Algaecides

ANS Control: Algaecides – Copper Sulfate, Chelated Copper Formulations, Endothall (as the mono (N,N-dimethylalkylamine) salt), and Algaecides containing Sodium Carbonate Peroxyhydrate

Targeted Species: Algaecides (or algicides) are used to control or suppress many species of planktonic, filamentous, and branched algae. Specific ANS of Concern – CAWS[1] that may be controlled or suppressed with algaecides include red macro-algae (*Bangia atropurpurea*), diatoms (*Cyclotella cryptica*, *C. pseudostelligera* and *Stephanodiscus binderanus*)[2], and grass kelp (*Enteromorpha flexuosa*).

Algaecides can be applied as a spray directed onto floating mats of algae, sprayed or injected directly into the water column, or applied as granular crystals or pellets dispensed to the water surface.

Selectivity: Algaecides can be selective or non-selective against algae. Selectivity depends on species, dose and timing of application, product formulation, and water chemistry (Cooke et al. 1993).

Developer/Manufacturer/Researcher: There are numerous formulations and manufacturers of algaecides registered by the U.S. Environmental Protection Agency (USEPA) for use in and around aquatic habitats. A list of most of the currently available algaecides and their respective manufacturers can be found in Appendix F of Gettys et al. (2009).

Pesticide Registration/Application: Pesticides, including algaecides, must be applied in accordance with the full product label as registered by the U.S. Environmental Protection Agency (USEPA). Users must read and follow the pesticide product label prior to each application. The registration status, trade name, and availability of pesticides are subject to change. The listing of a pesticide in this fact sheet or Appendix B does not represent an endorsement by the U.S. Army Corps of Engineers or the USEPA regarding its use for a particular purpose.

Brief Description: Algaecides are chemical substances that are specifically used to control or kill algae. Registered algaecides include copper sulfate, copper chelates (ethanolamines, ethylene diamines, triethanolamines, triethanolamine + ethylene diamine, and copper citrate/gluconate), endothall (as the mono (N,N-dimethylalkylamine) salt), and formulations containing the active ingredient sodium carbonate peroxyhydrate.

[1] For a complete list of the 39 specific ANS of Concern – CAWS, please see Table 1 of the main report.
[2] Cryptic algae (*Cyclotella cryptica*), cylindrical algae (*C. pseudostelligera*), and diatom (*Stephanodiscus binderanus*) are three (3) species of algae that belong to the algal subcategory of diatoms. For the purpose of this fact sheet, they will be referred to collectively as diatoms.

Similar to herbicides[3], algaecides must come in contact with and enter algal cells to be effective. Algaecides vary in their mechanism of action, but they are all considered "contact" pesticides, meaning they cause injury to only the algal cells or filaments that come in contact with or are exposed to dissolved algaecide, with little intercellular movement. Algaecides are used primarily to control algal growth in impounded waters, lakes, ponds, reservoirs, stock tanks, and irrigation conveyance systems. They can be applied as a spray directed onto an algal mat, sprayed or injected directly into the water column, or applied as granular crystals or pellets.

The mechanism of action for most algaecides is not well understood, but copper-based products are believed to target specific physiological processes such as electron transport in photosystem I, cell division and nitrogen fixation (Cooke et al. 1993; Senseman 2007). Endothall has been shown to cause electrolyte leakage from cell membranes and may also play a role in inhibition of lipid and protein biosynthesis (Senseman 2007). Algaecides containing sodium carbonate peroxyhydrate act to destroy algal cell membranes by forming hydroxyl free radicals.

Prior Applications: Algaecides can be used to control many species of algae, but they are typically applied once algae have been identified and are present in a body of water. They are not used in permanent chemical barriers. Algaecides can reduce the risk of nuisance algae spread, however, algaecide application typically does not result in eradication of algae. The following information summarizes what has been reported in literature on the use and effectiveness of algaecides for each ANS of concern – CAWS.

Red macro-algae, "Bangia atropurpurea": There is no published literature documenting algaecide effectiveness against this filamentous red macro-alga, however, it is likely that endothall and chelated copper-based algaecides will effectively control this species. The label for Hydrothol 191®[4], which contains the mono (N,N-dimethylalkylamine) salt of endothall, identifies product efficacy on a broad range of filamentous algae (United Phosphorus, Inc. 2010). Based on the structural character of *B. atropurpurea*, chelated copper formulations such as K-Tea™ (triethanolamine; SePRO Corporation) and Captain™ (copper carbonate; SePRO Corporation) will likely have activity against this species (West Bishop, SePRO Corporation, E-mail communication, 2011).

Diatoms, "Cyclotella cryptica," "C. pseudostelligera," and "Stephanodiscus binderanus": There is little published literature on algaecide effectiveness against these diatom species, but many diatom species are susceptible to copper sulfate and chelated copper formulations. The genus *Stephanodiscus* is included on many copper sulfate and chelated copper product labels as a sensitive genera which can be controlled by these compounds. Button et al. (1977) reported that an algal bloom in Hoover Reservoir, Franklin County, Ohio, composed primarily of diatoms including the genera *Stephanodiscus*, was controlled by copper sulfate. Non-copper algaecides containing endothall (as the mono (N,N-dimethylalkylamine) salt) and sodium carbonate

[3] For more information on this control technology, please see the fact sheet titled "Aquatic Herbicides."

[4] Manufacturers and products mentioned are examples only. Nothing contained herein constitutes an endorsement of a non-Federal entity, event, product, service, or enterprise by the U. S. Army Corps of Engineers or its employees.

peroxyhydrate have broad spectrum activity against planktonic algae and may be effective on these invasive diatom species.

Grass kelp, "Enteromorpha flexuosa": There is no published literature documenting algaecide effectiveness against grass kelp. The genus *Enteromorpha*, however, is included on many copper sulfate and chelated copper product labels as being susceptible to these algaecides. Non-copper algaecides containing sodium carbonate peroxyhydrate and endothall (as the mono (N,N-dimethylalkylamine) salt) have broad spectrum activity against green algae (Chlorophyta) and may be effective on grass kelp.

General Effectiveness: When properly applied, and in accordance with product label directions, algaecides can be effective for controlling or reducing the growth of unwanted algae. Due to their ability to reproduce quickly, however, algae are difficult to control long term. Once a body of water becomes infested with algae, it is unlikely that algaecides will eliminate all algae or their spores (algae reproduce by cell division and/or by formation of spores (Lembi 2009)). The efficacy of algaecides is short-lived in water and regrowth almost always occurs; as a result, re-treatment with algaecides is required (Ross & Lembi 1985; Cooke et al. 1993; Lembi 2009).

The efficacy of copper-containing algaecides can be impacted under certain environmental conditions. Copper is less effective in waters with high alkalinity and pH; it is also ineffective when water temperatures are less than 15 °C (Cooke et al. 1993).

Operating Constraints: Constraints for using algaecides in aquatic environments are defined on the manufacturer's product label and may include: restrictions for water use after algaecide application; when, where, and how the product can be applied; frequency and maximum rate of application; conditions that can reduce product efficacy; and potential impacts to sensitive, non-target species. Appropriate state and local regulatory agencies must be contacted and manufacturer product label directions followed prior to application of an algaecide to any body of water. Some states may require applicators of algaecides to be licensed and certified. Environmental conditions such as high pH and alkalinity, or water temperatures below 15 °C, will reduce the effectiveness of copper-containing algaecide formulations. Continuous use of copper-based algaecides may result in an accumulation of copper in sediments and, consequently, may restrict sediment reuse and disposal.

Cost Considerations: Cost of algaecide and application varies with product choice, method and rate of application, and management or treatment objective.

Implementation: Implementation costs would include the development of a management plan, purchase and application of the algaecide, and potential costs associated with monitoring residues in water (if required to determine Maximum Contamination Levels related to water use restrictions imposed by the algaecide label). Planning and design activities in this phase may include research and development of this Control, modeling, site selection, site-specific regulatory approval, plans and specifications, and real estate acquisition. Design will also include analysis of this Control's impact to existing waterway uses including, but not limited to, flood risk management, natural resources, navigation, recreation, water users and dischargers, and required mitigation measures.

Operations and Maintenance: Operation and maintenance costs would include monitoring effectiveness of algaecide treatment and reapplication when algae begin to reappear.

Mitigation: Design and cost for mitigation measures required to address impacts as a result of implementation of this Control cannot be determined at this time. Mitigation factors will be based on site-specific and project-specific requirements that will be addressed in subsequent, more detailed, evaluations.

Citations:

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