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Biology and Control of Algae[1]

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Introduction

The algae are a diverse grouping of plants that occur in a wide range of environmental habitats. Most occur in the fresh and salt waters that cover over 70% of the earths surface, but they also occur in the soil, on land plants, in permanent ice sheets, and snowfields. They are photosynthetic plants that contain chlorophyll, have simple reproductive structures, and their tissues are not differentiated into true roots, stems, or leaves.

Taxonomists have placed the algae into a number of major groups, or divisions, depending on certain characteristics. The commonly occurring algae are members of the following divisions: Bacillariophyta (diatoms), Charophyta (charophytes), Chlorophyta (green algae), Chrysophyta (yellow-green, or yellow-brown algae), Cryptophyta (cryptomonads), Cyanophyta (blue-green algae), Euglenophyta (euglenoids), Phaeophyta (brown algae) Pyrrhophyta (dinoflagellates), and Rhodophyta (red algae). At times references are made to the algae by these group names, so it is helpful to be familiar with them.

General Description

Algae display a great variety of growth forms. They range from unicellular or single cells, to fairly complex multicellular organisms. Some unicellular species are motile and can move around. Multicellular species display a variety of life forms; colonial and filamentous organization are two common examples. Colonies are aggregations of a few to many individual algal cells growing in association with one another. Filaments are strands of cells that can be either branched or unbranched. Some algae have such a complex growth form that they are mistaken for vascular plants – members of the charophyte group are one example.

The size of individual algal plants range from microscopic, unicellular species which are approximately 0.000039 in. (0.0010 mm) in diameter to large filamentous marine algae that obtain lengths of over 100 ft (30 m).

Growth Requirements

Like all organisms, the algae require certain conditions for growth; light, temperature, and the

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availability of inorganic nutrients are three major conditions. All algae require the radiant energy of sunlight to carry on the processes of photosynthesis. For different species there is a broad range of optimal light conditions. Some have high light requirements, while others only need minimal amounts of radiant energy for growth. Temperature is another important growth requirement. In fresh water the optimum temperature for growth of most algae lies between 59° F (15° C) and 77° F (25° C). However, some algae can actively grow at 32° F (0° C) while others grow in thermal springs or geysers where water temperatures are up to 185° F (85° C). In addition, the different requirements of various species for certain nutrients are an important factor for determining which species will be found in abundance in a given body of water.

Importance of Algae

The algae are an essential component of all aquatic systems since they serve as the base of the food chain for all other organisms. In terrestrial settings they are important members of the soil flora. In purification plants, water supply reservoirs, and sewage treatment plants they play a primary role in oxygenation and filtration.

Scientists use algae in bioassay tests for vitamins and as tools for investigations into plant physiology. The occurrence of fossilized algal remains help to date sedimentary rock.

In some countries, especially those that are in maritime districts, algae can play a small but important part in their economy. Extracts from algae, such as alginic acid, carrageenin, funori, and agar, all readily form gels or gel-like products. These derived substances are used as thickeners, emulsifiers, or stabilizers in the food, pharmaceutical, cosmetic, and textile industries. Diatomaceous earth, which is derived from the sedimentary remnants of the group of algae known as the diatoms has many important industrial uses. Other uses of algae are as food, fodder, and medicine.

Problems Caused by Algae

In addition to the benefits of algae to a body of water, occasionally there can be certain periods of excessive growth, or blooms, of one, two or more species which may cause certain problems for other organisms and degrade water quality.

In fresh water systems, many blooms are due to members of the blue-green algae which can grow so profusely that they can impart an objectionable odor, taste, and appearance to the water. The algae that typically produce these blooms are planktonic, or free-floating organisms, that can become distributed throughout the water body. The most common troublesome algae are species of blue-green algae of the following genera: *Lyngbya, Anabaena, Microcystis,* and *Aphanizomenon*; but some of the most detrimental problems are caused by minute flagellated species of yellow-green algae. In some cases the blooms can kill aquatic animals, livestock, and wildlife. Death or injury can be attributed to oxygen depletion within the water body or the injestion of toxins that are released by or contained in the bloom-causing algae.

Another major problem caused by algal blooms occurs when floating mats of algae collect at the surface of the water and cause an unsightly appearance. This occurs most frequently in small bodies of water. Infestations of submersed macrophytes can sometimes lead to these sorts of situations since they provide a site on which these algae tend to collect when the shoots of the macrophytes reach to the water's surface. In addition to the bad appearance, algal blooms can clog pump intakes and water filters.

Control Methods

When infestations of algae adversely affect the use of a body of water, it may become necessary to reduce the excessive algal populations or to modify the species composition promoting the occurrence of more desirable forms. Numerous algal control and management techniques have been attempted with varying degrees of success. Some are promising, others possible but as yet impractical. The methodologies fall into four major categories: *chemical*, *biological*, *physical*, and *combined* effects.

Algal control through the application of chemicals (algicides) is presently the most widely used technique. In general, most algicides are effective against a broad range of algal species; however, there are a few exceptions. Treatment methods vary from suspending a porous bag containing a granular algicide behind a boat to applying the algicides with sophisticated pumping systems in boats or aircraft. Sometimes there is insufficient control of the algae and this can be due to a number of reasons. It may be due to incorrect application rates of the algicides, which are sometimes difficult to determine because of varying environmental conditions and water chemistry. Other times it may be due to herbicidal resistance of the algae. Another factor may be reinfestation of algae by movement in from untreated areas.

One widely used type of algicide is copper compounds, especially copper sulfate. However, when copper as an inorganic salt is applied to relatively hard water it rapidly forms precipitates of copper hydroxide or copper carbonate. When this happens, the copper is no longer effective as an algicide. Complexing the copper with various organic substances has been shown to slow the precipitation and extend the length of the treatment effects. Both formulations are effective; the decision on which ones to use should be based on the severity of the problem, the availability of material, the cost of treatment, and the hardness of the water.

Refer to Table 1 for a listing of both specific algae and some general groupings such as “filamentous algae” and “planktonic algae”. Some suggested treatment rates and application instructions for several algicides are also shown. Table 2 shows the algicide formulation and the application sites where each algicide is labeled for use.

COPPER APPLICATION TECHNOLOGIES: When using algicides containing copper as the active ingredient, it may be helpful to follow certain procedures. A few suggestions, some of which are usually label instructions, are shown below:

1. Treat when the algal growth first becomes visible, as the problem may be more easily controlled at this time.
2. Treat on a clear, calm day when the water temperature is above 60° F (16° C).
3. Break up large algal mats before treatment. This may be done with a boat or from the shore.
4. Treat only 1/3 to 1/2 of the body of water at one time. This will aid in preventing loss of fish due to oxygen depletion.
5. Wait 1 to 2 weeks between retreatments. This will aid in preventing loss of fish due to oxygen depletion.
6. Treat when there is minimal water movement or flow.
7. Begin treatment along the shore and treat outward. This will allow fish to avoid concentrated spray mixture as it is being applied.
8. The products may be used for treating margins of water bodies when there is minimal water flow.
9. Clean application equipment immediately after use.

Terminology

Knowledge of certain terms will be helpful when reading information on algae control and interpreting instructions on alicide labels. A few of the terms are defined below:

Acid equivalent (a.e.) – theoretical yield of the parent acid from the chemical formulation.

Acre-foot – one acre of water which is one foot in depth.

Active ingredient (a.i.) – the part of the chemical formulation that produces the herbicidal effect.

Algae – photosynthetic plants that contain chlorophyll, have simple reproductive structures, and whose tissues are not differentiated into true roots, stems, or leaves.

Algal bloom – excessive or dense growths of a single or several species of algae. Usually of relatively short duration, but may persist for extended periods.

Algicide (Algaecide) – a chemical compound that kills algae.

Botanical plant name (Latin name) – in the proper context, the scientific name of a plant which is composed of two terms, a genus and species; but many times only the generic name is given. An exacting method of referring to a plant as opposed to a common name.

Chelate – a combination of a metal ion and an organic molecule which results in making the metal ion less reactive with other chemical species in the water.

Colonial algae – groups, or aggregations, of a few to many individual algal cells growing in association with one another.

Filamentous algae – algae which grow as filaments, or strands of cells; the filaments can either be branched or unbranched.

Formulation – the commercial pesticide product which consists of the active ingredient, inert ingredients and may contain a carrier, and/or other additives.

Granular herbicide – a dry herbicide formulation that is formed into small particles (granules), most of which may be composed of inert material. The granules aid in the even distribution of the herbicide.

Macrophyte – a large, or macroscopic, plant that is easily seen without aid of microscope.

Parts per million, weight (ppmw) – one part of a substance in one million parts of another substance, by weight; for example, approximately 2.762 lb of active ingredient applied to once acre-foot of water will give 1 ppmw.

Phytoplankton – the plant portion of the plankton community. They are usually microscopic and can grow as single cells, colonies, or filaments; some multicellular forms can be macroscopic.

Plankton – the community of organisms that drift or float in the water; some are capable of movement, but not against a current.

Precipitate – the formation of a solid substance that no longer will remain dissolved in water due to some physical or chemical process.

Rate – the weight of active ingredient or acid equivalent of a herbicide applied to a unit area; for example, 15 lb per acre.

Soft and hard waters – terms for classifying water based on the amount of $CaCO_3$, a water quality parameter. Soft waters are those in which total hardness is less than 50 mg $CaCO_3$ per liter (parts per million); hard waters are those in which total hardness is greater than 100 mg $CaCO_3$ per liter; moderately hard waters are those between 50 and 100 mg $CaCO_3$ per liter.

Vascular plant – a plant (macrophyte) with specialized conductive tissue.

Wettable powder – a finely divided dry formulation that can be readily suspended in water.

Table 1. Listing of Algae Controlled with Herbicide Trade Names and Active Ingredients.

Description of Algae Controlled as Shown on Herbicide Label	Herbicide Trade Name	Herbicide Active Ingredient
Algae	Agritec	copper
Algae	Algae Pro	copper
Algae	Bactrin	copper
Algae	Blue Viking Copper Sulfate Crystal	copper
Algae	Blue Viking Copper Sulfate Instant	copper
Algae	Captain	copper
Algae	Cutrine-Plus	copper
Algae	Earthtec Algicide	copper
Algae	Hydrothol 191	endothall
Algae	Hydrothol 191 Granular	endothall
Algae	K-TEA	copper
Algae	Liquid Trim	diquat
Algae	Pro-Teck	copper
Algae	Quick Kill	diquat
Algae	Reward	diquat
Algae	Stocktrine II	copper
Algae, Blue-green	Blue Viking Copper Sulfate Crystal	copper
Algae, Blue-green	Blue Viking Copper Sulfate Instant	copper
Algae, Blue-green	K-TEA	copper
Algae, Filamentous	Agritec	copper
Algae, Filamentous	Bactrin	copper
Algae, Filamentous	Blue Viking Copper Sulfate Crystal	copper
Algae, Filamentous	Blue Viking Copper Sulfate Instant	copper
Algae, Filamentous	Clearigate	copper
Algae, Filamentous	Cutrine-Plus	copper
Algae, Filamentous	Cutrine-Plus Granular	copper
Algae, Filamentous	Earthtec Algicide	copper
Algae, Filamentous	K-TEA	copper
Algae, Filamentous	Liquid Trim	diquat
Algae, Filamentous	Pro-Teck	copper
Algae, Filamentous	Weedtrine-D	diquat
Algae, Floating Filamentous Mats	AquaPlex	copper
Algae, Floating Filamentous Mats	Captain	copper
Algae, Green	Blue Viking Copper Sulfate Crystal	copper
Algae, Green	Blue Viking Copper Sulfate Instant	copper
Algae, Planktonic	Agritec	copper
Algae, Planktonic	AquaPlex	copper
Algae, Planktonic	Bactrin	copper
Algae, Planktonic	Blue Viking Copper Sulfate Crystal	copper
Algae, Planktonic	Blue Viking Copper Sulfate Instant	copper
Algae, Planktonic	Captain	copper
Algae, Planktonic	Clearigate	copper
Algae, Planktonic	Cutrine-Plus	copper

Table 1. Listing of Algae Controlled with Herbicide Trade Names and Active Ingredients.

Description of Algae Controlled as Shown on Herbicide Label	Herbicide Trade Name	Herbicide Active Ingredient
Algae, Planktonic	Earthtec Algicide	copper
Algae, Planktonic	K-TEA	copper
Algae, Planktonic	Pro-Teck	copper

Table 2. Listing of Herbicides for Algae Control with Application Instruction Suggestions, Active Ingredients and Use Precautions.

Herbicide Trade Name	Application Instruction Suggestions	Active Ingredient	Use Precautions
(Numerous)	Apply in a water carrier with sufficient volume of spray mixture to evenly apply mixture over the treatment area. Treat under calm, clear conditions, with relatively warm (at least 60° F) water temperatures for maximum control results. Mechanically disrupt heavy mats of floating algae prior to treatment. For floating algal mats, base the treatment rate on the upper few feet of the water column, where the algal infestation is growing. Partial or marginal treatments may be made (use somewhat higher rates). Algal treatment rates generally range from 0.2 to 0.4 ppmw copper ion. Heavy infestations may require repeat applications to achieve acceptable control. Use lower rates in the early stages of an infestation, and higher rates in heavier algal and weed infestations.	Copper	When treating dense algal infestations, treat only 1/3 to 1/2 of a body of water at one time, waiting until water quality improves (especially dissolved oxygen levels) before making subsequent applications. Treat from the shoreline outward, so as not to trap fish in concentrated spray mixture. Higher plants may be injured or killed at higher treatment rates, *i.e.* from 0.4 to 1.0 ppmw copper ion. Do not treat with rates above 1.0 ppmw copper ion.
Liquid Trim Quick Kill Reward Weedtrine-D	Controls *Spirogyra* spp. and *Pithophora* spp. **Reward:** Treat at the rate of 1.0 to 2.0 gal of product (use the equivalent of 2.0 lb ae per gal) per acre. Apply in a water carrier by injection or as a surface spray. **Weedtrine-D:** Treat at the rate of 0.5 to 1.5 ppmw diquat cation.	Diquat	**Reward:** For 2.0 gal per acre treatment, delay using treated water for the following: drinking – 3 days; livestock consumption – 3 days; filling spray tanks and irrigation to turf and ornamentals – 3 days; filling spray tanks and irrigation to food crops – 3 days. **Weedtrine-D:** Do not use treated water for animal consumption, spraying, irrigation, or domestic purposes for 5 days following treatment.

Table 2. Listing of Herbicides for Algae Control with Application Instruction Suggestions, Active Ingredients and Use Precautions.

Herbicide Trade Name	Application Instruction Suggestions	Active Ingredient	Use Precautions
Hydrothol 191	Treat at the rate of 0.05 to 1.5 ppmw ai.	Endothall	Due to fish toxicity, use of this product is suggested only by commercial applicators on a marginal or spot treatment rather than a full treatment of a water body. Inject evenly over the treatment area in at least 50 gal of spray mixture per acre. Apply in a water carrier. Do not treat more than 1/10 of a lake or pond with rates over 1.0 ppmw.
Hydrothol 191 Granular	Treat at the rate of 0.05 to 1.5 ppmw ai. Use at rates above 0.3 ppmw ai only for longer-term control or for difficult-to-control species.	Endothall	Apply evenly over the treatment area. Do not treat more than 1/10 of a lake or pond with rates over 1.0 ppmw. Applications above 0.3 ppmw should be made only by commercial applicators as marginal or spot treatments.