Notes on the Use of Copper Sulfate in Ponds[1]

by ALAN McINTOSH
Bionucleonics Department
Purdue University
West Lafayette, Ind. 47907

The effectiveness of copper sulfate as an algacide has been widely documented. SUTTON and BLACKBURN (1971) noted that a concentration of 1.0 ppm copper or less controls most species of algae. Phelps Dodge Refining Corporation, a manufacturer of copper sulfate, recommends 0.25 ppm copper sulfate for planktonic algae control, while 0.5 ppm is recommended for filamentous algae control.

Copper sulfate is also used for aquatic weed control. Phelps Dodge recommends doses of from 5 to 10 ppm copper sulfate in water with an alkalinity of less than 50 ppm, and 40 ppm copper sulfate in moderate to hard waters for weed control. SUTTON and BLACKBURN (1971) noted that concentrations of copper sulfate at 112 to 560 kg/ha were necessary to control submerged species, while emergent species seemed resistant to copper treatment. WARE (1966) found that copper sulfate at 50 lbs/surface acre gave 75% control of Elodea densa; at 100 lbs/surface acre, control was complete. CHANCELLOR et al. (1958) noted that a constant concentration of about 0.25 ppm copper in a stream eliminated Elodea canadensis, Potamogeton sp., and Lemna minor after 8 weeks.

In the current study, ponds with dense macrophyte and filamentous algae growths were treated with 1 and 3 ppm copper sulfate. The degree of control achieved and negative aspects of copper sulfate usage in these ponds are the subject of this paper.

MATERIALS AND METHODS

Description of Study Site

Two circular settling ponds, about 13.7 m in diameter and 2 m deep, served as study sites. Located at the old East Lansing, Michigan, Sewage Treatment Plant, the ponds are among a number of sites used by Michigan State University's Department of Fisheries and Wildlife for limnological research.

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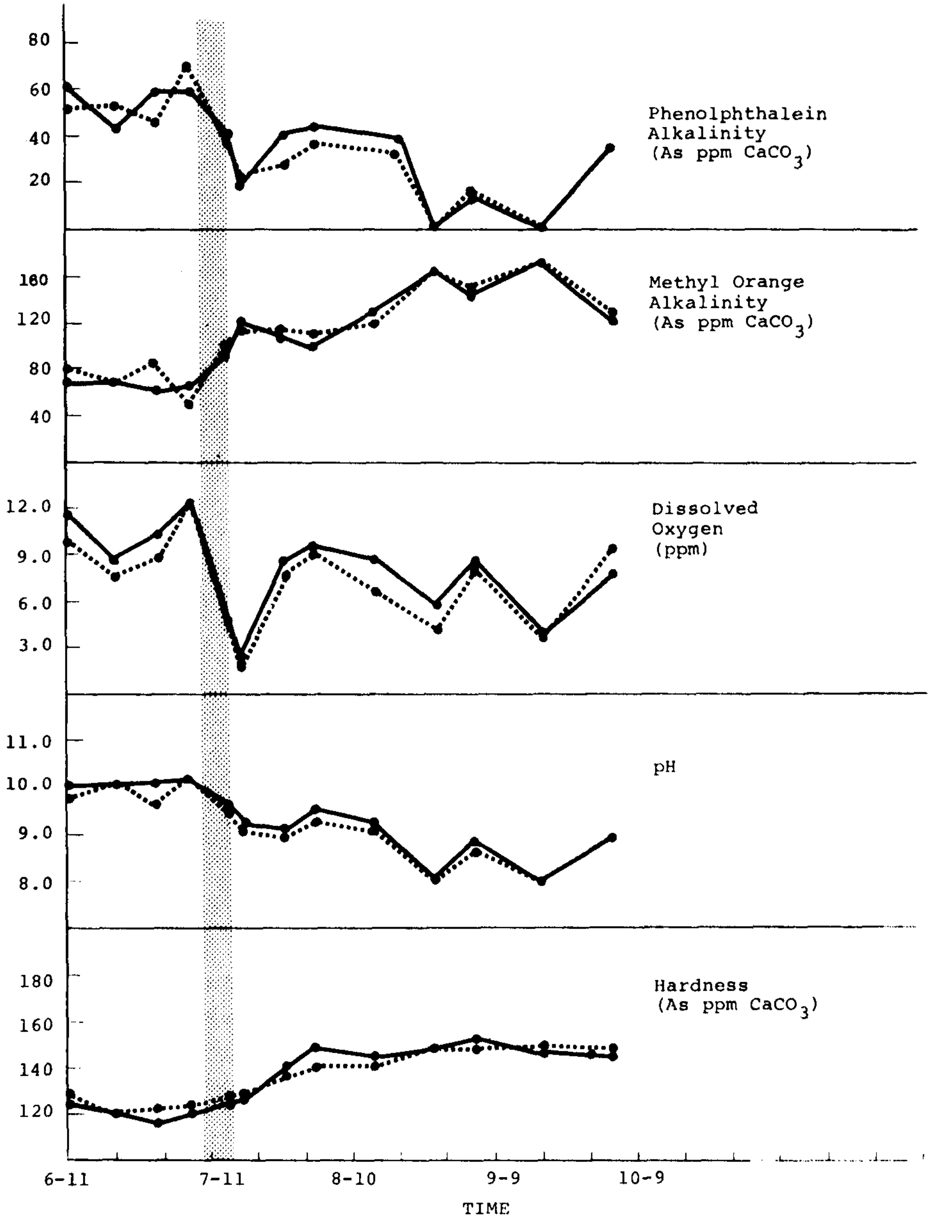

Fig. 1. Changes in water chemistry parameters over time in Pond A. Each point represents the average of 2 samples taken from the top (solid line) or bottom (broken line) of the pond. Shaded area denotes addition of 3 ppm copper sulfate.

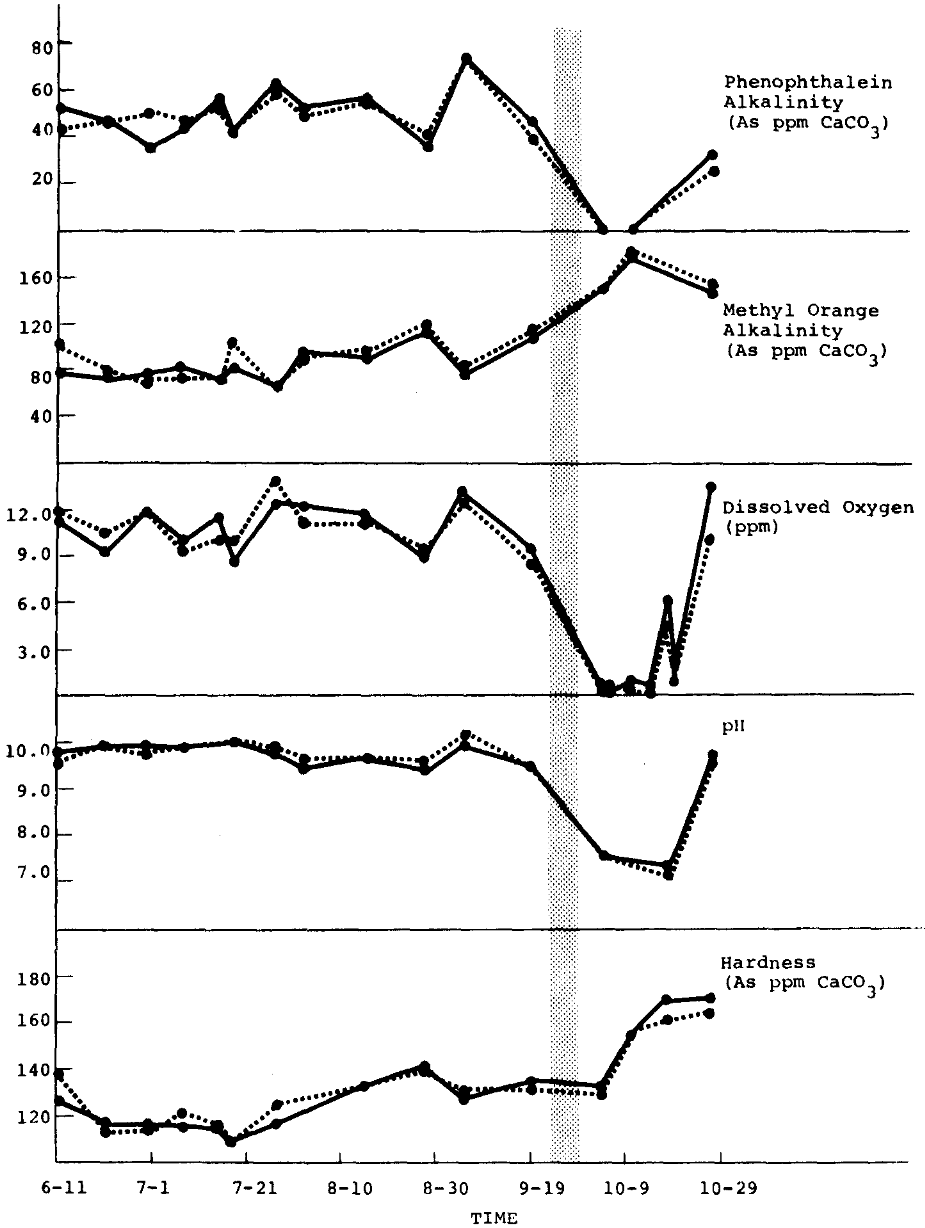

Fig. 2. Changes in water chemistry parameters over time in Pond B. Each point represents the average of 2 samples taken from the top (solid line) or bottom (broken line) of the pond. Shaded area denotes addition of 3 ppm copper sulfate.

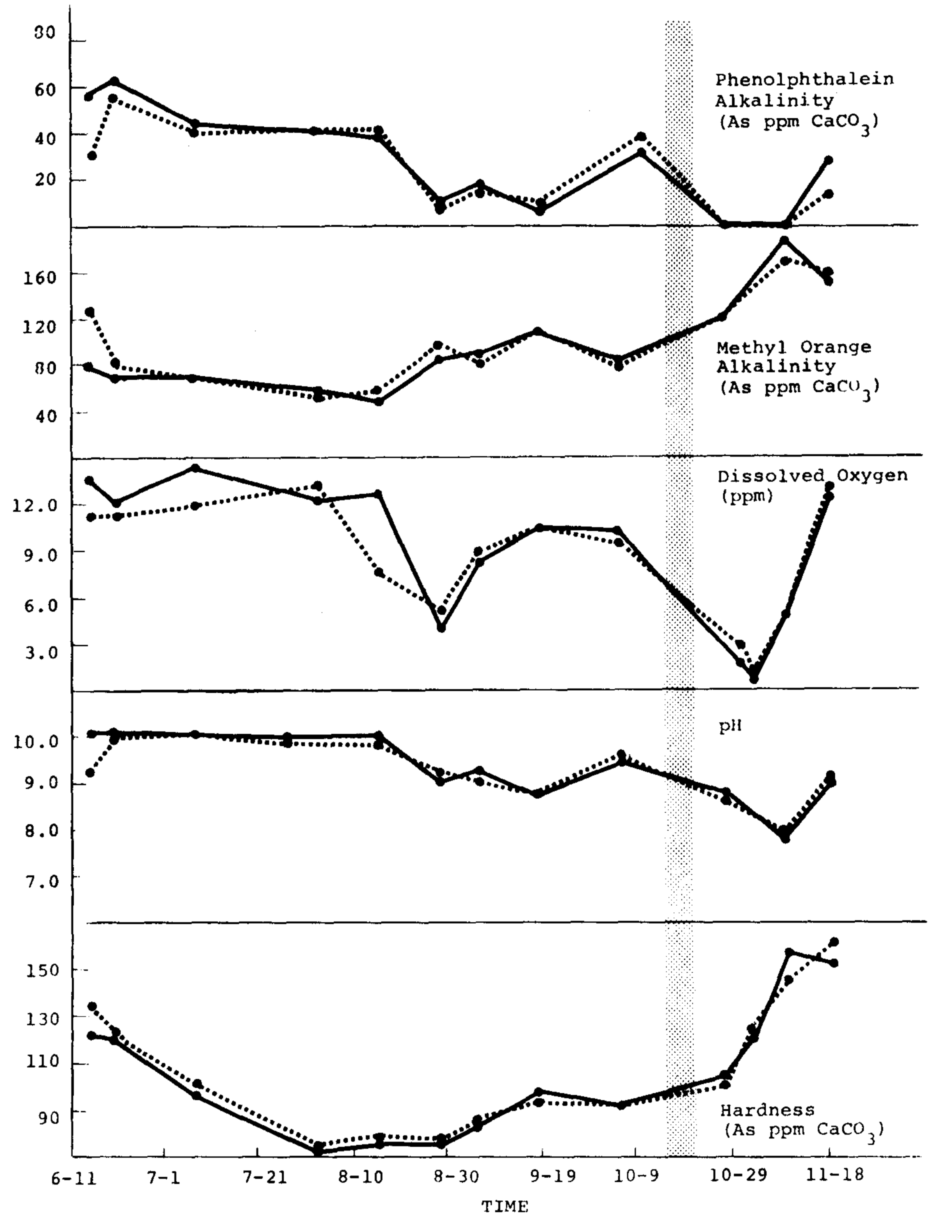

Fig. 3. Changes in water chemistry parameters over time in Pond C. Each point represents the average of 2 samples taken from the top (solid line) or bottom (broken line) of the pond. Shaded area denotes addition of 1 ppm copper sulfate.

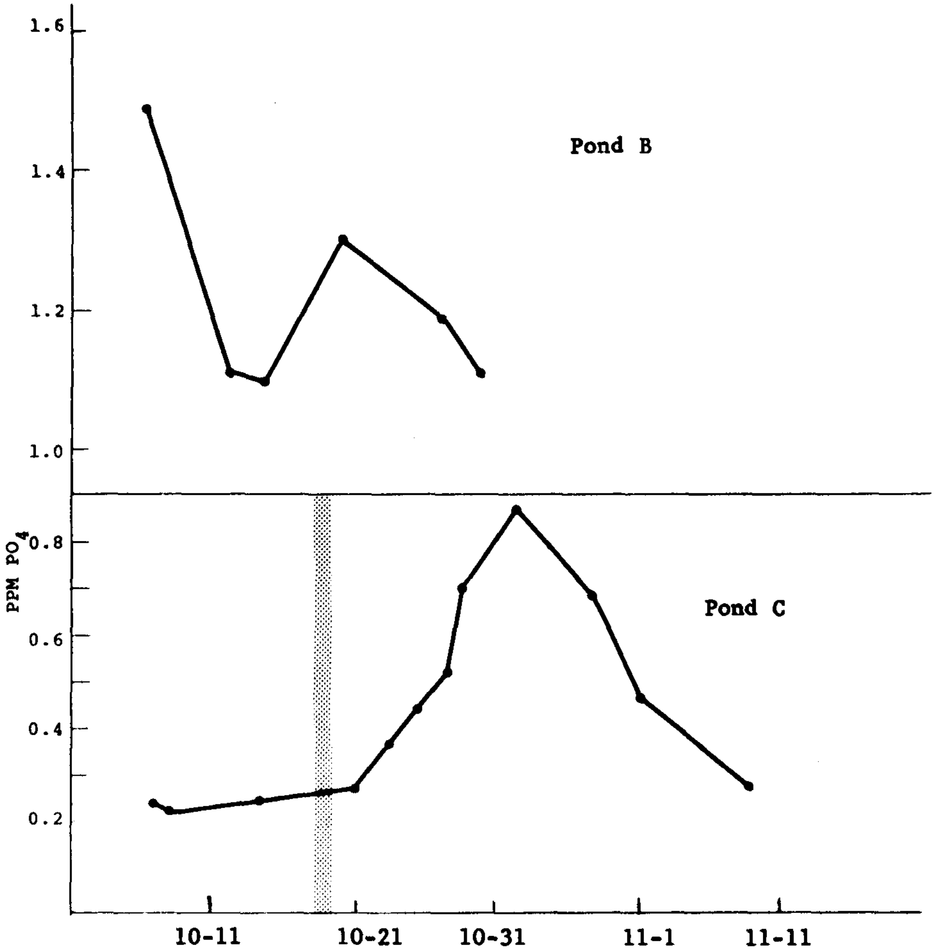

Fig. 4. Changes in PO_4 concentrations over time in Ponds B and C. Shaded area denotes addition of 1 ppm copper sulfate to Pond C.

In June 1970 the ponds were drained, and the bottoms were covered with 10 to 15 cm of black soil. The systems were refilled and left undisturbed until spring, 1971. During summer 1970, dense populations of aquatic macrophytes and filamentous algae had developed.

In May 1971 each pond was divided with a polyethylene sheet, effectively sealing off 2 semi-circular systems. Copper sulfate ($CuSO_4 \cdot 5H_2O$) solutions were prepared in distilled water from commercial grade copper sulfate and applied by hand to the surface of the ponds (Table 1).

TABLE 1.

Copper sulfate dosage rates and schedules.

System	Dosage Date	Dosage
Pond A	July 12, 1971	3 ppm copper sulfate
Pond B	September 26, 1971	3 ppm copper sulfate
Pond C	October 18, 1971	1 ppm copper sulfate

Water chemistry parameters, including pH, alkalinity, hardness, dissolved oxygen, and orthophosphate, were determined during the study (Figs. 1-4). Duplicate water samples were collected from near the top and bottom of each pond. Standard Methods for the Examination of Water and Wastewater (APHA, 1965) was used for chemical analyses.

Following treatment of each pond, visual observations on the fate of target species and overall pond conditions were made.

RESULTS AND DISCUSSION

A copper sulfate treatment of 3 ppm was added to Pond A on July 12. Elimination of *Oedogonium* sp. was rapid (Table 2). *Potamogeton crispus* and *Elodea Nuttallii* were severely damaged, although *Elodea* regenerated after 6 to 8 weeks.

Pond B received a treatment of 3 ppm copper sulfate on September 26. All species present, including *Elodea Nuttallii*, *Potamogeton crispus*, *Oedogonium* sp. and *Chara* sp. were eliminated from the pond.

Pond C was treated with 1 ppm copper sulfate on October 18. Only slight damage to *Chara* sp. and *Potamogeton crispus* was noted, while *Oedogonium* sp. and *Spirogyra* sp. were controlled at this level.

TABLE 2.

Target species control achieved in study ponds.

Pond	Treatment	Species Present	Degree of Control Obtained
A	3 ppm	Elodea Nuttallii	Partial
		Potamogeton crispus	Complete
		Oedogonium sp.	Complete
B	3 ppm	Elodea Nuttallii	Complete
		Potamogeton crispus	Complete
		Chara sp.	Complete
		Oedogonium sp.	Complete
C	1 ppm	Elodea Nuttallii	None
		Potamogeton crispus	None
		Chara sp.	None
		Spirogyra sp.	Complete

Removal of target species was temporary in Ponds A and B. By the 17th day after treatment in Pond A, a blue-green periphyton mat covered most surfaces. Lemna minor appeared by the 25th day, and Oscillatoria sp. and Hydrilla verticillata were visible by the 28th day. Potamogeton crispus was noted by the 37th day. Within 90 days, the plant mass present exceeded pre-treatment levels. In Pond B, large numbers of the green alga, Euglena sp. and Phacus sp. were noticed by the 14th day after treatment; they soon formed a green scum on the surface.

Orthophosphate (PO_4) levels were determined in 2 of the systems (Fig. 4). In Pond C, PO_4 levels were ascertained before and after copper sulfate treatment; peak concentration was reached 11 days after dosage. JEWELL (1971) noted that nutrient regeneration from decaying macrophytes reached a peak 5 to 10 days after the onset of decomposition.

PO_4 readings in Pond B began 11 days after treatment and reached a maximum of 1.45 ppm. Because plant mass and thus decomposition in Pond B was greater, PO_4 levels were higher than in Pond C. Levels reached in both ponds indicated an ample supply of phosphorus for algal blooms.

Deterioration of water quality occurred in all 3 ponds as plant tissues decomposed. In Pond C, only a slight odor and discoloration was noted. Pond A showed similar but somewhat more prolonged effects. In Pond B, where extensive decomposition of Chara occurred, the odor of H_2S was offensive. Water color darkened, and an organic scum appeared on the surface.

Water chemistry changes in Pond B after Chara decomposition were dramatic (Fig. 2). JEWELL (1971) noted that an indiscriminate application of herbicides to flowing or standing water might result in massive deoxygenation of the water. WHITWORTH and LANE (1969) noted that when 5 ppm copper sulfate was added to a simulated natural pond, oxygen production was suppressed for 2 to 3 days.

The decrease in D.O. in Pond B was dramatic with levels below 0.5 ppm for 10 days. Sudden drops in pH and increases in hardness and methyl orange alkalinity also resulted from the release of decomposition products from plant tissues.

Extensive toxicity was noted in Pond B during the period of low oxygen. Green sunfish (Lepomis cyanellus R.) present in the pond died, and zooplankton samples indicated that while ostracods survived, cladocera and copepods did not. A combination of low oxygen, production of H_2S, and release of copper from the Chara is thought to be responsible.

In Ponds A and C (Figs. 1 and 3), similar changes in water chemistry occurred but to a lesser degree. D.O. levels dropped rapidly but rose quickly. Increases in methyl orange alkalinity and hardness and decreases in pH were less pronounced.

During conditions of high temperatures and heavy algal or macrophytic growth, severe changes in pond ecosystems may result from copper sulfate dosage at levels normally recommended for aquatic weed control. Although target species control in the present study was satisfactory at 3 ppm copper sulfate, it was temporary, as green algae and periphyton growths returned to the ponds within 3 weeks after treatment.

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