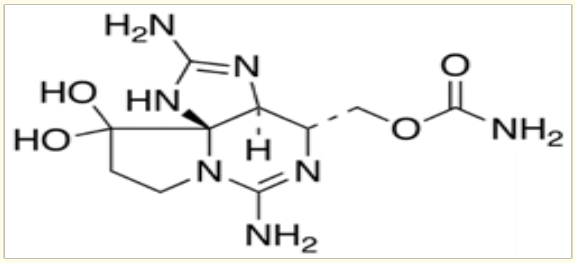


***Figure 3:*** Chemical structure of saxitoxin.

**Brevetoxins**

The brevetoxins (PbTx) are potent neurotoxins and cyclic polyethers which are tasteless, odorless, heat-stable lipid soluble and they are produced by the genus of Karenia. These toxins and their analogues cause NSP (Figure 4) [7].

**Symptoms, prevalence and toxicology**

Brevetoxins are histamine activators and sodium channel inhibitors [39]. The permissible limit is 800µg/kg of shellfish. Their intoxication can be caused by inhalation of breaking waves aerosols at coastlines. The symptoms include gastrointestinal, cardiac and respiratory disorders which eventually lead to the death [40,41]. Intoxication incidents are restricted to the US and New Zealand [42-44].

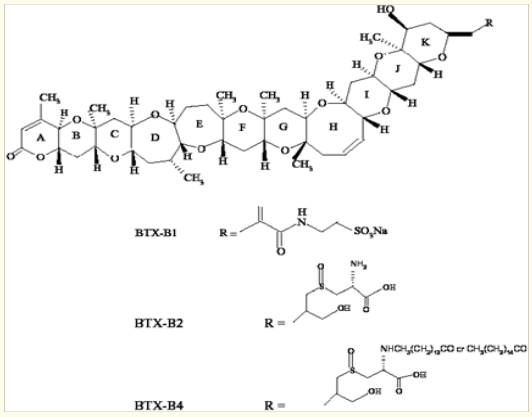


***Figure 4:*** Chemical structures of brevetoxin (PbTx) and its analogues.

**Okadaic acid**

Okadaicacid (OA)is produced by various dinoflagellates such as Dinophysis genus, OA and related toxins accumulate in the shellfish and cause DSP, their various analogues areDTX-1, DTX-2 and DTX-3 respectively (Figure5) [45].

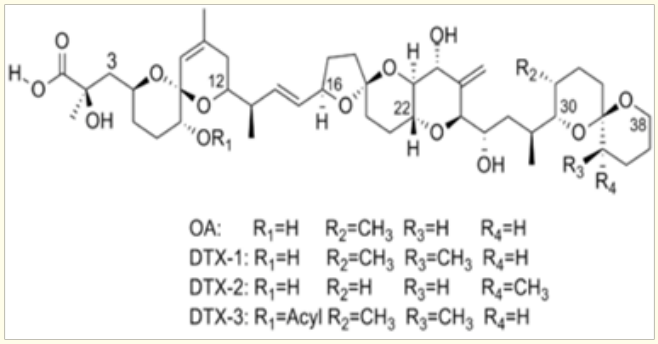


***Figure 5:*** *Chemicalstructuresofokadaic acid (OA)and its analogues.*

**Symptoms, prevalence and toxicology**

These toxins cause hyperphosphorylation by inhibiting these rine/threonine phosphatases which lead to the disturbance of cytoskeletal structures and disturbing the permeability of the cellular membrane. Permissible limit for OA is 45µg/kg of shellfish. Symptoms include various related gastrointestinal disorders; studies showed that they are also tumor inducers in animal tests [46-49]. OA has been identified at the costliness of Europe, US, Africa, Japan and Australia. The first intoxication incidence of DSP was reported at Netherlands in 1961 [48,50-55].

**Azaspiracids**

Azaspiracids (AZA) are the group of lipophilic polycyclic ether toxins produced by ubiquitously distributed small dinoflagellate genus of Azadinium (12-15 µm)(Figure 6). Many azaspiracid analogues have been identified such as AZA-1, AZA-2, and AZA-3 [28,52,58].

**Symptoms, prevalence and toxicology**

The toxin alters the normal physiology of cytoskeletal system by changing its structure; it also affects the E-cadherin system which is significant for cell-cell interactions [59-61]. The permissible level of AZA is 30µg/kg of shellfish. AZP intoxication results in gastrointestinal disorder [57,62]. The first intoxication incidence was reported in 1995 at Netherlands and Ireland after consumption of the contaminated shellfish. AZA toxins have been identified at coastline of Europe, US, Africa, and South America [52,56,57,63-69].

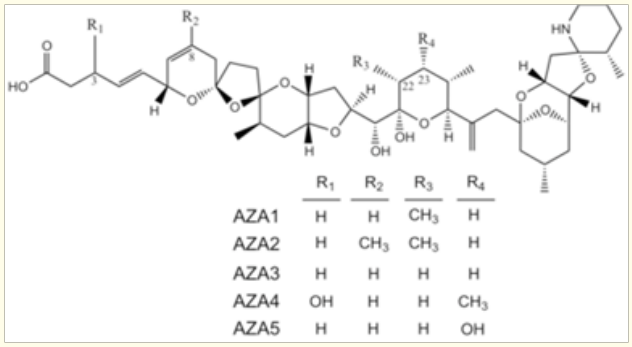


***Figure 6:*** *Chemical structures of azaspiracid and its analogues.*

## Conclusions

The algal blooms are responsible for the production of potent toxins in oceans waters world wide.These toxins accumulate in shellfish and transmit to seabirds, higher mammals and to the human causing sever physiological disorders including neuro, gastrointestinal, respiratory and cardiac. Therefore, it is important to carefully monitor their concentrations in contaminated seafood and in the marine water on regular basis. Toxins are a serious threat to the environment and human health and this study will further help in understanding the relationship of algal toxins to their toxicological effects in future.

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## Conflicts of Interest

The authors declare no conflict of interest.

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