COPTROL VS COPPER SULPHATE FOR THE TREATMENT OF ALGAE

Literature Review

By Sachintha Narangoda
Monash University
Bachelor of Environmental Science

Prepared for Aquatic Technologies

COPTROL VS COPPER SULPHATE FOR THE TREATMENT OF ALGAE

OVERVIEW

- This literature review compares the use of Copper Sulphate with the use of Coptrol to treat algae
- Copper compounds like copper sulphate are commonly used in the treatment of algae, but these often contain large amounts of harmful copper ions, making them unsafe for use in water intended for drinking, livestock watering and irrigation
- Coptrol consists of copper in a non-ionic chelated form that is completely safe to use around aquatic organisms like fish and crustaceans, and for use in irrigation and drinking water
- Coptrol can be used in all types of water, unlike copper sulphate
- Coptrol is highly effective, meaning less is required to treat the same amount of algae compared to copper sulphate, making it very cost-effective

INTRODUCTION

Blooms of algae are becoming more common in a wide range of aquatic ecosystems, particularly those found near residential, agricultural and recreational sites.[1,2] Algae blooms are associated with runoff from urban, suburban and agricultural lands that reach waterbodies like lakes, ponds and streams.[3] This runoff is often high in nitrogen and phosphorous, chemicals that algae thrive in.[4] Once an algae bloom is established in a waterbody, it severely impacts the quality of all water contained within, and poses a continuous danger to aquatic wildlife that occupies the waterbody.[5,6,7] In addition, the tainted water poses a severe health risk to any humans or livestock that consume or come into contact with the water.[8,9]

Copper in the form of copper sulphate has commonly been used as an algaecide since the early 1900s.[10,11] While copper has a toxic effect on most algae species, there are many inherent disadvantages associated with using copper in its copper sulphate form. Some of these include high dosages[12,13,14] and many associated health hazards.[15] Therefore, a better designed and modern approach of copper algaecide treatment in the form of Coptrol is recommended. Unlike copper sulphate, Coptrol requires a smaller application rate to achieve the same results, and is therefore a much safer alternative all round.[16]

IMPACTS OF ALGAL BLOOMS IN WATER

Environmental	▪ Cyanobacteria blooms form dense mats that prevent light and oxygen from entering the water[17] ▪ Cyanobacteria blooms release toxic compounds that alter water quality and reduce beneficial bacteria necessary for local water dynamics[17] ▪ Toxins released by Cyanobacteria blooms endanger the lives of local wildlife and reduce overall biodiversity[18,19]

Economic	▪ Algal mats block irrigation equipment (intakes, filters, pipes & pumps), reducing pumping efficiency and increasing pumping time and cost[20] ▪ Mats of algae obstruct commercial fishing nets resulting in reduced fish production[21] ▪ Cyanobacterial toxins prevent the usability of water for drinking, irrigation, livestock watering, etc.[18,21]
Social	▪ Cyanobacteria blooms release toxic compounds that cause serious illness in humans and domestic pets[17,18] ▪ Algal blooms contaminate water with unpleasant tastes and odours[17] ▪ Algal blooms alters the colour of open water bodies, reducing their natural beauty[17,21] ▪ Dense algal mats prevent recreational activities like swimming and fishing[21]

COPPER SULPHATE ALGAECIDES

- Copper sulphate has been used as an algaecide for decades; most algaecides are copper-based[10,11]
- In water, copper sulphate dissociates into copper ions and sulphate ions, greatly increasing the level of ionic copper available for uptake by non-target organisms[16]
- Ionic copper is quite toxic to many aquatic species, including most fish, crustaceans and other invertebrates,[15,16] and even large waterfowl like geese[22,23]
- Excess copper ions in drinking water cause many gastrointestinal diseases in both humans and livestock if consumed repeatedly[24,25,26,27]
- The tendency of un-chelated copper ions to bind to soil means that irrigation water treated with copper sulphate algaecides leads to the build-up of copper in soils at levels that can damage crops[28]
- Copper sulphate easily forms precipitates in hard water[12] or water that contains dissolved organic matter from soil runoff.[13] This means that less copper is available for uptake by algae, thus reducing its toxicity to algae
- The algae themselves release complex particles (ligands) that attach to dissolved copper ions, reducing the efficacy of copper sulphate-based algaecides[14,29]
- To overcome precipitation and neutralisation, large dosages of copper sulphate are required to remain effective as an algaecide[16]

COPTROL

- Coptrol is a chelated form of copper using organic agents, making it structurally different from copper sulphate[16]
- Coptrol does not form precipitates in hard water or water with dissolved organic matter, and is not neutralised by algae[15,30]
- Coptrol contains less elemental copper than copper sulphate, and all copper is present in a non-ionic chelated form, making it safer for non-target organisms[16]. Additionally, the dose of Coptrol needed for

successful treatment is significantly small. This makes it ideal for use in water intended for drinking, livestock or irrigation[31]

- Coptrol targets algae more effectively by readily passing through algal cell walls and membranes[16]
- Coptrol persists in water, thus maintaining its algitoxic ability for a long time[32]
- Due to Coptrol's high efficacy and long-term effects compared to copper sulphate, less Coptrol is required to achieve the same results as copper sulphate,[16] making it very cost-effective
- After being absorbed by algae, Coptrol's ultimate fate is as insoluble copper carbonate that is harmless to aquatic organisms, humans, livestock and crops[33]

BENEFITS OF COPTROL OVER COPPER SULPHATE ALGAECIDES

Table 1. Comparison of the benefits of using Coptrol instead of copper sulphate-based algaecides.

Copper Sulphate Algaecide	Coptrol
Precipitates rapidly in hard water or muddy water, reducing its efficacy[12,13]	Does not form precipitates in any type of water[15,30]
Is easily neutralised by particles produced by algae[14,29]	Is not affected by algal neutralising particles[30]
Does not last long in water[13]	Lasts longer in water, maintaining its algitoxicity for a longer period of time[32]
Large dosage is needed to remain effective as an algaecide[16]	Smaller dosage is required to treat the same amount of algae as other algaecides since it is absorbed easily by algae cells[16]
Greatly raises the amount of copper ions in water, which are toxic for waterfowl[22,23] and aquatic organisms including fish, crustaceans and invertebrates[15,16]	Is safe for use with waterfowl, fish and other aquatic organisms since its active copper constituent is in a non-ionic chelated form[16]
Not suitable for use in drinking water as the consumption of excess copper ions causes gastrointestinal diseases in humans and livestock[24,25,26,27]	Is ideal for use in drinking water since its active copper constituent is in a chelated form and causes no harm when consumed[16,31]
Not suitable for use in irrigation water as the un-chelated copper ions build up in soil and damage crops[28]	End products of treatment are chemically inert and pose no danger when present in irrigation water[33]

REFERENCES

1. Hallegraeff GM. A review of harmful algal blooms and their apparent global increase. Phycologia. 1993 Mar;32(2):79–99.

2. Lewitus AJ, Brock LM, Burke MK, DeMattio KA, Wilde SB. Lagoonal stormwater detention ponds as promoters of harmful algal blooms and eutrophication along the South Carolina coast. Harmful Algae. 2008 Dec;8(1):60–5.

3. Anderson DM, Burkholder JM, Cochlan WP, Glibert PM, Gobler CJ, Heil CA, et al. Harmful algal blooms and eutrophication: Examining linkages from selected coastal regions of the United States. Harmful Algae. 2008 Dec;8(1):39–53.

4. Heisler J, Glibert PM, Burkholder JM, Anderson DM, Cochlan W, Dennison WC, et al. Eutrophication and harmful algal blooms: A scientific consensus. Harmful Algae. 2008 Dec;8(1):3–13.

5. Lugomela C, Pratap HB, Mgaya YD. Cyanobacteria blooms—A possible cause of mass mortality of Lesser Flamingos in Lake Manyara and Lake Big Momela, Tanzania. Harmful Algae. 2006 Oct;5(5):534–541.

6. Foss AJ, Miles CO, Samdal IA, Løvberg KE, Wilkins AL, Rise F, et al. Analysis of free and metabolized microcystins in samples following a bird mortality event. Harmful Algae. 2018 Dec;80:117–129.

7. Landsberg JH, Hendrickson J, Tabuchi M, Kiryu Y, Williams BJ, Tomlinson MC. A large-scale sustained fish kill in the St. Johns River, Florida: A complex consequence of cyanobacteria blooms. Harmful Algae. 2020 Feb;92:101771.

8. Fogg GE. Harmful algae—a perspective. Harmful Algae. 2002 Mar;1(1):1–4.

9. Yuan M, Carmichael WW, Hilborn ED. Microcystin analysis in human sera and liver from human fatalities in Caruaru, Brazil 1996. Toxicon. 2006 Nov;48(6):627–640.

10. Flemming CA, Trevors JT. Copper toxicity and chemistry in the environment: a review. Water, Air, and Soil Pollution. 1989 Mar;44(1-2):143–158.

11. Thurman RB, Gerba CP, Bitton G. The molecular mechanisms of copper and silver ion disinfection of bacteria and viruses. Critical Reviews in Environmental Control. 1989 Jan;18(4):295–315.

12. Bartsch AF. Practical methods for control of algae and water weeds. Public Health Reports (1896-1970). 1954;69(8):749.

13. McKnight D. Chemical and biological processes controlling the response of a freshwater ecosystem to copper stress: A field study of the CuSO4 treatment of Mill Pond Reservoir, Burlington, Massachusetts. Limnology and Oceanography. 1981 May;26(3):518–531.

14. Moore JW, Ramamoorthy S, Ballantyne EE. Heavy metals in natural waters: applied monitoring and impact assessment. Berlin: Springer-Verlag; 1984.

15. Mastin BJ, Rodgers, JH. Toxicity and Bioavailability of Copper Herbicides (Clearigate, Cutrine-Plus, and Copper Sulfate) to Freshwater Animals. Archives of Environmental Contamination and Toxicology. 2000 Nov;39(4):445–451.

16. Closson KR, Paul EA. Comparison of the toxicity of two chelated copper algaecides and copper sulfate to non-target Fish. Bulletin of Environmental Contamination and Toxicology. 2014 Oct 5;93(6):660–665.

17. Selezneva AV, Seleznev VA, Sayriddinov SS. Nanofiltration to purify drinking water from cyanobacteria and microcystins in water supply systems. IOP Conference Series: Materials Science and Engineering. 2021 Mar 1;1079(2).

18. Kotut K, Ballot A, Krienitz L. Toxic cyanobacteria and their toxins in standing waters of Kenya: implications for water resource use. Journal of Water and Health. 2006 Jun 1;4(2):233–245.

19. Mateos-Sanz MA, Carrera D, López-Rodas V, Costas E. Toxic cyanobacteria and widlife conservation: Proposal of a procedure to demonstrate waterbird mass mortalities by microcystin. Acta Botanica Malacitana. 2009 Dec 1;34:5–10.

20. Mohamed ZA, El-Sharouny HM, Ali WSM. Microcystin production in benthic mats of cyanobacteria in the Nile River and irrigation canals, Egypt. Toxicon. 2006 Apr;47(5):584–590.

21. Yu W. Regional Algae Bloom: Natural disaster causes economic setback in private fishing charter in Southwest Florida. IOP Conference Series: Earth and Environmental Science. 2021 Feb 20;657.

22. Henderson BM, Winterfield RW. Acute Copper Toxicosis in the Canada Goose. Avian Diseases. 1975 Apr;19(2):385.

23. Eisler R. Copper hazards to fish, wildlife, and invertebrates : a synoptic review. Washington, D.C.: U.S. Geological Survey; 1998.

24. Fewtrell L, Kay D, Jones F, Baker A, Mowat A. Copper in drinking water — an investigation into possible health effects. Public Health. 1996 May;110(3):175–177.

25. Potera C. Copper in drinking water: using symptoms of exposure to define safety. Environmental Health Perspectives. 2004 Jul;112(10).

26. Stevenson H. Copper poisoning and photosensitisation in ewes. Livestock. 2008 Jan;13(1):56–59.

27. Oruc HH, Cengiz M, Beskaya A. Chronic Copper Toxicosis in sheep following the use of copper sulfate as a fungicide on fruit trees. Journal of Veterinary Diagnostic Investigation. 2009 Jul;21(4):540–543.

28. Salam D, El-Fadel M. Mobility and availability of copper in agricultural soils irrigated from water treated with copper sulfate algaecide. Water, Air, and Soil Pollution. 2008 Jun 6;195(1-4):3–13.

29. Rijstenbil J. Interactions of algal ligands, metal complexation and availability, and cell responses of the diatom *Ditylum brightwellii* with a gradual increase in copper. Aquatic Toxicology. 2002 Jan;56(2):115–131.

30. Elder JF, Horne AJ. Copper cycles and CuSO4 algicidal capacity in two California lakes. Environmental Management. 1978 Jan;2(1):17–30.

31. Cotruvo JA. 2017 WHO Guidelines for drinking water quality: First Addendum to the Fourth Edition. Journal - American Water Works Association. 2017 Jul 1;109:44–51.

32. Boyd CE. Water quality in warm water fish ponds. Department of Fisheries and Allied Aquaculture. Fisheries Research Unit. Auburn University Agricultural Experiment Station. Alabama, U.S.A. 1979:159–163.

33. Pagenkopf GK, Cameron D. Deposition of trace metals in stream sediments. Water, Air, and Soil Pollution. 1979 May;11(4).