

Harmful algal blooms (HABs) and their control

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Introduction

Algae are unicellular and/or multicellular, photosynthetic, eukaryotic and prokaryotic (cyanobacteria) organisms which play the major role in biofuels, bioplastics, nutraceuticals, foods, cosmetics, chemicals, fertilizers and nutrient supplements. Besides having huge beneficial character, excessive algal blooms (Harmful algal blooms) cause environmental deterioration and ill effect to living beings. Blooms are formed in both marine and fresh water ecosystems by phytoplankton including, dinoflagellates, diatoms and cyanobacteria. Harmful algal blooms reduce the water quality, affect water flora and fauna and cause food poisoning. Aquatic life is exposed to algal toxins by eating, breathing and/or touching these harmful algae. Harmful algal blooms have been increasing 15% worldwide in this decade. (Chen *et al.*, 2017). Algal toxins are responsible for >60,000 intoxication/year, overall mortality of about 1.5%. To control these harmful algal blooms using physical, chemical and biological methods have been used in freshwater and marine systems for small and large scale control of HABs.

Reason for excessive algal blooms

Excessive use of fertilizer in agricultural lands causes nitrogen and phosphorus fertilizer leaching from land to riverine system and leads to eutrophication (excessive algal growth). Discharge of industrial effluents to water bodies. Because of changing climate, ocean stratification occurs and its make the conditions favourable for algal growth and stagnant water are easily prone to algal blooms.

Common harmful algal blooms

HABs and poisoning	Causes
<i>Alexandrium</i> sp (Saxitoxins)	Affect nerves and muscles
<i>Karenia brevis</i> (Brevetoxin)	Nerve toxins/respiratory disease

<i>Pseudo-nitzschia</i> (Domoic acid)	Nerve disorder
<i>Microcystis</i> (Microcystin)	liver problem
<i>Gamberidiscus toxicus</i> (Ciguatera fish poison)	Neurological and cardiovascular disease
<i>Dinophysis</i> spp	Diarrhoea, vomiting
<i>Gymnodinium breve</i> (Neurotoxic shellfish poison)	Gastrointestinal and neurological disorder
<i>Alexandrium</i> spp (Paralytic shellfish poison)	Neurological disorder

Control of HABs

To control the harmful algae in aquatic ecosystems, control should carry out from head water streams to ocean continuum. Aquatic ecosystems are interconnected; they span from inland mountain streams, down to rivers, lakes and reservoirs, estuaries, and coastal margins. However, most management responses to eutrophication issues involve interventions aimed at treating individual segments of the freshwater-marine continuum and frequently focuses on the problem (blooms) rather than the underlying causes that often take place upstream of the bloom itself. Creation of riparian zone along the water body, growing phytoplankton, removal of bottom sediments is some of the old strategies to overcome and/or reduce harmful algal blooms. In recent days chemical, mechanical and biological methods used in algal bloom control (Sun *et al.*, 2018).

Chemical methods

Compound	Mechanisms	Example
Pre-oxidant	Coagulation	Ozone (0.6 mg/l), Chlorine dioxide(1 mg/l), Permanganate (5-10 ppm), Ferrate (10 mg /l)
Algaecide	Affect electron transport system, modify enzymatic activities	Copper sulphate (1 mg/l)

Clay	coagulate algal cell make flocculation	Montmorillonite, Kaolinite, Sericite, illite
Lime (1:4)	Affect chlorophyll	Slake lime (Ca(OH) ₂), Calcite (CaCO ₃)
Aluminium /Ferric salts	Destabilization of negatively-charged particles	Aluminium Sulphate (10-40 mg/l) Ferric chloride (15-20 mg/l)
Hydrogen peroxide 8-15ml of 3% in 50L H ₂ O		

Mechanical methods

Methods	Mechanisms
Aeration	Air is pumped in pond/lake Disrupt the stratification & limit the nutrients
Mechanical mixing	Pump water from the surface downwards /draw water from the bottom up.
Surface skimming	Blooms often forms scums Use oil skimmer for removal
Ultrasound	Ultrasonic of particular frequency used to kill the algae by destroy cell structure
Filtration	Remove the excess nutrients & debris and collected in the filter box/ skimmer

Biological control

Bacteria producing bioflocculating agent used for controlling and/or removing algal blooms. Bacteria producing exopolysaccharides create the flocculation in water bodies. Bacteria used for bioflocculation are *Porphyrobacter* and flavobacteriaceae induce EPS in *Microcystis aeruginosa* and *Marinobacter* spp, *Firmicutes* sp induce EPS in *Thalassiosiraa weissflogii* (diatoms). Induced EPS create the flocculation in the aquatic ecosystem. Fungus also plays

the major role algal control for example *Aspergillus niger*, *Trametes hirsuta* and *Streptomyces* spp. produce useful bioflocculants (Meyer *et al.*, 2017).

Conclusion

Harmful algal bloom causes numerous ill effects of environment and living being. Appropriate control measure with minimal side effect is needed. Some of the strategies to control HABs are reduction of algal bloom from upstream onwards, biological control method is ecofriendly, create awareness among the peoples, easy hand tool for HABs detection and/or forecasting is needed.

Reference

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