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Algal Toxins and their Impact on Human Health

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ABSTRACT

Different species of fresh water Blue Green Algae namely *Anabaena sp.*, *Aphanizomenon sp.*, *Coleosphaerium sp., Gloeotrichia sp*, *Lyngbea sp.*, *Microcystis sp.*and *Nodularia sp.* are capable of producing a number of toxins. These toxins are secondary metabolites which are highly toxic to human beings and other animals. These toxins belong to different classes such as cyclic peptides, Alkaloides and Lipopolysaccharides.

Key words: Blue Green Algae, Toxins, Human Health.

INTRODUCTION

Algal toxins are organic molecules produced by a variety of algal species from fresh, brackish and marine waters (Falconer, 1993). Over the past three decades, the occurrence of harmful toxic algal incidents has increased in many parts of the World (Anderson , 1989 and Shum way, 1990). Many bloom forming species of algae are capable of producing biologically active secondary metabolites which are highly toxic to human health and other animals (Pearson *et al.,* 2010). Cyanobacteria can produce different type of Cyanotoxins which belongs to four major classes namely Neurotoxins, Hepatotoxins, Cytotoxins, Dermatotoxins and Lipo polysaccharides. The present review reports an overview of various toxins of algae and their impact on human health and other animals.

Eutrophication

Eutrophication is a process whereby water bodies such as lakes, estuaries, or slow moving streams receive excess nutrients that stimulate excessive plant growth such as algae, periphyton attached algae and naissance plant weeds. This enhanced plant growth often called an Algal Bloom and it reduces the dissolved oxygen, decreased transparency of light, bottom phytoplankton died in the water. When dead plant material decomposes and can cause other organisms to die (Thyagarajan *et al.,* 2007).

Cyanobacteria

Cyanobacteria also known as Blue Green Algae Gram-Negative, Photo synthetic, prokaryote found in a variety of habitats such as Fresh, Brackish, marine, hyper saline, volcanic ash, desert sand, rocks and terrestrial environments. (Chorus & Bartram 1999). They play important role in the biological cycling of elements and show diversity of aquatic communities. Cyanobacteria have both beneficial and detrimental properties. When judged from human perspective the extensive growth of Cyanobacteria can create a considerable nuisance for management of inland waters and they may also release various toxic substances in to the water. The water quality problems caused by dense population of Cyanobacteria are intrinsic, many and various and can have a great impact on the health of humans and other animals. (Masango,2007).

Toxins produced by Blue Green Algae

Of the more than 50 genera of blue green algae at least 8 have exhibited toxic characteristics of these include *Anabaena sp.*, *Aphanizomenon sp.,*

Coelosphaerium sp., *Gleotrichia sp.*, *Lyngbea sp.*, *Nodularia* sp., and *Nostoc* sp. (Mike Collins, 1978). The incidents of toxicity of these blue green algae have been reported by Schwimmer and Schwimmer 1964; 1968). The earliest reports of Cyanobacteria poisoning may have been around 1,000 years ago. When general Zlu-Ge-Ling reported mortalities in troops that drank water from a river in southern China. But first known incidents of Cyanobacteria toxin poisoning was from an Australian lake in 1878 (Chorus and Bartram,1999, Francis, 1878)

Cyanobacteria produce variety of toxins called cyanotoxins. Cyanotoxins are diverse group of natural toxins. In spite of their aquatic origin most of the Cyanobacteria that have been identified, so far appear to be more hazardous to humans and other aquatic animals (Carmichel, 1992; Chorus and Bartrman,1999 ; Falconer and Humpage , 2005 and Codd *et al.,* 2005a).

Neurotoxins

Neurotoxins are produced by different genera of Cyanobacteria including *Anabaena* sp, *Aphanizomenon* sp, *Microcystis* sp, *Planktothrix* sp, *Raphidopsis* sp, *Cylindrospermium* sp, Phormidium sp, and *Oscillatoria* sp.

Neurotoxins of Oscillatoria sp. and *Anabaena* sp. have been responsible for animal poisoning (Carmichael 1997; Braind *et al.,* 2003; John.,H; Rodgers.JR, 2008). Neurotoxins usually cause acute effects in vertebrates including rapid paralysis of the peripheral skeletal and respiratory muscles. Neurotoxins affect the nervous system of the animals. Anatoxin-A inhibits transmission at the neuromuscular junction by molecular mimicry of the neurotransmitter, Acetylcholine (John.H &Rodgers JR *et al.,* 2008)

Hepatotoxins

The cyclic penta peptide Nodularin is most commonly produced from the filamentous, planktonic, Cyanobacterium, *Nodularia spumigena.* This species generally form toxic blooms in brackish and estuarine environment (Pearson *et al.,*2010). Nodularin is a potent hepatotoxin for humans and other animal. It induces liver hemorrhage in mice, when it injected in artificial way. The toxic effects of nodularin are primarily associated with the hepatic cells due to active transport of the toxin to liver via the bile acid, multi specific organic anion transporters (Pearson *et al.,* 2010; Runnegar *et al.*, 1995). The consumption of *N.spumigena* may cause massive liver hemorrhage in animals (Nehring.,1993; Carmichael and Eshedor.,1988; Carmichel.,1994; Francis 1878).

Saxitoxins

Saxitoxins are heterocyclic guanidine neurotoxins act like carbamate pesticides produced by different fresh water algae like *Anabaena circinalis*, *Aphanizomenon., Aphanizomenon gracilie., Lyngbea wolleri* are responsible for shell fish poisoning. Blooms of these toxic species have led to mass kills of fish, native mammals and live stock as well as the contamination of fresh water resources. (Negri Jones.,GJ *et al* 1995; Sawyer Gentile., 1968). Saxitoxin bind to site I on the voltage –dependent Sodium channel inhibiting channel conductance and thereby causing blockade of neuronal activity

Paralytic shell fish poisoning symptoms generally onset with in 30 min of ingestion and invariably begin with a tingling or burning of lips, tounge and throat increase to total numbness of face (Lewellyn.,2006). The saxitoxin causes several health problems in humans include perspiration, vomiting, diarrhea. In case of acute poisoning numbness may be spread to neck and extremities and progress to muscular weakness, loss of motor coordination, and finally leads to paralysis (Lewellyn, 2006).

Lipopolysacchrides (LPS)

Lipopolysaccharides are known as irritant toxins and are generally found in the outer membrane of the cell wall of Gram-negative bacteria, including Cyanobacteria, where they form complexes with proteins and phospholipids. It is generally the fatty acid component of the LPS molecule that elicits an irritant allergic response in humans and mammals. Cyanobacterial LPS are considerably less potent than LPS from pathogenic Gram-negative bacteria such as *Salmonella (*Chorus and Bartram, 1999 and Masango,2007). LPS is a potent activator of macrophages and can results in the production of cytokines and growth factors.

Cylindrospermopsin

Cylindrospermopsin is a polyketide derived alkaloid was first discovered in 1979, when 148 people were hospitalized with the symptoms of hepatoenteritis on palm island (Queen land) Australia, it was due to *C.racibarskii.(* Bourkae *et al., 1980;* Byth *et al., 1980;* Hawkins *et al* 1985*;* Ohtaic *et al.,* 1992). It also effects domestic animals. (Saker *et al.,*1999). Generally it is a cytotoxin that blocks glutathione, protein synthesis, and cytochrome p450. (Runnegar *et al*.,1995; Runnegar *et al.,*1994; Froscio *et al*., 2003). It also interfering with systems of Liver, Nerves, Thymus and Heart and is considered a potential carcinogen. (Runnegar et al.,1995; Runnegar *et al., 1994;* Runneagr *et al.,*2002; Kiss *et al.,*2002).

Cylindrospermopsin is produced by eight fresh water Cyanobacterial members includes *Cylindrospermopsis raciborskii, Aphanizomenon ovalisporum, Aphanizomenon flos- aquae Anabaena bergi, Anabaena lapponica*, *Lyngbya wollei*, *Rhaphidiopsis carvata, Umezakia natans.* Out of these eight members *Cylindrospermopsis raciborskii* presents a major problem for eater management on globally. (Neilan *et al.,*2003).

Anatoxins

There are three families of cyanobacterial neurotoxins are known namely Anatoxin-a and Homoanatoxin-a, Anatoxin-a(s), Saxitoxin (Mahmood & Carmichael 1987; Carmichael *et al.,* 1992). Anatoxin-a is one of the neurotoxic alkaloids tht have been produced from cyanobacteria include *Anabaena, Planktothrix,(Oscillatoria), Aphanizomenon, Cylindrospermum, Microcystis spp.* Anatoxin-a is a bi cyclic secondary amine that mimics the neurotransmitter acetyl choline and binds to the nicotinic acetyl choline receptor at the axon terminal at the neuro muscular interface Botana, 2007.Huisman *et al.,* 2005. Binding of anatoxin- a is irreversible, the sodium channel is locked open, becomes over stimulate, fatigued and eventually paralyzed. (Carmichael, 1975). Anatoxin-a exposure results in a lack of oxygen to the brain, subsequent convulsions and death by suffocation.

Homo Anatoxin produced by *Oscillatoria formosa ,* it is a methyl analogue of Anatoxin-(A) (Carmichael 1992).

Anatoxin-a (s) produced by *A.flos-aquae*, (Matsunaga *et al*., 1989) and induced salivation in mice by which it can be differentiated from other cyanobacterial neurotoxins. It acts as an irreversible anti cholinesterase inhibitor (Mahmood & Carmichael, 1987).

Contactdermatitis

Allergic dermal reactions of varying severity have been reported from a number of fresh water cyanobacterial genera. Anabaena sp., Aphanizomenon sp., Nodularia sp., Oscillatoria sp., Gleotrichia sp., after recreational exposure. Reports from USA have recorded allergic reactions from recreational exposure and the cyanobacterial pigment, Cyanophycin has been shown to be responsible in one case (Cohen and Reif *et al*., 1953). Skin irritations were a frequent symptoms found in an epidemiological study by Pilotto *et al* (1997). Heise (1949) described that ocular and nasal irritation in swimmers exposed to Oscollatoriaceae. Cyanobacterial toxins can cause severe allergic reactions in sensitive individuals (Cohen and Reif *et al.,* 1953)

Microcystins

Microcystins produced by *Microcystis aeruginosa., Microcystis viridis., Aphanizomenon flos-aquae., Oscillatoria haplosporium* and *Anabaena* species are associated with Microcystins. *M.aeruginosa* are most frequently associated with the algal blooms and associated with hepatotoxicity. (Chorus&Bartram *et al.,* 1999 ; Hitzfeld and Hoger, 2000). Microcystins are cyclic hepta peptides with variable aminoacids at seven different positions. The microcystins are generally associated with Hepato toxicity (Chorus and Bartram ,1999.)

The name microcystis derived from the toxins that were first isolated from Microcystis.aeruginosa. The toxicity of microcystis is due to their strong binding to protein phosphatases (Chorus and Bartram 1999; Hitzfeld,and Hoger *et al*., 2000; Pilotti *et al*.,1999; Tervola and Eriksson &Brautigan 1994; Runnegar&Gerdes et.al 1991; Runnegar&Berndt *et al* 1995; Dawson 1998.)

Up on ingestion, Microcystin is transported to liver by organic anion transport proteins where

they exert their toxicity via inhibition of proteins. Inhibition of protein phosphates can lead to excessive phospharylation of structural filaments, subsequent cytoskeletal degradation and breakdown of hepatic ultra structure. (Eriksson and Toivola *et al* 1990; Sahin & Tencalla *et al* 1995). Neighboring cells and sinusoidal capillaries causes blood to become pooled in the liver tissues. This ultimately results in local tissue damage, organ failure and hemorrhagic shock.

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