



Using
Copper Sulfate
to Control
Algae
in
Water Supply
Impoundments

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Algae in Aquatic Ecosystems

Algae — microscopic, free-floating plants — play an important role in aquatic ecosystems and have a direct effect on the health of these systems. Through their photosynthetic processes, algae use carbon dioxide, converting it to organic matter and oxygen (figure 1). Algae are important sources of dissolved oxygen in a water impoundment and constitute the basic building blocks of the aquatic food chain. They cause water quality problems only when they proliferate so much that they upset the ecological balance.

To prevent such proliferation, lake and watershed managers often try to reduce the amounts of nutrients entering lake waters, which act like fertilizers in promoting algal growth. But when excessive numbers of problem-causing algae develop despite these efforts, selective control of algae is needed.

Copper sulfate is frequently used for algal control, and sometimes it is applied on a routine basis during summer months, whether or not it is actually needed. This practice should be discouraged. *Water supply managers should try to identify the causes of their particular problems and should take corrective measures selectively rather than on a shot-in-the-dark basis.*

Algal Types and Effects

Algae are generally classified into four major types: blue-greens, greens, diatoms, and flagellates. Although all four types of algae can cause problems in lakes and water supply operations, blue-green algae tend to cause the worst problems. Because of this, control of blue-green algae is most likely to be required. Fortunately, blue-green algae are more sensitive to the effects of copper than are other algae, and consequently this type is most easily controlled by copper sulfate applications.

Blue-green algae contain gas pockets that cause them to float on the surface of the water under quiescent conditions, forming unsightly scums during excessive algal growths, or algal "blooms" (see cover photograph). Some blue-green algae are toxic to fish and animals and can cause skin irritations and gastrointestinal disturbances in humans. The presence of nuisance blue-green algae is evidenced by algal scums; by tiny "grass-clippings" filaments or tiny round, green colonies of algae in the water column; or by a very green or pea-soup water color in conjunction with reduced water transparency.

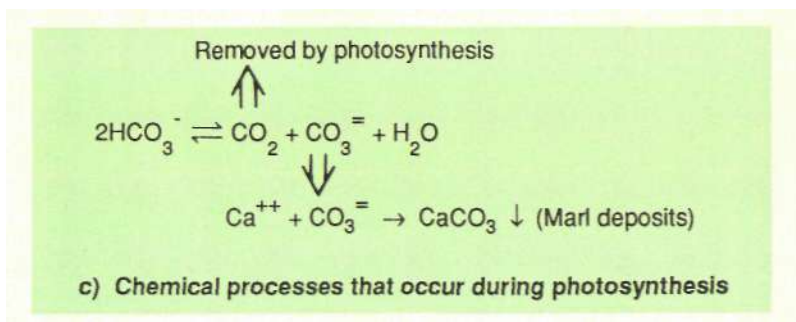
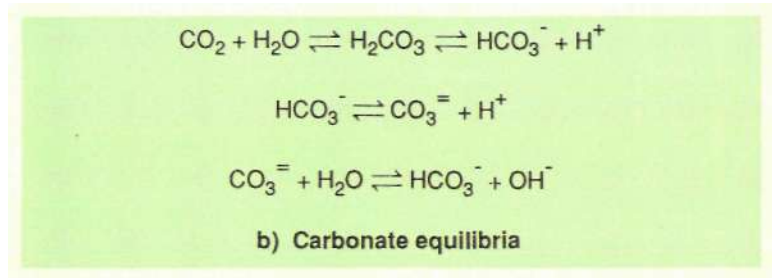
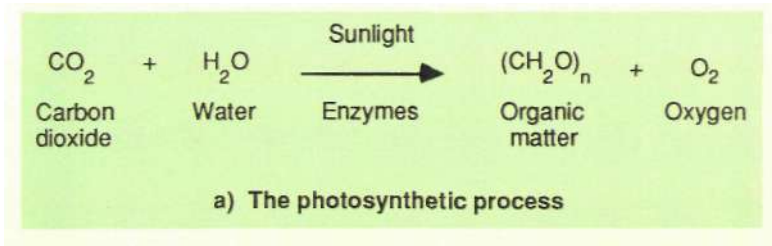


Figure 1. During photosynthesis, algae use energy from sunlight in their conversion of chemically bound carbon dioxide from bicarbonate sources to organic matter and oxygen. The removal of carbon dioxide from the water results in a decrease in alkalinity and an increase in pH.

The effects of algal blooms are seen not only in lakes, but also in the treatment and use of finished waters. When present in large numbers, algae may cause water treatment filters to clog, resulting in shorter filter runs and a need for frequent backwashes, which increases operating costs. Excessive algae—especially blue-green algae in bloom conditions—can also cause taste and odor problems in finished waters.

Checking for Excessive Algal Growth

Lake waters may be inspected for a number of indicators of excessive algal growths. Algal blooms often decrease the transparency of lake waters, which can be determined by Secchi disk readings. Reduced transparency caused by algal blooms is usually associated with greenish water color and tiny dots or filaments of algae seen against the white background of a Secchi disk as an observer looks through the water column. Other indicators include increased pH values (above 8 units), decreased alkalinity, and dissolved oxygen (DO) supersaturation, which occur as a result of algal photosynthesis (see figure 1).

If water supply managers want to determine whether dissolved oxygen is at supersaturated levels in their lake waters, they can use table 1 as a guide to the amount of dissolved oxygen that waters can hold at different temperatures. If the concentration of dissolved oxygen exceeds the value shown for a given temperature, then dissolved oxygen supersaturation is occurring and may indicate the presence of algal blooms.

Table 2 shows values for pH, alkalinity, temperature, dissolved oxygen, and percentage of dissolved oxygen saturation measured by Illinois State Water Survey researchers at the surface of Lake Loami, near Springfield, Illinois, during the summer of 1987. The values shown are typical of the high level of photosynthesis that is expected during summer months.

Table 1. Values Representing Dissolved Oxygen Saturation
at the Temperatures Indicated

(Dissolved oxygen in milligrams per liter; temperature in degrees Celsius)

Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO
0.0	14.7	5.0	12.8	10.0	11.3	15.0	10.0	20.0	9.0	25.0	8.2
0.5	14.5	5.5	12.6	10.5	11.1	15.5	9.9	20.5	8.9	25.5	8.1
1.0	14.3	6.0	12.5	11.0	11.0	16.0	9.8	21.0	8.8	26.0	8.0
1.5	14.1	6.5	12.3	11.5	10.9	16.5	9.7	21.5	8.8	26.5	8.0
2.0	13.9	7.0	12.1	12.0	10.8	17.0	9.6	22.0	8.7	27.0	7.9
2.5	13.7	7.5	12.0	12.5	10.6	17.5	9.5	22.5	8.6	27.5	7.8
3.0	13.5	8.0	11.8	13.0	10.5	18.0	9.4	23.0	8.5	28.0	7.7
3.5	13.3	8.5	11.7	13.5	10.4	18.5	9.3	23.5	8.4	28.5	7.7
4.0	13.1	9.0	11.6	14.0	10.3	19.0	9.2	24.0	8.3	29.0	7.6
4.5	13.0	9.5	11.4	14.5	10.2	19.5	9.1	24.5	8.3	29.5	7.5

Note: This table can be used as a guide in determining whether lake waters are supersaturated with oxygen. Supersaturation provides an indication that excessive amounts of algae may be present.

Table 2. Some Surface Water Quality Characteristics of Lake Loami during Summer Months (1987)

	Copper sulfate applied 6/17					Copper sulfate applied 8/17					
	5/6	5/20	6/3	6/17	7/1	7/14	7/28	8/11	8/25	9/8	9/23
pH, units	8.6	9.4	9.7	10.0	8.7	8.8	9.4	9.4	8.0	8.5	8.9
Alkalinity, mg/L	167	100	101	104	108	119	110	111	124	130	138
Temperature, ° C	18.4	26.9	25.1	29.0	25.2	26.1	31.1	28.3	23.9	24.4	18.7
Diss. oxygen (DO), mg/L	9.4	12.6	9.0	12.6	4.6	6.7	9.3	8.6	4.7	7.7	9.0
Percent DO saturation	101	160	110	166	57	84	127	112	56	93	97

The table indicates the changes in these values that occurred after copper sulfate applications at Lake Loami on June 17 and August 17. Following these treatments, pH decreased, alkalinity increased, and dissolved oxygen and the percentage of dissolved oxygen saturation decreased.



Optimal Copper Sulfate Dosages

Frequently, much more copper sulfate is applied than necessary. In one recent year, copper sulfate was applied in Illinois impoundments at an average rate of 22 pounds per acre, and in some lakes as much as 80 pounds per acre was used. But research has shown that 5.4 pounds of copper sulfate per acre of lake surface is sufficient to control problem-causing blue-green algae in waters with high alkalinity — alkalinity greater than 40 milligrams per liter (mg/L) as calcium carbonate (CaCO₃). Most Illinois lakes are in that category.

Copper sulfate (CuSO₄ · 5H₂O) application is recommended at the rate of 1 mg/L for the top 2 feet of the lake surface, where algal growth predominantly occurs (figure 2). This amount is equivalent to 5.4 pounds per acre of lake surface. For example, for a lake with 50 acres of surface area, 270 pounds of copper sulfate should be used per application. *The application rate should be calculated on the basis of the top 2 feet of the lake surface, not on the basis of the entire volume of the lake.*

Note that 1 mg/L of copper sulfate expressed as CuSO₄ · 5H₂O is equivalent to 0.26 mg/L as Cu²⁺. The literature indicates that a concentration of 0.05

to 0.10 mg/L as Cu^{2+} is effective in controlling blue-green algae in pure cultures under laboratory conditions. This is equivalent to 0.2 to 0.4 mg/L as $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$. For field applications, however, concentrations of about 0.26 mg/L as Cu^{2+} are generally suggested.

Applying far more copper sulfate than necessary is uneconomical and ecologically undesirable. Excessive amounts of copper can kill fish and other bottom organisms, and copper tends to accumulate in bottom sediments.

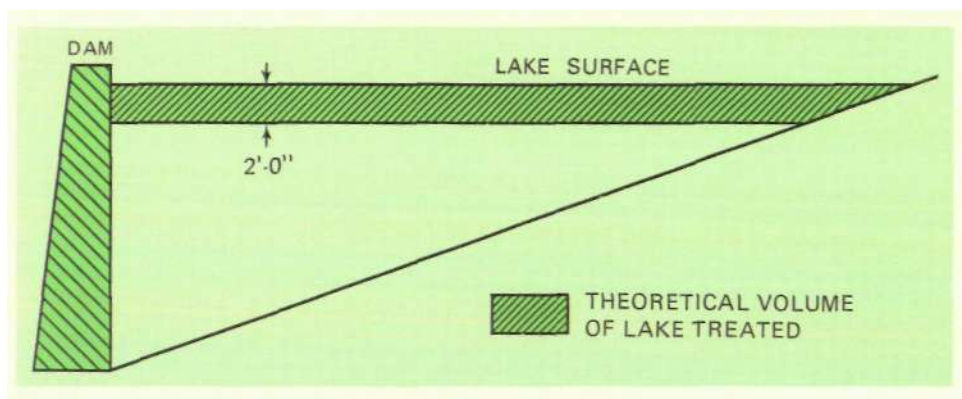


Figure 2. Schematic diagram showing the area to consider in calculating the amount of copper sulfate to apply to an impoundment

Increasing Copper Sulfate Solubility

In lake waters that are high in alkalinity, copper solubility decreases as pH increases. As indicated in figure 3, copper solubility decreases during algal-bloom periods, when the pH level is high.

Only the copper in solution (and not the copper precipitate) is effective in controlling floating algae. Applying citric acid along with copper sulfate enables copper to remain in solution for a longer period, enhancing its algicidal effect. A ratio of copper sulfate to citric acid of 2:1 by weight (5.4 pounds per acre of copper sulfate to 2.7 pounds of citric acid) has been found effective in controlling blue-green algae.

Table 3 shows the copper concentrations observed in Lake Catherine, one of the Fox Chain of Lakes in northeastern Illinois, following copper sulfate applications with and without the addition of citric acid. These results are

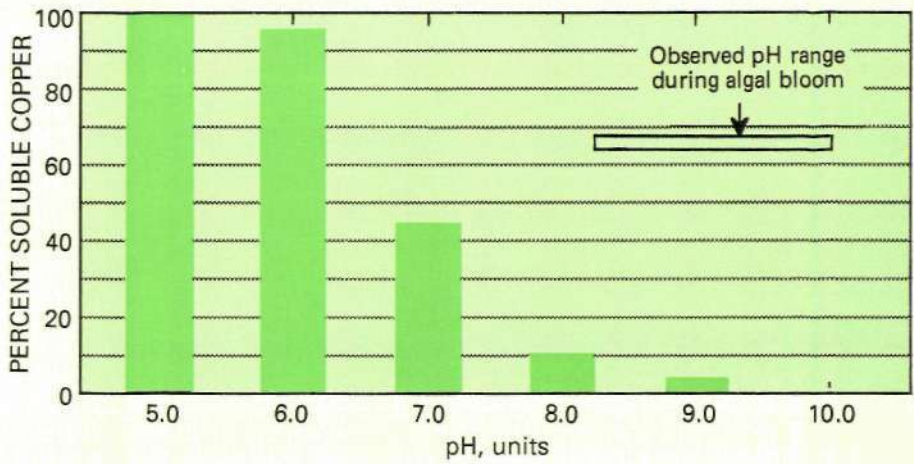


Figure 3. Relationship between pH and soluble copper in high-alkalinity waters (alkalinity greater than 40 mg/L as CaCO₃)

Table 3. Copper Concentrations in Lake Catherine after Copper Sulfate Applications with and without Citric Acid (Concentrations in milligrams per liter as copper)

Location	Copper sulfate only		Copper sulfate with citric acid	
	6/21/79*	6/22/79	7/5/79*	7/6/79
1A	0.08	0.03	0.82	0.11
1B	0.23	0.08	0.07	0.15
2A	0.08	0.02	0.02	0.13
2B	0.29	0.03	0.11	0.15
3A	0.00	0.02	0.28	0.10
3B	0.25	0.03	0.07	0.19
4A	0.00	0.03	0.04	0.02
4B	0.02	0.02	0.12	0.15
5A	0.00	0.00	0.02	0.07
5B	0.10	0.02	0.07	0.07
6A	0.02	0.02	0.06	0.03
6B	0.04	0.02	0.07	0.07
7A	0.00	0.02	0.09	0.15
7B	0.04	0.02	0.09	0.10

* Date of chemical application

Note: 1,000 pounds of copper sulfate and 500 pounds of citric acid were used. Chemicals were applied from a single location, using an aerator. 1A = surface sample at station 1, 1B = sample taken 5 feet from surface at station 1, and so on. (See figure 4 for locations of the sampling stations.)

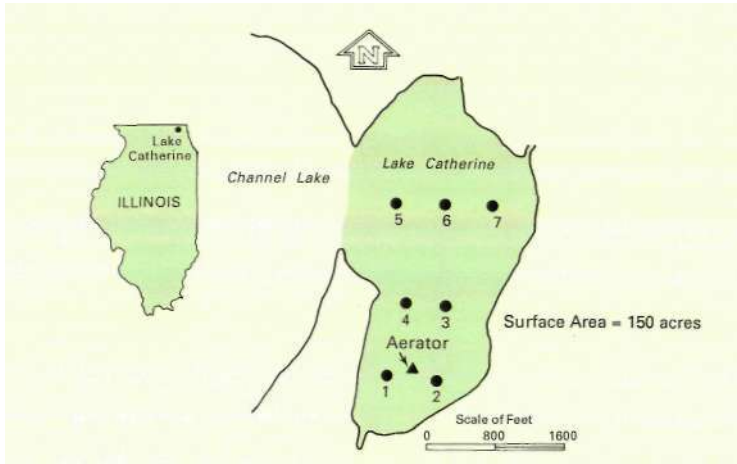


Figure 4. Locations of the Lake Catherine sampling stations and aerator used in a study of the benefits of adding citric acid at the time of copper sulfate applications (See table 3)

from a Water Survey study conducted in 1979. As can be seen, significantly greater concentrations of copper remained in solution one day after the application of copper sulfate and citric acid.

Changes Caused by Copper Sulfate Applications

Figure 5 indicates water quality conditions that may be expected during the 10 days after a copper sulfate application. This figure shows the copper concentrations, algal densities, pH levels, and dissolved oxygen concentrations at Lake Loami's surface on June 17, 1987 (when copper sulfate and citric acid were applied), and 1, 3, 5, 7, and 10 days afterward. The June 17 algae, pH, and oxygen determinations were made before the chemical treatment, and the copper measurement was made after the treatment.

As shown in figure 5a, copper concentrations remained above the background level (which is about 0.02 mg/L) for at least 10 days after the copper sulfate application. After that, the concentrations would have been expected to decrease to the background level.

The algae found in Lake Loami (figure 5b) were primarily green algae. The algal density initially decreased after the copper sulfate application, but it

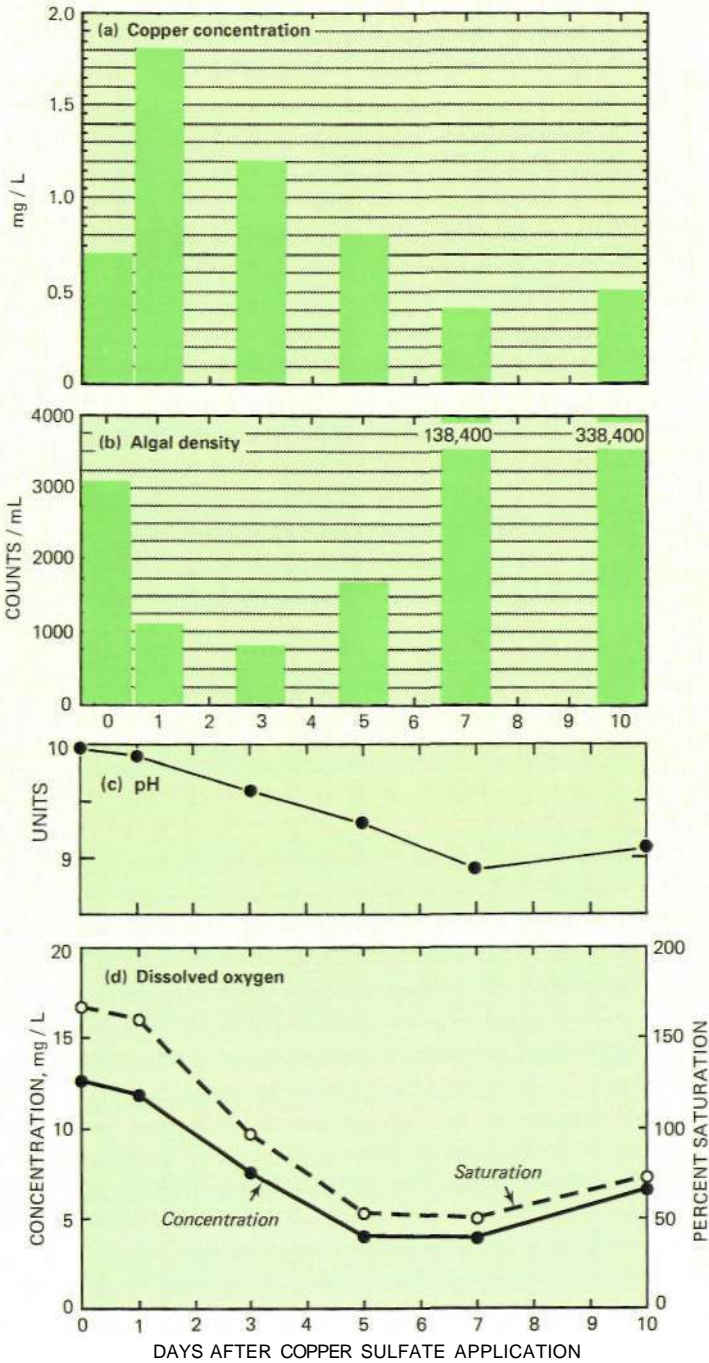


Figure 5. Changes in a) copper concentration, b) algal density, c) pH, and d) dissolved oxygen in Lake Loami after copper sulfate application on June 17, 1987

increased tremendously after the seventh day. This algal bloom did not cause filter clogging or taste and odor problems. Most likely, the algae were removed in the coagulation/sedimentation process at the water treatment plant. Figures 5c and 5d show that after the chemical treatment, pH and dissolved oxygen concentrations in the lake decreased greatly before they began to recover.

The results in figure 5b show that algal regrowth may occur within a very short period after algicide treatment. This phenomenon, which is often seen, demonstrates the impossibility of completely eliminating algae and the futility of using copper sulfate to prevent algal blooms.

Alternate Methods of Lake Management

Before chemical treatments are used in a water supply impoundment, other methods of lake management should be explored. *Water Survey researchers have found that tastes and odors in finished waters often arise not because of the presence of algae, but because raw waters are being withdrawn from the deep, anaerobic zone of the lake.* The substances released into these deep waters from bottom sediments during periods of lake stratification may be the cause of the unpleasant tastes and odors. If this is the case, moving the raw water intake nearer the lake's surface, where adequate oxygen exists, may be sufficient to solve the problem.

Other solutions to water quality problems include optimizing the coagulation and sedimentation processes at the water treatment plant, installing a mechanical aeration/destratification device or a compressed-air aeration system in the lake, and reducing the input of nutrients (particularly phosphorus) to the lake to reduce algal growth.

Guidelines for Algal Control

The following suggestions are offered for dealing with algal blooms in water supply impoundments in Illinois:

- The practice of routinely applying algaecides, whether or not they are actually needed in a particular situation, should be discouraged.

- The basis of lake chemical treatment should be the selective control of problem-causing blue-green algae. *A common indicator of excessive growths of blue-green algae is the presence of algal scums.* Other indicators include a very green or pea-soup water color associated with reduced Secchi transparency readings, increased pH, reduced alkalinity, oxygen supersaturation, and problems with water treatment operations.
- If copper sulfate treatment is needed, a rate of 5.4 pounds per acre of lake surface appears to be adequate.
- In waters that are high in alkalinity (alkalinity greater than 40 mg/L as CaCO₃), the addition of citric acid in the weight ratio of 2 copper sulfate to 1 citric acid helps keep the copper in solution longer. The chemicals may be applied in any standard manner.
- If an algicide application is carried out, a detailed record should be kept at the treatment plant, outlining the necessity for the treatment and the treatment outcome. This will greatly facilitate proper lake management and future decisions regarding the use of algaecides.
- Qualitative assessments of taste and odor problems should be part of routine plant operation. In addition, the number, frequency, and nature of consumer complaints about taste and odor problems should be recorded. To test for odors in finished waters, a 100-milliliter water sample (which is about 3 ounces) should be placed in an Erlenmeyer flask. The flask should be covered tightly with aluminum foil and heated gradually in a water bath (not over an open flame) until the temperature of the sample reaches 40° C (104° F). The cover should then be removed and the sample subjected to a nose test.
- Periodic monitoring (at least once every two weeks) of the dissolved oxygen and temperature profiles at the deepest part of the lake or near the water intake will help greatly in water system management.
- Alternate methods of dealing with water quality problems (such as water intake manipulation, aeration/destratification, and coagulation and sedimentation) should be explored prior to chemical treatment of a lake.

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