3.7.4 Aquatic Herbicide Application Methods

William T. Haller: University of Florida, Gainesville FL (emeritus); whaller@ufl.edu

Introduction

All pesticide labels contain very specific information regarding how they are to be stored, handled and applied. It is illegal to use any herbicide in, on or over water unless it is registered by the United States Environmental Protection Agency (EPA) for that purpose and has aquatic use directions on the label (Section 3.7). States may have pesticide use regulations that are more strict than federal regulations; thus, several states require that aquatic pesticide applicators be certified and licensed before they may purchase, handle and apply pesticides and that permits are obtained before aquatic pesticides are applied. Potential users of pesticides should contact state agencies such as county cooperative extension offices, state game and fish agencies or state environmental authorities to ensure compliance with any additional state-specific use restrictions.

A few herbicides may be applied directly from the container; for example, the labels of some copper sulfate herbicides suggest placing the dry granules in a cloth bag and towing the filled bag behind a boat to ensure uniform application throughout the water column. However, the majority of aquatic herbicides must be diluted or mixed with water before application. The purpose of the diluent (water) is to ensure consistent coverage of the target weeds so the herbicide can be absorbed into the plants. Most herbicide labels state that applicators should "use sufficient diluent to obtain uniform coverage of the target weed." Some labels are more restrictive and specify the amount of diluent to be used during application of the herbicide. For example, a label may specify "apply in 50 to 150 gallons of water per acre for adequate coverage". The public often believes that the mixture being applied to weeds is concentrated herbicide, but this is rarely – if ever – the case because herbicides are mixed with large volumes of water. Applicators are required by law to have the label at the application site and it is critical that they read the label carefully before aquatic herbicides are diluted, mixed and applied to ensure that the herbicide is applied in a legal, safe and effective manner.

All pesticides are most hazardous to the applicator when they are in concentrated form and being mixed with diluent (water) to prepare for application. Applicators also may handle the herbicide concentrate several times daily and possibly several days each week. Each herbicide label specifies the type of safety equipment applicators are required to wear to minimize their contact with the concentrate. Thus, although many aquatic herbicides do not have swimming restrictions following treatment, the applicators may be required to wear hazmat suits, gloves and face shields when mixing and applying a product, implying a greater hazard than the treated water actually poses to the public. The concentrate may contain several thousand parts per million (ppm) in the formulation, but the final strength is only 1 or 2 ppm or less when applied and mixed into submersed weed treatment site.

Foliar applications

Foliar herbicides are mixed with water and sprayed on the foliage of floating or emergent plants in a given area. The goal during foliar application of an aquatic herbicide is to obtain good coverage and ensure that the maximum amount of herbicide is taken up by the target weed. Most floating and emergent plants have a waxy layer (cuticle) on their leaves and stems that must be penetrated in order for the herbicide to be taken up by the plant. The labels of some aquatic herbicides suggest or require the addition of surfactants (Section 3.7.3) that dissolve the cuticle and

facilitate uptake of the herbicide by the plant. For example, a label may state that “a surfactant may be applied at a rate of 0.25 to 0.5% (1 to 2 quarts per 100 gallons) with the tank mix to get best results”. In this example, the addition of a surfactant is not required by the label (“may be used”), so its use is optional; other herbicide labels require (“must be used”) the use of surfactants.

Just as carpenters and electricians have specialized equipment for their work, aquatic applicators often have tank- and pump-equipped boats and trucks for the application of herbicide treatments. A typical boat may hold a pump (calibrated to apply from 4 to 10 gallons per minute of a herbicide mix) and a 50- to 100-gallon mix tank. This equipment is calibrated by the applicator to apply the correct amount of herbicide over the area to be treated. Selectivity, or the ability to control weeds growing among native plants, is usually accomplished by choosing the appropriate herbicide or by using a handgun for targeted application of the herbicide mix only to the weeds and not to the desired native species. This is not always possible but is practiced as much as equipment and herbicide selection allow. Riparian owners and lake users may sometimes see damaged or brown native plants in addition to the target weeds 1 or 2 weeks after an herbicide treatment and conclude that all vegetation – including desirable native plants – is dead. However, some non-target plants (particularly perennial and emergent species) often recover and will recolonize the treated site a few weeks following application.

Most homeowners have small “pump-up” garden sprayers or backpack sprayers for lawn and garden use. Herbicide labels may include use directions for mixing the herbicide for small or localized spot treatments using small equipment. For example, if control of clumps of purple loosestrife along a shoreline is desired, the herbicide label may state “mix a 1 to 2% solution of herbicide in a backpack sprayer and spray weeds to wet”. A gallon of water contains 128 fluid ounces, so the applicator would add 1.28 fluid ounces of herbicide to 127 fluid ounces of water to get a 1% solution. A 2% herbicide solution would be 2 x 1.28 fluid ounces, or 2.5 fluid ounces of herbicide per gallon of total tank mix. Be careful; some herbicides cannot be used in sprayers that will also be used for garden or ornamental plants, as some leftover herbicides can be quite toxic to other plants. Where is this information? On the label that is attached to every herbicide container!

The foliar application of herbicides to emergent and floating-leaved plants is generally well understood by homeowners because this is common practice for applying insecticides and other products to ornamental, lawn and garden plants. The application of herbicides for submersed weed control, however, is often more complicated and thus more difficult to understand.

Submersed aquatic applications

The control of submersed aquatic weeds is much more difficult than control of emergent aquatic plants for the following reasons:

- Fewer herbicides are registered for submersed treatments
- The amount of herbicide needed depends on the depth of the water
- Wind, waves, inflow, outflow and currents dilute herbicides
- It takes more time to treat and cover submersed plants
- Submersed weeds are generally much more expensive to treat
- The growth stage and area covered by the plants are important
- Use of treated water for irrigation and drinking may be restricted

These general factors – and additional site-specific ones – determine which herbicides should be used to control submersed aquatic weeds. Water flow, dilution and water use are often the critical factors to consider when choosing an herbicide. Water flow and dilution may result in herbicide concentration/exposure times (CET) that are insufficient for herbicides to be effective (Section 3.7.1). There are also water restrictions on many herbicides for use near potable water intakes and water used for irrigation. Herbicide labels will include specific use restrictions.

From the information above, it should be clear that the least complicated, easiest scenario where aquatic herbicides are used to control submersed weeds is in a small pond with no water flow or water use restrictions. There are several herbicides to choose from, and once applied at recommended concentrations, there are no concentration:exposure time or water use concerns. In contrast, a narrow strip of submersed weeds along the shoreline of a 300-acre lake may have the same area and volume as that small pond, but is subject to wind and wave action, water currents and potential water use for irrigation of agricultural crops; therefore, managing this strip is much more complicated and may not be possible.

There are three general types of submersed aquatic weed herbicides based upon their concentration:exposure times and modes of action: contact herbicides, slow-acting systemic herbicides and fast-acting systemic herbicides.

Contact herbicides

Contact herbicides are applied at relatively high concentrations, have very short half-lives in water and require a contact time of hours to a few days to kill plants. They include copper products, diquat, endothall, carfentrazone and flumioxazin which may be applied along strips of shoreline and in relatively small areas where dilution is high, provided contact of the herbicide with the target weed is maintained for an amount of time sufficient to achieve control. The decision to use a contact herbicide is site-specific and the greatest chance of success occurs when herbicide applications are done on calm days to optimize contact times. Contact herbicides in general provide 3 to 6 months of weed control, depending upon the weed, geographical area of application (northern US vs. southern US) and length of growing season.

Systemic or enzyme-inhibiting herbicides

Systemic enzyme-inhibiting herbicides are generally applied at concentrations lower than contact herbicides, must remain in contact with target weeds for relatively long times (up to 45 days or more) and are very slow to control submersed aquatic weeds. These herbicides are often applied as low-dose whole-lake treatments to control weeds throughout the pond or lake. Systemic enzyme-inhibiting herbicides include fluridone, penoxsulam, bispyribac and topramezone. These herbicides are applied at rates of 15 to 45 ppb (parts per billion); concentrations can be maintained with additional treatments over several weeks to control hydrilla (Section 2.2), Eurasian watermilfoil (Section 2.3) and other submersed species. Imazamox is applied at higher rates (100 to 200 ppb) and requires a slightly shorter contact time.

Systemic herbicides with short contact times

There are always exceptions to the rule and the auxin herbicides 2,4-D and triclopyr are the exceptions in this case. Both are systemic herbicides but are absorbed in lethal doses by the target weeds in a relatively short time (1 to 4 days) depending upon the concentration applied. These two herbicides are effective for selective control of Eurasian watermilfoil and other dicot (broadleaf) weeds. Concentrations of these herbicides for submersed weed control generally range from 1 to 2 ppm (parts per million). 2,4-D and triclopyr are applied at the highest labeled dose in areas where dilution is most likely to occur (such as small treatment areas and in strip treatments along shorelines) and on dense mature plants. Lower doses may be used in large treatment areas and in protected coves and bays with little water exchange. A new auxin-mimic herbicide, florpyrauxifen-benzyl, has a concentration:exposure time requirement of as little as a few hours exposure to 5 to 45 ppb depending upon the weed being treated. Most auxin herbicides control broadleaf weeds (dicots), but this herbicide also controls some grass (monocot) weeds as well. Rapid uptake of florpyrauxifen-benzyl and its selective control of many submersed weeds indicates that it can be used in small plot or partial lake treatments. Extensive field research is currently in progress to further delineate the potential of this new product on submersed as well as floating and emergent species.

Application of formulations

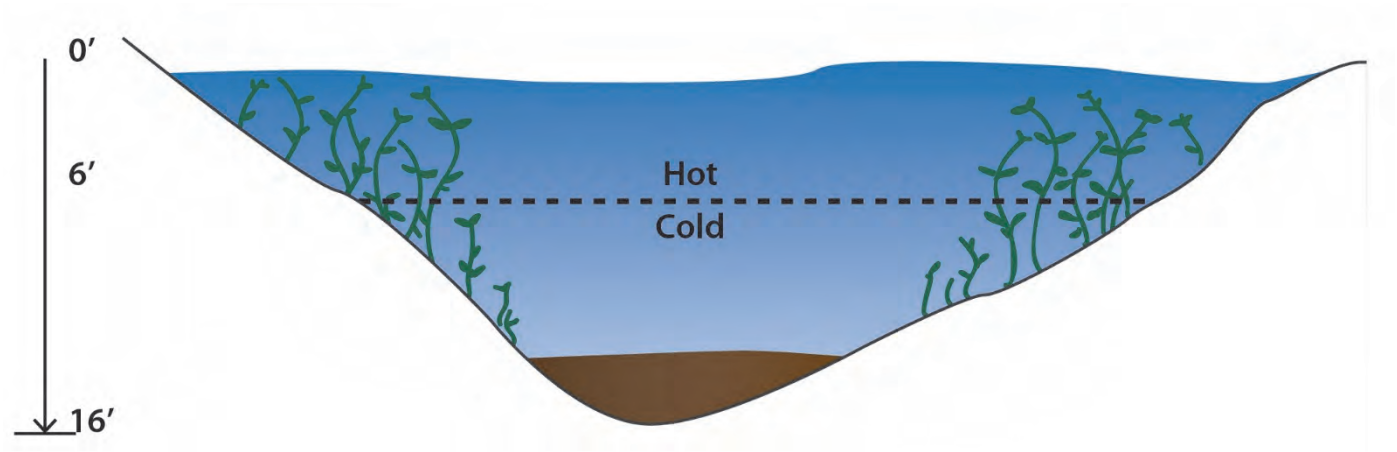
Herbicide formulation refers to how a herbicide is sold (as a liquid, granular or other form) and this determines the type of equipment needed for application of the herbicide. Many aquatic herbicides are sold as both liquid and granular formulations because many are used for both foliar and submersed aquatic weeds. For example, you would not apply

2,4-D as a granular formulation for foliar applications to purple loosestrife (Section 2.16); you would use a liquid formulation. The formulations of aquatic herbicides are listed in Section 3.7.1.

Liquid formulations can be applied to submersed aquatic weeds in several ways, with the type of application determined by the specific location, size and depth of the treatment area. Surface applications are typically done along shorelines and under or around boathouses and docks where water depths average 3 to 6 feet deep. Granular and deep-hose applications are often used in deeper water, particularly in water where submersed weeds are growing in water from 6 to 20 feet deep. The objective of these deep-water treatments is to ensure that the herbicide mixes in the water column and reaches the plant beds where they can be taken up by the target weeds.

Effect of thermoclines

Temperature-dependent thermoclines often develop in lakes and other non-flowing waters during summer, particularly in northern regions. A thermocline occurs when the upper and lower portions of the water separate into warm and cool layers. Swimmers are often familiar with this phenomenon; for example, water in the upper layer of a lake feels warm, but diving down to depths of 6, 8 or 12 feet can be shockingly cold. This thermal stratification is well-known to applicators of aquatic herbicides as well and can reduce the effectiveness of herbicide treatments because the warm upper and cool lower layers of the water do not mix. Herbicides applied to the surface of the water may control upper portions of weeds, but herbicides do not diffuse or penetrate into the deeper cool layers. As a result, root crowns, rhizomes and low-growing plants below the thermocline are not controlled by the herbicide. The depth of the thermocline is influenced by water clarity and varies among lakes, but water temperature within the thermocline typically drops 2 °F for each 3 feet change in depth. If aquatic weeds are growing above and below the thermocline, deep-water injection of liquid herbicides or application of granular herbicides may be used to control weeds in both thermal zones.



Foliar and submersed concentrations

The labels of most aquatic herbicides allow foliar applications for floating and emergent weed problems and the directions for this use are clearly stated on the herbicide labels. Foliar-applied herbicides such as 2,4-D, triclopyr, glyphosate, diquat, endothall, imazapyr and imazamox are usually mixed with 50 to 100 gallons of water per acre treated according to label directions and a surfactant is usually added to the tank mix to facilitate herbicide absorption or to ensure even coverage of the target plants. These herbicides are typically applied in “pounds per acre” with one pound of the herbicide’s active ingredient in 100 gallons of water, resulting in a 0.1% concentration (1000 ppm) in the mix tank. This relatively high concentration is needed to ensure that the emergent plant absorbs enough herbicide to kill the

weed on contact or through translocation to the site where the herbicide kills the plant. More recently registered systemic enzyme-inhibiting herbicides such as carfentrazone, flumioxazin, penoxsulam, bispyribac and topramezone and the auxin mimic florpyrauxifen-benzyl are applied at much lower rates of only a very few ounces per acre.

Fortunately, the use of herbicides to control submersed aquatic weeds usually requires much lower concentrations of herbicides in the water to be effective. This is because most submersed plants lack the waxy cuticles that slow herbicide uptake in emergent plants and the leaves of many submersed plants are only a few cells thick. Tank mixes may still call for one pound of herbicide in 100 gallons of water, but when diluted in one acre-foot of water, the concentration of herbicide that contacts submersed plants is only 1/2.7 or 0.370 ppm (370 ppb) due to the dilution effect of the water being treated (see Section 3.7.1 for instructions on calculating ppm and ppb). Eurasian watermilfoil can be controlled with as little as 10 ppb of fluridone, but control of this weed with triclopyr or 2,4–D may require up to 2 ppm (2000 ppb). The ability of herbicides to control submersed weeds at such low concentrations contrasts sharply with the concentrations required to control larger, more tolerant floating and emergent weeds. Of course, if the treatment site is very deep (such as 10 to 12 feet), the total amount of herbicide used per acre for submersed weed control increases as well and can exceed the amounts applied in foliar applications, but the final diluted herbicide concentration in the water for submersed treatments is typically less than that contained in foliar sprays.

Selectivity

Weed control in an aquatic ecosystem is very different from weed control in an agricultural setting. For example, farmers want to control all the weeds in a cornfield without affecting the corn, whereas managers of natural and aquatic areas often wish to control a single weed species growing among 50 to 100 desirable native species. Research regarding selectivity of aquatic herbicides is ongoing and depends upon the following factors:

- Choice of herbicide: some herbicides control submersed weeds without affecting a number of other desirable nontarget plants, but the choice of herbicides that work in this manner is limited and complete selectivity is not always possible. As a result, herbicide selection is often dictated by the types of native species present in the proposed treatment area. In general, herbicides applied for submersed weed control have little effect on rooted emergent species due to the relatively low concentrations of herbicides used to control submersed weeds. The use of the water from the proposed aquatic weed treatment site also dictates and plays a significant role in selection of which herbicide to use. The EPA and the Food and Drug Administration (FDA) determine if any potable water use restrictions, crop irrigation restrictions and fishing or swimming restrictions may be necessary to protect human health and the environment. These restrictions are clearly stated on the herbicide labels. Currently, there are no fishing (fish consumption) or swimming/ recreational use restrictions on any of the aquatic herbicides listed in this manual, but irrigation restrictions are more common. Labels for triclopyr and imazapyr state that treated water may not be used for irrigation for 120 days following treatment unless a chemical assay shows less than 1 ppb in the water; diquat has a 5-day irrigation restriction and several other herbicides have irrigation restrictions as well. Always check the label and also your responsible state agency since some states have additional water use restrictions.

- Dose or amount of herbicide: not all plants are equally susceptible to herbicides. Application rates needed to control different weeds are usually listed on the herbicide label.

• Stage of plant growth: some herbicides used for submersed weed control can be applied in very early spring when weeds are actively growing and native plants are still dormant. The use of some herbicides such as glyphosate and imazapyr on emergent perennial grasses such as phragmites (Section 2.17) and cattails seems to be more effective if applied in the late summer or fall when the plants more effectively translocate the herbicide down into the plant roots and rhizomes prior to winter dormancy.

• Selective foliar application: handguns can be used to target and apply herbicides only to the weeds and minimize damage to nontarget species. However, this method is not feasible in most submersed treatments.

Although selective treatment of submersed weeds is more difficult than treatment of floating and emergent weeds, the reduction in growth and coverage of submersed weeds generally results in less weed competition and quick recovery of native species in the treated area. This occurs because most submersed weeds reproduce by vegetative means and many nontarget native plants reproduce by seeds. Elimination of dense weed canopies and the reduction of competition from invasive weeds often results in germination and growth of desirable species during the season of the herbicide treatment or soon thereafter.

Summary

Small-scale foliar application of herbicides to emergent and floating weeds is easily within the capabilities of most riparian homeowners, provided the correct herbicide is chosen and label directions are followed. The application of herbicides to aquatic weeds in large areas or for submersed weed control is more expensive, complicated and often requires specialized equipment to obtain the most cost-effective control. Selectivity results from a combination of factors, including herbicide choice, time of year and nontarget desirable species in the proposed treatment area. The size or area of the treatment site also affects the concentration-exposure time requirements for herbicides. In addition to label requirements, all these factors that affect submersed weed control clearly indicate that experienced state agencies responsible for permitting and managing aquatic resources be contacted prior to undertaking weed control projects.

The discussion in this Section is directed towards riparian homeowner associations and others conducting similar large-scale weed control programs in pubic waters; however, the principles, rules and regulations also apply to the thousands of private pond owners in the US. Aquatic weed control in small ponds is not as complicated as large public operations, but there are some factors to be considered. These include: What is the primary use of the water? Is it used for irrigation? Does water flow from the pond? Are there irrigation or potable water uses downstream? Despite being “private”, some states require permits be obtained to use herbicides in these ponds and may have additional regulations if there is water flow out of the ponds. Aquatic herbicides are usually available in the marketplace in smaller containers or as diluted products for the do-it-yourself pond owner. Also, every state has commercial companies that offer pond management services such as fish stocking, water quality monitoring, aeration, mechanical, chemical and other related services. The Cooperative Extension Service in your county, as well as your environmental state agency, can usually help with plant identification, pond management questions and are likely aware of commercial companies serving your area.

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Page 194 upper: Submersed herbicide application with trailing hoses; Thomas McNabb, Clean Lakes Inc.
Page 194 lower: Thermocline; Joshua Huey, University of Florida
Page 195: Herbicide application; William Haller, University of Florida