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Toxic Algae and Effects of Algal Poisoning in Animals and Human Beings

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ABSTRACT

Algae include primitive thalloid plants having enormous uses. Despite of many beneficial activities, some algae cause sickness or death to the living organisms, called 'toxic algae'. Not only fresh water algae are toxic but marine algae are also toxic. A species may have different strains, some of which may be toxic and other non-toxic. Toxic algae affect different body parts of an organism. Algal blooms which generally appear in green, blue or brownish colour in warm seasons for longer duration, can look like foam, scum, or mats or like paint floating on the surface of water, contain a large numbers of pigmented cells and hence composed of bio-toxins. These toxins are secondary metabolites which are produced by a varity of algal species and harmful to organisms. The present paper describes the toxic algae belonging to Cyanophyceae, Dinophyceae, and Chlorophyceae groups; toxins produced by algae, and the effects of algal poisoning on animals and human beings.

Keywords: *Algae, Toxins, Poisoning, Cyanophyceae, Dinophyceae, Chlorophyceae*

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INTRODUCTION

Freshwater algae being a natural part of the aquatic ecosystem, when growing out of control under suitable environmental conditions like stagnant, warm water and in nutrient-rich level, may be due to the addition of fertilizers and its runoff in to the water bodies, if not managed effectively; sometimes produces toxic or harmful effects in the life of other organisms like fish, marine mammals, birds, and even human beings (Amasha & Aly, 2019; Alshehri, 2020). Harmful algal blooms promoted by human activities as well as climate change (Sinha *et al.,* 2017; Gobler, 2020; Trainer *et al.,* 2020; Burford *et al.,* 2020). Mostly toxic algae belonging to Cyanophyta and dinoflagellates have been reported. The toxicity depends on the ecological and developmental conditions of the algae. Environmental conditions influence the biosynthesis of toxin production in algae (Boopathi & Ki, 2014). Secondary metabolites play role in the colonization and bloom formation (Kurmayer *et al.,* 2016). Algal poisoning has been reported from Argentina, Australia, Bermuda, Brazil, Britain, Canada, Central America, Finland, Israel, Morocco, New Zealand, North America, Russia, South Africa, and U.S.A. (Kamat, 1982). It may be noted that *Microcystis aeruginosa* is a common alga throughout India. In temple ponds, it is probably the most common alga, but no toxic effects are recorded. *Anabaena flos-aquae* is also not rare in India. It is customary and religious also for the devotees to wash their feet and hands and even gargle with water from the temple ponds. This is a sort of ritual and it is certainly unhygienic when the water contains bloom (Kamat, 1982).

MATERIALS AND METHODS

An analysis of various toxic algae reported from the literature was carried out and an account belonging to different algal groups and their effects on animals and human beings were included in the results.

RESULTS AND DISCUSSION

Examples of Toxic Algae

Cyanophyceae

Anabaena circinalis, A. flos-aquae, A. inequalis, A. limnetica, A. nadsonii, A. scheremetievi, Aphanizomenonflos-aquae, Aphanothececyanea, A. nidularis, Gloetrichiaechinulata, Lyngbyabizgei, Microcystis aeruginosa, M. toxica, Nidulariaspermigena.

Dinophyceae

Gymnodinium brevis, G. flavum, G. mikimotoi, G. veneficum, Gonyauloxcatenella, G. monilata, G. tamarensis, Prymnesiumparvum, Pyrodiniumphoneus.

Chlorophyceae

Chlorella and Scenedesmus

Toxins Produced by Algae

Toxins may be produced according to the strains of the different species. According to Gorham *et al.* (1964) toxin of *Anabaena flos-aquae, A. lemmermannii,* is a polypeptide. The toxin of *Microcystis* is a non-volatile, acidic component with great absorption qualities and is a neurotoxin. It is a cyclic

peptide composed of about 10 amino acids; some of them are D-serine, L-ornithine, aspartic acid, and glutamic acid. Gorham *et al.* (1964) isolated 28 strains of *Microcystics aeruginoua*out of which less than 1/3 rd produce FDF. He also found that different strains of this alga are genetically heterogeneous for toxin production.

The toxin of *Prymnesium pervum* is nondialyzable, thermolable, and Acidlabile. The endotoxin of *Gonyavlox*is retired to as Ichthyosarcodin with a chemical formula C_{16} H_{31} NO_{16}.

It is an alkaloid, nonvolatile, water-soluble, and acid-stable. It can be stored for many months without losing its strength. The poison is thought to be ten times more potent than strychnine and its effects are more like those of *Botulina* poisoning. One millionth of a gram injected is sufficient to kill a mouse.

The toxin of *Gymnodiniumveneficium* is water-soluble, ether soluble, acid labile, of high molecular weight, and acts on the nervous system.

Effects of algal poisoning

Algal toxins have been found poisonous to fishes, shell fishes, mussels, live stocks, cattles, horses, swines, water fowls, ducks, chickens birds, etc and even human beings. Symptoms and survival time vary from case to case. Cases of the death of a full grown cow and other cattle in ½ an hour or less are known (Kamat, 1982).

Besides death, the harmful effects of algae (e.g. *Microcystistoxica*) include loss of weight, weakness, liver pathology, abortion, etc. Some pigments like phycocyanin are sensitive to light and when they are in blood capillaries, cause internal burning and peeling of the skin.

The toxin extracted from *Microcystis* when given to animals shows an enlargement in of the liver tissue, a failure of blood to clot, and congestion within the spleen (Kamat, 1982).

The toxin produced by *Gymnodinium*affects both nerves and muscles and inhibit the response of skeletal muscles to acetylcholine by depolarizing membranes over which nerve impulse pass.

Symptoms produced by toxins of *Gonyavlax*are dizziness, nervous disorders, and death within 30 minutes and 24 hours respectively.

Algal poisoning in Animals

Dogs and livestock account for majority of cyanotoxin poisoning in animals (Wood, 2016). An overview of cyanobacterial poisoning in livestock, wild mammals and birds has been studied by Stewart *et al.* in 2008. Poisoning of fish and other animals have been reported by a large number of workers as under:

Gymnodiniumveneficum, a dianoflagellate is known to be toxic to mussels along the coasts of California and Washington.

The toxin of *Gymnodinium*is enough to kill whole schools (school) of fish within many square miles particularly in the gully of Mexico, and the New Jersey coast where the alga forms the Red tide (Kamat, 1982).

Kamat (1982) has also reported the following examples:

a) Perch and crappies were killed in an aquarium containing *Aphanizomenon*bloom, even though oxygen was maintained at 8 ppm.
b) Laboratory animals, when given extracts from *Microcystis, Anabaena,* and *Aphanizomenon*intravenously, intra peritoneally or orally, died within 3 minutes to 48 hrs.
c) The toxin of *Gymnodinium*is lethal for more than 20 different spp. of laboratory animals.

Many a time's fish deaths on a large scale are reported from different parts of India, almost always these deaths are due to depletion of the oxygen during nights and mostly during cloudy days, which may be mistaken for toxic effects (Kamat, 1982). Infact, according to some, mortality is partly caused by O_2 deficiency and partly by a toxin produced by algal bloom of *Microcystis aeruginosa, Anabaena flos-aquae, Aphanizomenonflos-aquae.*

Prymnesiumparvum, a minute dinoflagellate is known to be extremely toxic to fishes in fish ponds in Isarael and other countries.

Algal Poisoning in Man

There are some indications that algae are occasionally toxic to human beings. Recreational activities are responsible for approximately half of the cyanotoxins poisoning in human beings (Wood, 2016; Vidal *et al.,* 2017)

1. According to Schwimmer and Schwimmer (1964) algae like *Anabaena circularis, Aphanizomenon, Microcystis, Oscillatoriaintestenii, Protothecaportoricensis,* and unidentified algae have been reported to cause gastro intestinal disorders in man.
2. Schwimmer and Schwimmer (1964) have also reported that:
   a) *Gymnodinium brevis* causes burning of eyes, throat, irritation of respiratory tract, etc. and
   b) *Anabena*and *Lyngbya majuscule* causes skin disorders.
3. Swimmers coming in contact with this algae bloom suffer from severe irritation and dermatitis, called dermatitis eschearotica. It also causes allergic conjunctivitis.
4. Reddy and Mastan (2015) has reported that a number of blue green algal species producing toxins (secondary metabolites) which are harmful to humans beings. These toxins belong to cyclic peptides, alkaloids and lipopolysaccharides.
5. Levesque *et al.* (2016) have studied the acute health effects associated with endotoxins due to the exposure to cyanobacteria.
6. Buratti *et al.* (2017) have studied the toxicological profile of cyanotoxins and their risks for human health.
7. Kubickova *et al.* (2019) have studied the effects of cyanobacterial toxins in humans.
8. Young *et al.* (2020) have carried out scoping review showing acute patterns of illness in humans due to exposure to harmful algal blooms.

Algae grow abundantly in water reservoirs where an excess of nutrients are available to them. This algal growth floats on the water surface and looks like foam or soap/other. In warmer season these blooms progress and persist for longer duration (Moore *et al.,* 2015; Grifith's *et al.,* 2019). It is called water bloom. The harmful algal blooms responds to climate change (Huisman *et al.,* 2018; Ralston & Moore, 2020). Bloom forming algae release certain toxins. Although all the algae poisons mentioned cause considerable economic losses, the ones that have caused human deaths and sickness are of great public health importance in certain areas are the poisons from certain toxic algae that have causes shellfish poisoning in humans (Das & Sarkar, 2012; Trevino *et al.,* 2015). The trend toward the use of more products from the sea as food for man and the culturing of various algae for food makes it important that we know more about various toxic algae and the toxins that they produce. Proper management of nutrients ending up in water bodies, to stop excessive use of fertilizers and limiting erosion are the steps necessarily required for the solution.

CONCLUSION

It can be concluded from the present study that algal members mostly belonging to cyanophyaceae are more toxic followed by dinophyceae and Chlorophyceae. Environmental factors like light intensity and temperature leading to more accumulation of algal biomass and hence algal toxin production which ultimately have harmful effects in aquatic life as well as in the animals and human beings on land directly or indirectly.

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