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NOTES

Sodium Carbonate Peroxyhydrate as a Potential Algicide[1]

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INTRODUCTION

The use of phytotoxic chemicals for algal control is extremely restricted and only a few compounds are registered for use. Copper sulfate pentahydrate ($CuSO_4$ $5H_2O$) and simazine (6-chloro-*N*,*N*'-diethyl-1,3,5,-triazine-2,4-diamine) are the most extensively used algicides, and both are registered by the Environmental Protection Agency for use in food fish culture (3).

A need exists for the development of additional safe and effective compounds as algicides which will not restrict the use of the water. Recent research has shown that H_2O_2 may provide for environmentally acceptable chemical management of submersed aquatic macrophytes and algae. Hydrilla [*Hydrilla verticillata* (L.f.) Royle #[3] HYLLI) and coontail (*Ceratophyllum demersum* L. # CEYDE) were sensitive to H_2O_2, but alligatorweed [*Alternanthera philoxeroides* (Mart.) Griseb. # ALRPH] and waterhyacinth [*Eichornia crassipes* (Mart.) Solms # EICCR] were not damaged at similar exposure levels (11). Guppies (*Lebistes reticulatus*) exposed to H_2O_2 in the presence of coontail were not killed at concentrations toxic to the plants. Combining H_2O_2 with low levels of copper enhanced both efficacy and the rate at which acceptable (>80%) control of coontail was attained (6, 8).

As early as 1969, H_2O_2 was recommended as a treatment for control of slimes and algae in cooling towers (13). Hydrogen peroxide was reported to have potential as an algicide for use with aluminum alloy water systems. Water quality and oxygen conditions were improved by H_2O_2 in a lake without creating long-term environmental disturbances (1). The H_2O_2 caused a sharp decrease in chlorophyll *a* and reduced the total volume of phytoplankton in the lake.

Kay, et al. (7) evaluated H_2O_2 as an algicide for potential use in commercial aquaculture. Concentrations of 0.5, 0.2, and 0.05 mM H_2O_2 reduced chlorophyll concentrations to ≤5 percent of those for the untreated controls for *Ankistrodesmus* sp. (*Chlorophyta*: chlorococcales), *Raphidiopsis* sp. (*Cyanophyta*: oscillatoriales), and *Microcystis* sp. (*Cyanophyta*: chroococcales), respectively, by 24 h after treatment in the laboratory. Barrion and Feuillade (2) reported that H_2O_2 was more toxic to a cyanophyte (*Oscillatoria rubescens* DeCandolle) than to a chlorophyte (*Pandorina morum* Bory). Fowler and Barrett (4) have reported on H_2O_2 as an algicide for control of filamentous species.

Although dilute H_2O_2 has apparent potential as an algicide, concentrated H_2O_2 liquid can be hazardous to applicators. Sodium carbonate peroxyhydrate (SCP) has been formulated into granules[4] which decompose upon contact with water into H_2O_2 and sodium carbonate. These granules may provide the safety and ease of application to make H_2O_2 practical for control of algae. The objective of this study was to compare granular and liquid forms of H_2O_2 as to efficacy in the laboratory against blue-green algae and their safety to fingerling catfish. This report follows an abstract published previously (12) and Ouzts et al. (10) have reported SCP to be an effective algicide for sewage lagoons.[5]

MATERIALS AND METHODS

Suspensions (100-ml aliquots) of *Anabaena* sp. and *Raphidiopsis* sp. algae in a commercial medium[6] were treated in 250-ml Erlenmeyer flasks, five flasks or replications per treatment, with SCP or H_2O_2 at equivalent dosages of 10 mg/L of H_2O_2 and held in an environmental control chamber at 25 ± 2 C with a 12-h photoperiod at 450 $\mu E \cdot m^{-2} \cdot s^{-1}$ photosynthetic photon flux density. According to Boyd (3), "chlorophyll *a* determination on the particulate matter which may be removed from a water sample by filtration provides a good estimate of phytoplankton density." Therefore, chlorophyll *a* levels of treated and untreated (control) samples were determined spectrophotometrically at 665 nm 24 h after treatment to estimate relative algal densities. The chlorophyll was extracted

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[3]Letters following this symbol are a WSSA-approved computer code from Composite List of Weeds, Weed Sci. 32, Suppl. 2. Available from WSSA, 309 West Clark St., Champaign, IL 61820.

[4]Interox® FB™-Sodium Percarbonate manufactured by Interox America, P.O. Box 27328, Houston, TX. Mention of a trademark, proprietary product, or vendor does not constitute a guarantee or warranty of the product by the U.S. Dep. Agric. and does not imply its approval to the exclusion of other products or vendors that may also be suitable.

[5]Ouzts, J. C. 1987. Hydrogen Peroxide as an Algicide in Sewage Lagoons. M.S. Thesis, Delta State University, Cleveland, MS 38733. 35 pp.

[6]Carolina Alga-Gro® in Carolina Spring Water® available from Carolina Biological Supply Company, Burlington, NC 27215.

with 90% methanol for 24 h at 4 C (9) and the suspensions were filtered through a 0.45 μm filter.[7] The chlorophyll-bleaching efficacies of SCP and H_2O_2 were estimated by comparing the absorbance of the methanol extracts with a standard curve prepared from a commercial source of chlorophyll *a* dissolved in methanol. The experiment was repeated.

One hundred fifty 10- to 15-cm channel catfish fingerlings were divided and 15 fingerlings placed in each of ten 38-L aquaria each containing 30 L aged tap water which was continuously aerated; and either SCP or H_2O_2 was added at ten equivalent oxidant concentrations (as H_2O_2) varying from 0 to 50 mg oxidant/L. The water was changed and the oxidant renewed daily for 96 h; dead fish were removed as detected. The experiment was conducted twice. The 96-h LC50 and LC01 values were estimated by probit analysis (5).

RESULTS AND DISCUSSION

The SCP granules and liquid H_2O_2, at equivalent concentrations of 10 mg/L as H_2O_2, were similar in their bleaching action against each species of blue-green algae after 24 h (Table 1). The apparent differences in bleaching between the two algal species could not be determined statistically because initial cell densities may have differed. Nevertheless, the chlorophyll concentrations were similar; thus *Raphidiopsis* sp. appeared to be more sensitive to the oxidants than *Anabaena* sp. By 24 h after treatment with the oxidants, *Raphidiopsis* sp. had lost >2 times more chlorophyll than had *Anabaena* sp. The levels of chlorophyll in the untreated controls of both were similar at 1.6 and 1.7 mg/L, respectively. The results described here are similar to those found earlier for H_2O_2 against *Raphidiopsis* sp. (6).

The SCP granules and liquid H_2O_2 when applied at equivalent oxidizing strengths, were nearly equal in toxicity to catfish fingerlings 10 to 15 cm long. The 96-h LC50's (about 30 ± 3 mg/L) for H_2O_2 and SCP in this test were very similar to a previous trial (9) when the LC50 for $H_2O_2$was 36 mg/L for similar-sized channel catfish. The 96-h lower fiducial limits of the LC01s of the SCP granules and the liquid H_2O_2 were 10.5 and 15.6 mg/L, respectively. In the field, 3 mg H_2O_2/L will bleach algae satisfactorily (7). Therefore, at least a three-fold margin of safety (based upon the lower fiducial limit of the 96-h LC01) would exist for catfish if a 3 mg H_2O_2/L treatment were used for control of algae in a field pond.

The SCP granules are effective as an algicide against blue-green algae, and the granules compare favorably with equivalent oxidizing strengths of liquid H_2O_2 in safety to catfish fingerlings. Further toxicity tests would verify the safety of H_2O_2 to fish and field testing should be done to determine effects of H_2O_2 on other alga species.

[7]Millipore® filters available from Millipore/Continental Water Systems, Asby Rd. Bedford, MA 01730.

TABLE 1. LOSS OF CHLOROPHYLL FROM *ANABAENA* SP. AND *RAPHIDIOPSIS* SP. 24 H AFTER TREATMENT WITH SODIUM CARBONATE PEROXYHYDRATE (SCP) OR H_2O_2 (AS 10 MG/L H_2O_2) IN THE GROWTH CHAMBER AT 450 μE·m $^{-2}$·s $^{-1}$.

Treatment	*Anabaena* sp		*Raphidiopsis* sp	
	Chlorophyll	Reduction	Chlorophyll	Reduction
	(mg/L)	(%)	(mg/L)	(%)
Control	1.69	—	1.57	—
SCP	1.17	31.0 a[a]	0.43	72.6 a
H_2O_2	1.17	31.0 a	0.32	79.8 a

[a]Means within the column followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test. Each value is the mean of 5 replications with data from duplicate experiments combined.

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LITERATURE CITED

1. Balvay, G. 1981. Quelques consequences biologiques du traitment d'un lac avec du peroxyde d'hydrogene aur la bioscenose planctonique. [Biological consequences of treating a lake with hydrogen peroxide on the plankton biocenosis.] Water Res. 15:691-696.
2. Barrion, G. and M. Feuillade. 1986. Hydrogen peroxide as a potential algicide for *Oscillatoria rubescens* D.C. Water Res. 20:619-623.
3. Boyd, C. E. 1979. Water quality in warm water fish ponds. Agric. Exp. Stn., Aubrn Univ., Auburn, Ala., 359 pp.
4. Fowler, M. C. and P. R. F. Barrett. 1986. Preliminary studies on the potential of hydrogen peroxide as an algicide on filamentous species. Proc. EWRS/AAB 7th Symp. on Aquat. Weeds. pp. 113-118.
5. Goodnight, J. H. 1979. PROBIT procedure. Pages 367-360 *in* J. T. Helwig and K. A. Council, eds., SAS Users Guide, SAS Institute, Inc., Cary, NC.
6. Kay, S. H. and P. C. Quimby, Jr. 1981. Response of coontail to H_2O_2 ± Cu. Abstract, J. Miss. Acad. Sci., Suppl. 26:18.
7. Kay, S. H. and P. C. Quimby, Jr., and J. D. Ouzts. 1982. H_2O_2: A potential algicide for aquaculture. Proc. South. Weed Science Soc. 35:275-289.
8. Kay, S. H., P. C. Quimby, Jr., and J. D. Ouzts. 1983. Control of coontail with hydrogen peroxide and copper. J. Aquat. Plant Manage. 21:38-40.
9. Kay, S. H., P. C. Quimby, Jr., and J. D. Ouzts. 1984. Photo-enhancement of hydrogen peroxide toxicity to submersed vascular plants and algae. J. Aquat. Plant Manage. 22:25-34.
10. Ouzts, J. C., J. D. Ouzts, and P. C. Quimby, Jr. 1987. Hydrogen peroxide as an algicide in sewage lagoons. Abstract, J. Miss. Acad. Sci., Suppl. 32:10.
11. Quimby, P. C., Jr. 1981. Preliminary evaluation of hydrogen peroxide as a potential herbicide for aquatic weeds. J. Aquat. Plant Manage. 19:53-55.
12. Quimby, P. C., Jr. and S. H. Kay. 1984. Sodium carbonate peroxyhydrate as a new algicide. Abstracts, Weed Science Soc. Amer., p. 41 (Abstract).
13. Sladeckova, A. 1969. Control of slimes and algae in cooling systems. Verh. Int. Verein. Limnol. 17:532-538.
14. Wilde, E. W. and B. D. McLaughlin. 1981. Selecting an algicide for use with aluminum alloys. Water Res. 15:1117-1124.