

## Chapter 4

### Algal Blooms

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**ABSTRACT:-** When the planktonic algae grow in sufficient numbers and accumulate or cover the water surface of the water body, this condition is known as an algal bloom or water bloom. It gives a distinct colour to the entire water body. The colour of the algae determines the colour of the water blooms. It may be temporary or permanent.

A large number of factors are found to be associated with the formation of water blooms. These are; water temperature, water movements, sunlight, inorganic and organic nutrients, pollution level, and heavy metals of the water body. Algae-causing water blooms are *Microcystis sp.*, *Gonyaulax sp.*, *Gymnodinium sp.*, *Spirulina sp.*, *Nostoc sp.*, *Anabaenopsis sp.*, *Volvox sp.*, *Zygnema sp.*, *Pandorina sp.*, *Chroococcus sp.*, *Merismopedia sp.*, *Ceratium sp.*, *Nitzschia sp.*, etc. Algal blooms have a positive and negative role in our daily life.

**Keywords:** Algal bloom, Blue-green algae, Prokaryotic/eukaryotic algae, Water pollution, Stagnant water, Factors of Algal blooms, and Algal toxins of water bloom.

#### INTRODUCTION

Algae are diverse and large groups of simple photosynthetic, unicellular/multicellular, eukaryotic/prokaryotic organisms<sup>1</sup>. They may be microscopic or macroscopic. The algae are predominantly aquatic and are found in freshwater, salt water, or brackish water. Freshwater



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forms of algae are abundantly found in ponds, lakes flowing streams, and water reservoirs. In habit, they may be free-swimming, free-floating, or attached to the bottom in the shallow water. The free-floating and free-swimming minute algae are known as phytoplankton<sup>2</sup>. The algae that grow attached to the bottom in shallow water along the edges of waterbodies of seas and lakes are known as benthos. Water blooms are formed by the growth of a solitary algae or rarely by a few algae. When the algae are abundant in a pond or lake to give a distinct colour to the entire water body, such an algal growth is called an ALGAL bloom<sup>3</sup>. The colour of the algae determines the colour of the water blooms. The algae involved in the formation of water blooms are generally phytoplanktons.

The rapid growth and multiplication of algae, which usually belong to the class Cynophyceae, a few members of Chlorophyceae, Chrysophyceae, Euglenophyceae, and Pyrophyceae generally form algal blooms<sup>4</sup>. Water blooms may be temporary or permanent. The water blooms are usually thick during winter and summer while during the rainy season, the bloom becomes thin due to rainfall. Algal blooms can be of many colours including blue-green, yellow, brown, pink, and red. Depending upon the type of algae algal bloom may produce bad-smelling scum, foam, froth, or a paint-like slick<sup>5</sup>. Some Algal water blooms are harmful because they produce toxins, which are dangerous to humans and other aquatic organisms. Blue-green algae can produce cyanotoxins. The most frequently reported type of bloom-forming Cynophyceae algal genus is *Microcystis* spp. Algal blooms can cause massive fish kill due to cyanotoxins. Algae causing water blooms are *Microcystis* spp., *Oscillatoria* spp., *Arthrospira* spp., *Anabaena* spp., *Suriella* spp., *Gonyaulax* spp., *Fragilaria* spp., *Volvox* spp., *Pandorina* spp., *Chroococcus* spp., *Melosira* spp., *Nitzschia* spp., *Spirulina* spp., *Gonium* spp., etc.

#### **CAUSES OF ALGAL BLOOMS:**

Algal Blooms occur both naturally in the environment and as a result of human activities. However, the latter are vastly increasing the frequency, prevalence, and toxicity of algal blooms<sup>6</sup>. The following are some of the main causes of algal blooms. These are (i) Nutrient pollution, (ii) Warm water, (iii) Still water, (iv) Climate change, etc.

(i) **Nutrient pollution:** Nitrogen and Phosphorus are essential for the growth and development of macro and microalgae. However,

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when the urban and rural surfaces, agricultural run-offs, animal manures, and chemical fertilizers washed from farms by rains are discharged to the water bodies, they become excessively nourished. This excess nutrition causes heavy growth and development of algal biomass in the water body leading to Algal bloom formation. This phenomenon is known as nutrient pollution<sup>7</sup>. This is the main cause of algal blooms. So many industries and towns dominate Jharkhand. From these industries, effluents are discharged directly into the water body without any prior treatment. This polluted water is enriched with so many nutrients which when poured into a water body, support Algal Bloom. Gas vacuoles found in blue-green algae are also highly responsible for bloom formation. Due to this gas, vacuole algae float on the water surface, and under favourable condition, they reproduce asexually and grows very fast. By using the nutrients of the polluted water of the water body, they develop day by day and ultimately cover the entire surface of the water body developing into an algal bloom.

**(ii) Warm water:** India is a country with a warm climate. In India Jharkhand is a state of industries and mines of so many ores and coals. Jharkhand has many industrial towns like Bokaro, Jamshedpur, Dhanbad, Ranchi, Muri, Giridih, Daltonganj, etc. Due to industries, warm water effluents are discharged into freshwater bodies, which in turn increase the temperature of the water body. The warm water of the water body like Ponds, Lakes, Rivers, and other man-made water reservoirs favours the luxuriant growth of blue-green algae and other bloom-forming algae. At higher temperatures, water bloom formation is triggered to some extent. As algal blooms grow thicker, the dark surface of the algae mat absorbs more sunlight, which leads to warmer water and growth that is more algal<sup>8</sup>. Since a stratified layer of water is formed based on temperature, which in turn promotes Algal bloom.

**(iii) Still water:** India is a union of states and union territories. Among them, Jharkhand is an important state Jharkhand is located on the Chhotanagpur plateau. The geography of Jharkhand is different. Here rainwater is stored by making dams, ponds, wasteland development, watershed development, etc. These water bodies store rainwater in stagnant forms. Stagnant or slow-moving water are thermally stratified and some strata or layer favour algal blooms. They float on top of cooler water. Man-made waterbodies store still water,

for example: dams, canals, ponds, lakes, etc. Stagnant water is favourable for the growth and development of aquatic organisms specially for bloom-forming algae<sup>9</sup>.

(iv) **Climate change:** India is a developing country. Here urbanization and industrialisation are growing day and night. The forest-cutting rate is also very rapid. Jharkhand is also suffering from deforestation. The percentage cover of forest area is decreasing day by day in Jharkhand. Jharkhand is also badly affected by pollution. Climate change increases the frequency and duration of drought in many parts of the country, which intensify extreme storms<sup>10</sup>. Longer duration of drought alternating with heavy rainfall increases runoff from agricultural lands and other sources, leading to higher nitrogen levels in waterbodies leading to the formation of algal blooms. Burning fossil fuel, deforestation, industrialization, urbanization, etc. increase the amount of CO<sub>2</sub> in the atmosphere. This triggers the algal blooms because blue-green algae feed on the CO<sub>2</sub> not only present in the atmosphere above the water body but also depend on CO<sub>2</sub> dissolved in water. On seasonal changes, algae of algal bloom complete their life span and die and settle down to the bottom of the waterbody where they decompose and then release carbon that is sequestered giving out more fuel for the growth of blue-green algae and other algae in a cyclic way.

#### **USES OF ALGAL BLOOMS:**

It can be subdivided into different subtopics: (i) Food for flamingos, (ii) Attracting colour of the waterbody, (iii) Development of fertility in the soil, (iv) Nitrogen fixation, (v) To suppress the growth of submerged weeds, (vi) Killing of larvae of mosquito *Culex* spp. and *Anopheles* spp.

(i) **Food for flamingos and aquatic herbivores:** Algal blooms forming algae are generally minute and microscopic. They provide food to aquatic herbivores and flamingos.

(ii) **Attracting colour of water body:** Algal blooms give attractive colour to the water body. These algae form coloured mats on the entire surface of the water body. This scene of the water bloom is very amusing. This is important for tourist attraction and entertainment. This helps in raising the economy of the concerned area.

(iii) **Development of fertility in soil:** Agricultural farms irrigated by the water of the waterbody having algal blooms develop fertility in the soil<sup>11</sup>. Because the water of such water body contains

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high amounts of nitrogen, phosphorus, magnesium, and many more nutrients. These act as natural fertilizers. This in turn increases the production of the crops.

**(iv) Nitrogen Fixation:** We live in an ocean of nitrogen because 78% of the atmosphere is made of nitrogen. In the atmosphere, nitrogen is found in molecular forms. The algae do not use it directly. It is reduced by hydrogen and converted to compounds of nitrogen. Algae involved in algal bloom formation fix atmospheric nitrogen<sup>12</sup>. This process is very important for agriculture. Due to this, algae are beneficial for farming.

**(v) Suppression of growth of submerged weeds:** Algae makes a coloured mat on the surface of the water body. This covers the entire water surface of the water body. This layer captures the maximum percentage of sunlight for photosynthesis<sup>13</sup>. Therefore, this layer creates a struggle for the existence of genera living below the layer of water. In this way, Algae forming algal blooms suppress the growth of submerged weeds by interfering in sunlight trapping for photosynthesis.

**(vi) Killing larva of mosquitos:** Algae of algal blooms produce so many toxins. Toxins produced by the algae of algal blooms kill larvae of mosquitos like *Culex* spp. and *Anopheles* spp.<sup>14</sup>. These mosquitos are the vectors of many protozoans and helminths, which in turn cause many diseases. This is very useful for controlling diseases like malaria, filaria, dengue, etc.

#### **NEGATIVE IMPACT OF ALGAL BLOOMS:**

(i) Health problems, (ii) Imperilled drinking water supply, (iii) Economic costs (iv) Sickened animals, (v) Dead zones, and (vi) Increased turbidity.

**(i) Health problems:** People can suffer from toxins of algal bloom, when they swallow or swim in affected water, eat poisoned fish, or inhale airborne water droplets of polluted water of the water body. Depending on the level of exposure to the polluted water of the water body and the type of algal toxin in the water body health disorders may range from mild to severe and ultimately lead to death. Toxins produced by algal blooms may be neurotoxins, dermatotoxins, or hepatotoxins. Neurotoxins affect the nervous system of the human being. Dermatotoxins affect the skin and related parts. Hepatotoxins are very dangerous. They affect the liver of human beings causing death<sup>15</sup>.

**(ii) Imperilled drinking water supply:** algae of algal blooms, which affect human health and other organisms depending on it, contaminate drinking water periodically.

**(iii) Economic costs:** Algal blooms cause lakes, dams, ponds, watersheds, and other waterbodies unsightly and dangerous, which reduces tourism development, recreation standards, commercial fishing, and marketing and property value. This increases water quality management costs, problems in monitoring water quality, and treatment costs of water quality.

**(iv) Sickened animal:** The algal blooms of the waterbody release toxins in water, which cause large-scale fish killing and disturb other organisms too depending on this polluted water<sup>[16]</sup>. Due to this, the entire food chain and food web of the aquatic ecosystem are challenged and badly disturbed.

**(v) Dead zones:** Nontoxic algal blooms have a lethal effect on the organisms of aquatic ecosystems in the form of dead zones. These dead zones are the areas in the water body with very little oxygen, where aquatic life cannot survive. It is also known as a low oxygen content zone *i.e.*, a hypoxic zone<sup>17</sup>. It is produced due to eutrophication or excess nutrition, in this condition water body becomes heavily polluted with nutrients like nitrogen, phosphorus, magnesium, other heavy metals, and organic nutrients. Algae, bacteria, and other organisms in an algal bloom die after completing their life span, consequently, the decomposition processes of the dead organisms begin, due to which most of the surrounding oxygen gets used up, which causes oxygen deficiencies in the dead zone. Due to this, other organisms in an affected water body start suffocating because oxygen is needed for respiration and die or are forced by the environment to relocate themselves for survival. Therefore, ultimately all aerobic organisms die due to lack of oxygen.

**(vi) Increased turbidity:** Algal blooms on the water surface create a turbid underwater environment. This turbid layer from reaching inside for bottom-dwelling phytoplankton, including plants, prevents sunlight. The plants living below this turbid layer in the water body are an important source of food and act as hosts for the other organisms of the food chain and without them, entire aquatic food webs of the ecosystems get disturbed. Thus, the turbid layer of the algal bloom of

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the water body disturbs the entire aquatic ecosystem by absorbing sunlight<sup>18</sup>.

**PREVENTION OF ALGAL BLOOMS:**

Prevention of algal bloom is detailed through the following points:

(i) Better farming practices, (ii) Green infrastructure, (iii) Water body and conservation policy, (iv) Management and monitoring of water blooms, (v) Application of copper sulfate or chloride salts of calcium, (vi) mechanical removal of blooms, and (vii) Biological control of bloom by virus, fungi, and bacteria.

**(i) Better farming practices:** Some regenerative practices used by farmers help us capture rainfall water where it falls instead of allowing this nutrient-enriched water directly into the water body. These practices are cover crops plantation, increasing the area of the plantation, tillage reduction, proper application of compost and manure then adding fertilizer to the farms.

**(ii) Development of Green infrastructure:** A huge amount of untreated runoff rainwater is discharged into water bodies. This contains a high level of nutrients, which triggers algal bloom development. Development of green infrastructure like tree plantation, green roofing, and developing gardens of rain water-absorbing plants like shrubs and water-absorbing grasses, etc. These can prevent algal bloom development by preventing the direct flow of rainwater into the water body<sup>19</sup>.

**(iii) Water body and conservation policy:** The government should take some initiative to make policy regarding water conservation of the available natural waterbody so that it can be maintained pollution-free. Government should take steps regarding the establishment of industry causing pollution in the environment. There should be very rigid legal provisions for defaulters of industry causing water pollution. This can prevent water bloom formation.

**(iv) Management and Monitoring of water bloom:** With the help of satellite-oriented research work, proper data is collected regarding algal blooms. This data is used for public awareness on a mass level and nationwide to mitigate the problem of water bloom formation and its consequences. Without the collaboration of people and their participation, it is difficult to monitor and prevent this problem<sup>20,21</sup>.

(v) **Chemical treatment of water body:** To prevent algal blooms formation in waterbodies copper sulfate or chlorine as bleaching powder or calcium hypochlorite are used<sup>22</sup>. As the high concentration of chemicals that are algacides may be lethal to fish and aquatic animals, it is applied in low concentration.

(vi) **Mechanical removal of algae-making algal blooms:** Algal blooms can also be removed by mechanical means by covering the water with floating plants or with the parts of the plants like banana leaves, bamboo culms, etc.

(vii) **Biological control:** Algal blooms can also be controlled by using living beings such as Cyanophages, Chytridales (Phycomycetes), Gram-negative bacteria, etc. The biological control of algal blooms is much more economical, easier, and advisable than chemical control. In biological control, living organisms such as viruses, fungi, or bacteria feed on algae and kill them<sup>23</sup>. As a consequence, algal bloom formation is prevented.

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