Nova Scotia
Aquatic Vegetation
Supplement

NOVA SCOTIA
Environment and Labour

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Section 1 - the Nature of Aquatic Plants

An aquatic plant can be simply defined on the basis of where it occurs. Its entire life cycle, from seed to flower, can be spent at least partially submerged in water. Terrestrial plants, on the other hand, would be hard pressed to survive any substantial length of time under water.

Like terrestrial vegetation, aquatic plants germinate from seed or spores, undergo a growth phase, produce seeds or spores and then die back as winter approaches. A few aquatic plants may be annuals living for one season and reproducing from seed. However, most are perennials living indefinitely and reproducing by rhizomes (underground stems), tubers,or winter buds, as well as by seed.

Beneficial Role

Aquatic plants play an important role in a lake, pond, or river environment. Rooted forms of aquatic vegetation help stabilize soil, thus preventing erosion of shoreline areas and reducing disturbance of bottom mud (also called hydrosoil). Erosion of shoreline soil increases turbidity and adds nutrients to the water creating undesirable water quality for fish production. During heavy winds, un-stabilized lake hydrosoil may become stirred up creating turbid conditions. Suspension of rich organic soils in the water may lead to dissolved oxygen depletion which is hazardous to fish populations.

Aquatic plants add oxygen to the water during the process of photosynthesis. Oxygen in the water is essential to the survival of fish and other aquatic organisms and aids in the breakdown of organic pollutants through chemical and biological means.

Aquatic vegetation provides an important basic food source for theexistence of aquatic animal life. Plant matter is fed upon by zooplankton and aquatic insects which are in turn fed upon by fish. Many birds and mammals also depend upon aquatic plants as a food source. Aquatic vegetation also provides nesting sites, breeding areas, and shelter against predation and adverse climatic conditions.

Detrimental Role

Certain species of aquatic vegetation may be induced to undergo such rapid and prolific growth that their beneficial nature can be lost. This takes place if environmental conditions are favourable,such as an excess of nutrients or a lack of natural controls (predators, parasites, or competing species). Prolific growth of aquatic vegetation becomes detrimental when it interferes with human's use of a water body or it threatens the existence of animals or plants which cohabit the aquatic environment.

Some of the problems associated with the overabundant growth of aquatic weeds are:

In Lakes and Ponds:

- interfere with or effectively prevent recreational activities such as fishing, boating, swimming, or water skiing alter feeding activity of game fish by sheltering food organisms
- cause winter-kill of fish by depleting oxygen levels through decay processes under ice cover
- plug water intakes
- reduce shoreline property values
- provide breeding sites for certain insect pests
- impart bad taste and odour to water; deplete oxygen following mass die off by blooms during summer, or release toxic substances into the water.

Irrigation and Drainage channels:

- reduce carrying capacities resulting in water shortages downstream and overflowing of banks
- reduce flow rates resulting in increased siltation and increased water losses due to evaporation and seepage plug intake screens and sprinkler heads

Environmental Factors Influencing The Growth Of Aquatic Plants

Under ideal circumstances (which seldom occur in nature) an aquatic environment exists in a state of slowly changing balance. Over time, a lake or pond will age, through erosion-and consequent shallowing, until it eventually fills in and becomes dry land. This process takes hundreds to thousands of year:.

A system of balances exists among plant, animal, and microbial populations in the aquatic environment. This system works to correct any tendency for one population to flourish at the expense of others. It also ensures that the aging process remains gradual.

If the balance is tipped through some change in the aquatic environment, the survival of a certain species may be favoured over another. The favoured population may thrive causing others to decrease or disappear entirely. For example, if factor necessary for the survival of a plant eating fish were removed from a system, two major effects could be seen due to the resulting imbalance. The fish would disappear and the plants on which it fed would flourish because a major control on their survival is no longer present. This uncontrolled plant growth would have undesirable consequences for other members of the aquatic community.

If a foreign organism is introduced to a system, it could cause problems because controls on its growth, which are present in its previous home, are absent in the new one. Similarly, in newly constructed canals or reservoirs, natural checks and balances do not initially exist; therefore, pioneering organisms (often weeds)gain a strong foothold.

The growth of aquatic vegetation is negatively and positively influenced by a number of environmental conditions. In a balanced system, these conditions act to keep aquatic plant growth at desirable levels. If one or more of these conditions change so as to favour growth, and if natural inhibitions do not compensate., the result will be an overabundance of aquatic plants. Overabundant aquatic plant growth results in problems for humans and nature, and accelerates the aging process of water bodies.

Included among the environmental factors that influence aquatic plant growth are:

- **Sunlight** - Sunlight is required as an energy source for photosynthesis, hence it effects food production and plant growth. Water depth and clarity influence the amount of sunlight reaching submersed species and therefore, will limit the depth at which they will grow. The amount of sunlight required to sustain life varies among species so that each species will have a maximum depth that it can inhabit.

- **Nutrients** - Nutrients including nitrogen and phosphorous are necessary for the growth and development of aquatic plants. Rooted aquatic plants absorb nutrients from the hydrosoil. Submersed, free floating plants and algae are able to remove nutrients from the water column. Nutrient sources include decaying organic matter in the hydrosoil and water. Effluent from sewage plants or industrial areas also contribute nutrients to a water body. Runoff from agricultural land containing artificial fertilizers or animal manure can significantly increase nitrogen and phosphorus levels in watercourses. Specific recommendations on proper manure management can be found in the provincial government's guidelines for the management and use of animal manure in Nova Scotia.

- **Dissolved Gases** - Aquatic plants use carbon dioxide and oxygen for food production and metabolism. The presence of these gases in water is of particular importance for plants that grow entirely beneath the water surface.

Section 2 - Aquatic Plant Identification

- **Water Temperature** - Water temperature influences the rate of photosynthesis and metabolism, thereby effecting growth and development.

- **Bottom Type** - The texture and composition of the hydrosoil are important in determining the successful establishment of rooted aquatic plants. Sand, clay, or gravel are generally low in nutrient composition and are therefore not conducive to plant development. Medium textured soils with high nutrient content are good for plant establishment and growth.

- **Parasites, Competitors, Predators, and Pathogens** - These components of the aquatic environment act as natural controlagents on the growth and development of aquatic plants. Plants introduced from foreign areas often become Weeds because these controls are not present in the new environment.

Identification of aquatic plants is based on the shape and structure of leaf, flower and stem, as well as notation of growth, habit, and location within the aquatic system. Often, identification of the species level requires the use of a microscope or at least a magnifying glass and an identification textbook% Identification can be made easier, if one is aware of the general category to which a particular aquatic plant belongs.

Common aquatic plants can be divided into two main groups: the algae and the aquatic macrophytes. These two groups can be further divided into categories based on growth habit and general structure.

Algae

Algae are single cells or aggregates of cells which do not possess true leaves, stems, roots or flowers. They are considered plants because they carry on photosynthesis. Individual algae can vary in size, some being microscopic while others are easily visible to the naked eye. There are three basic categories of algae.

- **Planktonic Algae** - These exist freely in the water column as single cells or clumps of cells. They appear as tiny specks or small grass clippings and are green, blue green or brown. Under a "bloom" situation, some species impart a pea soup character to the water. Certain species are responsible for imparting bad taste and odour to water as they die off, while others may produce toxins, rendering the water poisonous. Rapid decay of dying algae blooms may deplete the water of enough oxygen to cause summer kill of fish. Examples: *Aphanizomenon, Anabaena*

- **Filamentous Algae** - These algae are long, stringy, and hairlike, and are often attached to rocks, larger aquatic plants or other surfaces under water. Stringy masses of filamentous algae may inhabit the bottom during cooler weather and rise to the surface as a bubble-filled scum during warm sunny weather. Examples: *Cladophora,, Spirogyra*

- **Macrophytic or Branching Algae -** These are larger forms of algae, that at first glance, resemble certain species of aquatic macrophytes. They are branched, coarse in texture dueto a crusty coating of mineral deposits, and have whorled leaf-like structures. Macrophytic algae can form thick beds on the bottom and when brought into the air they give off a fishy or skunk-like odour. Examples: *Chara, Nitella*

Aquatic Macrophytes

These are aquatic plants, other than algae, that are large enoughto be seen with the naked eye. The vast majority of aquatic macrophytes possess true leaves, stems, roots, and flowers. There are four general categories of aquatic macrophytes:

- **Free Floating** - These plants exist at or near the water surface and are not attached to the bottom or any submerged object. They are freely moved about by wind and wave action. Examples: duckweed, bladderwort, liverwort

- **Submersed** - These are rooted or attached plants which are completely submerged, except for the flowering structures insome species. Many spread by rhizomes (underground stems) and produce tubers or buds which enables survival under adverse conditions, such as desiccation, or ice cover. Submersed plants are most abundantat depths of 0.2 to 4 metres.
  Examples: pondweeds, water milfoils, coontail, Canada waterweed

- **Floating Leaved** - These plants are rooted in the hydrosoil, have large, broad floating leaves on long leaf stalks, and flowers extending above the surface. They are perennials with stout rhizomes (underground stems) or creeping root stalks. Examples: water lily, water smartweed

- **Emergent** - These are rooted in the hydrosoil or on exposed soil where the water table is within 0.5 metres of the soil surface. Leaves and flowers extend above the water surface on rigid stems. Examples: cattail, bulrushes

These categories for aquatic plants can be used as an initial stepto identification. The distinctions between each category are broad and some species can be placed in more than one category as they may have a different structure under a different environmentalcondition. For example, water smartweed may also be seen in an emergent form on shoreline areas. These categories are useful, however, as a starting point to identification.

References that are useful for aquatic plant identification:

Prescott, G. W. 1972. How to Know the Freshwater Algae. Wm. C. Brown Co. Publishers. Dubuque, Iowa.

Roland, A.E. and Smith E.C. 1998. The Flora of Nova Scotia. The Nova Scotia Museum, Halifax, Nova Scotia.

Section 3 - the Management of Aquatic Plants

When aquatic plant growth causes problems, there are management or control measures that can be employed. The short term goal of aquatic plant management is to simply reduce or eliminate the existing stand. In the long term, however, the objective of aquatic plant management is to maintain the growth of aquatic plants at an acceptable level - one that is environmentally sound and aesthetically pleasing, and permits efficient use of water.

Overabundant aquatic plant growth is a symptom of a disorder or imbalance in the aquatic environment. This imbalance may be an excess of nutrients as is often the case, or a lack of competing species and predators. Aquatic plant problems cannot be solved bya single, treatment of existing plants. Aquatic plant management is a long term task that requires treatment of symptoms (plant growth) as well as causes. A cure is attained when ecological balance is restored and maintained.

When planning for aquatic plant control, the prime consideration is water use. A control method that may be appropriate in a lake used for recreation may not be appropriate for an irrigation reservoir or canal. What may be suitable in a cooling pond may not be suitable in a farm pond. A drainage ditch may require near total removal of vegetation, whereas, in a lake used for fishing, a certain amount of vegetation is required for fish habitat.

One must be aware of secondary consequences that could occur following implementation of a control measure. Occasionally, removal of one type of vegetation favours the growth of another. Algae blooms could occur due to release of nutrients when submersed macrophytes are killed. Growth of submersed macrophytes may be stimulated by increased light levels when surface covering plants or planktonic algae are removed. Erosion of shoreline soils is a problem when all vegetation is removed. Fish mortality could occur due to suffocation as decaying plants use up dissolved oxygen in the water.

An ideal aquatic plant management program would provic long term solutions and avoid undesirable side effects resulting from control measures.

Aquatic pant management techniques involve a number of different principles each showing a particular advantage to a particular set of circumstances. No single technique is a total remedy in itself. The aquatic plant manager must choose techniques or combinations of techniques that would be most appropriate to each aquatic weed problem. This combination of control techniques is an example of integrated pest management (IPM). Chemical control should be used only when other techniques are ineffective.

Aquatic plant management techniques can be grouped into five categories:

- prevention
- habitat manipulation
- mechanical
- biological
- chemical

Prevention

As aquatic weed growth gets more and more severe, the cost of control becomes greater in proportion. It also becomes increasingly difficult to restore the affected water body to a useful state. Prevention of aquatic weed problems is desirable from an economic, operational, and environmental standpoint.

Before an aquatic weed problem occurs, preventative measures shouldbe implemented by incorporating them into design, construction, and/or maintenance. Preventative measures can also be used after an aquatic plant control program is undertaken.

Some preventative approaches to aquatic plant management:

Channel Design and Construction

- Use artificial channel linings when feasible, to provide a physical barrier to rooting and growth.
- Construct channels deep and narrow with steep banks to limit light and suppress growth of rooted species.
- Use as steep a grade as possible to allow swift flow rates and prevent deposition of silt, seeds, and fragments.
- Avoid having pockets of standing water when channels are drained. Standing water left over winter will allow overwintering plant structures to survive to grow next spring.
- Seed ditch banks to suitable low growing grasses to prevent soil erosion and silt deposition downstream. Design channels for carrying capacities greater than maximum projected flows. This will prevent bank overflow due to aquatic plant growth. It is important to remember, however, that slow currents and shallow water are favourable to aquatic plant growth and should be avoided.

Pond Design and Construction

- Construct steeply sloping banks that are seeded, gravelled, or otherwise protected from soil erosion.
- Clear the basin of topsoil and organic debris before filling
- Prevent silt laden and nutrient rich run-off from directly entering ponds
- Allow for control structures which allow you to raise and lower the water level. Water level fluctuation can be effective against some aquatic plant species.

Maintenance

Conduct surveillance to detect aquatic plant infestationsin their early stages so that control measures can be implemented at a minimal cost.
Remove trash, weed fragments, and other debris from the water.
Prevent deposition of aquatic weed fragments carried from other areas on boating equipment.
Fluctuate water levels periodically to desiccate submersed species and drown shoreline weeds.

Habitat Manipulation

Habitat manipulation is a management technique aimed at altering one or more environmental conditions to make conditions unfavourable for plant growth. Future growth is minimized as longas the altered state is maintained.

Environmental conditions that are optimal for one species of aquatic plant may not be optimal for another. Thereby, use of a single technique may work for one species or group of species but may not work for a different species. It may be necessary to varyor combine techniques in order to improve overall effectiveness.

Some habitat manipulation techniques that have been used for aquatic plant management are:

1. Light Limitation

Water Soluble Dyes

- absorb- light, reducing penetration through the water column, thereby suppressing plant growth limits to confined water bodies with little or no input of fresh water
- not effective in water less than 1 metre deep

Dredging

- deepens water body beyond point at which sufficient light reaches the bottom
- limited to small areas due to expense and spoils disposal
- dredging depth depends on water colour and clarity. Note that dredging too shallow has no effect and dredging too deep, though effective, is unnecessarily costly.

Floating Shades (black polyethylene sheets)

- blocks out light at the surface
- effective and can be removed after plants have died
- limited to small areas, prevents use of water surface while installed and must be anchored well

Bottom Barriers

- sheets of polyethylene, fibreglass or fabric laid over the bottom
- limits light and also provide a physical barrier togrowth
- use restricted to small areas
- duration of control depends on duration of installation and siltation rates

Shading Vegetation on Banks

- reduces weed growth near shorelines

2. Water Temperature Reduction

Replacing Warm Water With Cold Water

- practical only in small water bodies

Shading

- planting shading vegetation on banks reduces daytime water heating and also limits light

3. Nutrient Limitation (Aluminum, Iron, Calcium Compounds)

- precipitate phosphorous from the water column
- success has been reported when aluminum and calcium are used in combination with aeration
- nutrient inputs must be controlled, however, nutrients in hydrosoil are still available for uptake by rooted plants
- most effective on planktonic (suspended) algae
- limited to small water bodies

4. Water Level Fluctuation

- lowering of water levels over winter exposes submersed aquatic plants to desiccation and freezing
- raising water levels may drown some emergent species
- limited to water bodies with control structures
- temporary draw down does not control all species

5. Bottom Substrate Alteration

Dredging

- removes nutrient rich sediments
- limited to small areas
- drastically changes aquatic environment

Addition of Clean Sand or Gravel

- a poor rooting medium lacking nutrients for growth
- limited to small areas
- control may be temporary and procedure cannot be repeated indefinitely

It is important to remember that any habitat alteration along or in public waters requires approval from the appropriate government agency.

Mechanical Control

The objective of mechanical control is to remove vegetation from its habitat by manual or mechanical methods.

Unless root systems are removed, mechanical control methods are short term in effect. Consequently, more than one treatment is required per season. All mechanical methods exhibit one significant advantage - results are promptly apparent. The water body can be used immediately after treatment. To their disadvantage, mechanical control methods are often labour intensive, slow, and some machines may be costly to purchase, operate, and maintain.

Following mechanical control operations, aquatic plant debris must be removed from the water. This is to prevent regrowth from fragments, to avoid reintroduction of nutrients from plant pieces as they decay, and to prevent clogging of downstream structures and intakes.

Mechanical control techniques include

Hand Pulling or Cutting

- practical for light infestations of submersed aquatic plants in shallow waters, such as around boat docks or small swimming areas
- plants may be pulled by hand, rake or hook, or may be cut-off by sweeping a thin fibreglass or metal rod along the bottom
- severed or pulled plant pieces will float to the surface where they should be removed and disposed of on shore
- these procedures may have to be repeated during the season unless roots are removed as well

Dragging

- could include towing a gang of hooks behind a boat or dragging a heavy chain down a ditch between two tractors

Cutting

- aquatic plant cutters for submersed weeds are available commercially or can be constructed from plans. They consist of a cutting bar mounted on a floating self-propelled platform
- depth of cutting depends on the reach of the cutting bar
- emergent plants should be cut below water level for longer lasting control
- time of cutting of perennials should correspond to when food reserves in root systems are low (during early stages of flowering)
- emergent plants ie. cattails can be eventually controlled by 2-3 cuttings per season

Harvesting

- aquatic plant harvesters utilize a cutting system coupled with a mechanism to remove fragments from the water

Rotovating

- involves tilling the hydrosoil to dislodge aquatic plants which float to the surface where they can be removed (rotovating the hydrosoil following draw-down exposes roots and rhizomes to freezing and desiccation)

Suction

- operates on the principle of a large vacuum cleaner
- aquatic plants and sediment are sucked up from the bottom

Biological Control

Biological control of aquatic plants involves the introduction of native or foreign predators, disease organisms or parasites to the aquatic system. Examples include grass carp (weed eating fish), midge larvae, weevils or snails. When a foreign organism is introduced to any ecosystem there is a chance that the organism could develop into a more serious pest than the original. This is a particular danger in aquatic systems because water bodies are often not completely closed off from each other.

The use of biological agents for aquatic weed control should not be undertaken without first consulting with provincial authorities. One must be able to predict what will happen to the foreign organism once it is introduced to the system. More research is required into biological control before this can happen. For these reasons biological control of aquatic vegetation is not yet a technique that can be put into general use.

Section 3 - Herbicide Use for Aquatic Plant Control

Fisheries Protection

Aquatic herbicides with the exception of copper and acrolein are not directly toxic to fish at normal use rates. Fish can be affected however by secondary occurrences due to aquatic weed control activities.

Two things happen when aquatic plants are killed. First, because photosynthetic processes cease, an important source of oxygen to the water no longer exists. Second, the dead plants quickly begin to decay, using up what oxygen is present in the water. The result is fish mortality due to suffocation, if the quantity of decaying vegetation is large enough.

Another effect results from the removal of fish habitat. Fish use aquatic vegetation directly for cover and indirectly for food and reproduction. They cannot survive without aquatic plants.

Here are some measures that can be taken to avoid adversely affecting fish populations while undertaking aquatic weed control.

- Begin applications at shoreline and work outwards to avoid trapping fish in shallow water.
- Treat large areas in strips; do 1/2 of the total area at one time, the remainder 2-3 weeks later.
- Do not apply more than the recommended rate of application. Apply evenly over the area to be treated to avoid pockets of high concentration.
- Identify important fish spawning or habitat areas and avoid treating these.
- Treat early in the season before weeds become dense. This will lessen oxygen problems.
- If oxygen depletion cannot be avoided, aerate the water immediately following application and for about one week.
- When fish are of concern in a farm pond, be very careful when using copper compounds. Copper compounds are toxic to fish particularly in soft water.

Provincial Requirements,

The application of any pest control product directly into a watercourse requires a permit from the Nova Scotia Department of Environment. There are no exemptions to this permit requirement. A provincial applicators licence (Class 4) may also be required. The application form for an aquatic pest control project is in the appendix. Aquatic herbicides affect plants in different ways. Table 1 indicates the mode of action for various types of herbicides.

TABLE 1: AQUATIC HERBICIDES - MODE OF ACTION

HERBICIDE	MODE OF ACTION
COPPER	• absorbed well by algae, • poorly by foliage of other plants • translocated throughout the • plant; affects enzyme systems
DIURON	• absorbed well by roots, poorly by foliage; • translocated upwards through system; • acts as an inhibitor of photosynthesis
DIQUAT	• rapidly absorbed by plant tissues; • contact herbicide and is not translocated; • kills top growth only (seasonal control)
SIMAZINE	• absorbed well by roots; poorly by foliage; • translocated upwards, accumulates on leaves and growing points; • acts as an inhibitor of photosynthesis
WATER SOLUABLE DYE	• inhibits photosynthesis by blocking light
2,4-D	• absorbed by roots and foliage • translocated throughout the plant accumulating at growing points; • causes abnormal growth response

Application Equipment and Techniques

Treatment of water bodies such as lakes or ponds requires the use of a boat or other floating craft. Craft can be fitted with conventional or homemade application pumps, tanks, booms, hoses, etc. provided that the weight of this equipment (wet or dry) plus operators does not exceed the craft's capacity. A distribution boom fitted with trailing weighted hoses at the nozzle points can be used for injecting liquid sprays beneath the water surface. Replace hoses with nozzles for surface application.

Two large drums mounted on their sides with a weighted hose trailing from the drum opening, 'serve to deliver liquids beneath the water surface by gravity. Filler spouts must be attached and a device for measuring fluid levels in the drums is needed. Make practice runs, using water, to determine how quickly the tanks will empty (output) at expected speeds of application.

Smaller areas can be treated by injecting a regulated flow of herbicide solution through a hose into the slipstream of an outboard motor. Alternatively, a boat bailer can be mounted on the cavitation plate of an outboard with a hose running into the spray tank. The chemical is drawn out by suction into the prop wash. With both these methods, the action of the outboard helps to disperse the chemical through the water.

A word of caution about the use of outboard motors for chemical application. Some herbicides - notably diquat - are completely inactivated when they come into contact with soil. Use of outboards in shallow water will stir up the bottom causing the hydrosoil to become suspended in water. The suspended sediment will render the chemical ineffective. Treat shallow areas from shore or from a rowboat using a spray gun or backpack sprayer forsurface application. NEVER stir up the bottom when applying diquat, diuron, simazine, or copper solutions to water.

Granular formulations can be applied with rotary seeders to provide even distribution. Rotary seeders can be power or hand driven. Hand driven seeders are appropriate for small areas.

Correct distribution of herbicide over the treatment area is imperative. Know how much chemical is being delivered by your equipment, keep your speed constant, shut off delivery when turning and know how wide a swath the chemical makes in one pass. Use reference points such as buoys or markers on shore so that you know what areas have been covered. Mark, with buoys, deeper areas that may require more chemical.

Emergent aquatic plants can be treated by using a power spray gun or backpack sprayer. Plant foliage must be thoroughly wetted with the prescribed spray solution. The effectiveness of some products may be improved if a wetting agent (spreader-sticker) is added to the spray solution. Wetting agents are available commercially. Be sure to refer to the label of the product to ensure compatibility with wetting agents. When spraying emergent plants, try to keep sprays on the foliage. Avoid hitting the water.

When using wettable powder formulations it is necessary that the spray solution be kept agitated so that screens, hoses, and fittings do not get clogged. Check periodically to make sure sprayer components are operating efficiently.

Timing the Application of Aquatic Herbicides

The timing of a herbicide application is critical to the success of any weed control operation (Table 2). Timing will vary with the herbicide used and the type of plant being treated. With the exception of soil active residual herbicides, all treatments should be made before seeds are formed.

TABLE 2: TIMING OF HERBICIDE APPLICATION

HERBICIDE	TARGET VEGETATION	TIMING OF APPLICATION
COPPER	• planktonic algae • filamentous algae • chara	• when algae growth first becomes visible and water temperature is above 15C • bright sunny days
ACROLEIN	• weeds and algae	• early in season when plants are actively growing but before growth becomes dense
DIQUAT	• submersed aquatic plants	• when plants are actively growing but before growth becomes dense • when water temperatures reach 18C or above • at dawn, dusk or on an overcast day
DIURON	• weeds and grasses in irrigation and drainage ditches • submersed aquatic plants and algae in ponds	• preferably fall, after ditches are drawn down but before ground is frozen • early in season when plants are actively growing but before growth becomes dense
SIMAZINE	• submersed aquatic plants • non-filamentous algae • non flowing water treatment • rooted aquatic plants (submersed and emergent) • draw down treatment	• early in season when plants are actively growing but before growth becomes dense • in the fall before soil is frozen or as early in the spring as conditions permit
WATER SOLUABLE DYE	• inhibits photosynthesis by blocking light	• early in the season before algae and weed growth develops
2,4-D	• submersed aquatic plants	• early in season when plants are actively growing but before growth becomes dense

Parts per Million

Parts per million (ppm) is simply a convenient way to express the concentration of one substance in another when that one substance is in very small quantity compared to the other. One ppm is equal to one part of a substance in one million of the same parts of another substance. A part is either the weight or volume of the substance.

Add 1 kg of salt to 1,000,000 L of water. Instead of saying the concentration of salt in water is 1 kg per 1,000,000 kg (Note: 1,000,000 L of water weights 1,000,000 kg - it is necessary to use identical units in ppm calculations) we use the more convenient term and say the concentration of salt is 1 ppm.

With herbicides, ppm refers to the concentration of active ingredient in the substance to which the herbicide is applied or added. The substance could be water, soil or plant matter. This term is used in chemical analysis, in technical journals, in some government publications, and on a few herbicide labels.

Section 5 - Calculations for Herbicide Application

When using herbicides in water, it is of the utmost importance to calculate rates of application correctly. An error can be expensive, disastrous to non-target organisms in the water and tothe applicator himself. Adverse effects can occur long distances from the application area, cause contamination of drinking water, or decrease the general water quality with tastes and colours. As a result, a claim for damages may be filed against the applicator. It pays to understand rate calculations.

In order to calculate the amount of chemical to be used, it is necessary to measure the water area and average depth.

If the pond or lake is square or rectangular with relatively straight sides, take several measurements to determine average length and average width. Make certain to measure the longest and shortest distances in determining these averages. Then multiply the average length by the average width measurement to get the surface area in square metres. For example, a pond with an average length of 200 metres and an average width of 45 metres has 9,000 square metres.

If the pond is circular, take several measurements of the diameter, then determine the average of these measurements. Divide the average diameter by two to get the length of the radius, then use the formula area = 3.1416 x radius squared to determine the surface area in square metres. Some chemical applications are made on the basis of surface hectares. Since one hectare contains 10,000 square metres divide 10,000 into the number of square metres to obtain surface hectares.

To find average depth, take depth measurements at various points along the length and width of the pond. Include measurements from the deepest and shallowest areas. When determining average depth, use a maximum of 3 metres because practically all aquatic vegetation lives in water less than 3 metres depth. To calculate cubic metres in the pond, multiply surface hectares by average depth. Many aquatic herbicide labels provide tables showing application rates based on the number of kilograms of commercial product per hectare. The amount of chemical to apply can be read directly from these tables.

Exercises

1. How many L of product would one need in order to treat a 2 ha reservoir? The rate of application stated on the label is 6 L in 100 L of water per surface ha.

2. A rectangular pond measures 100 m long by 70 m wide. The average depth is 4 in. How much product would be needed to treat the entire pond at a rate of application of 5 kg per ha-m?

3. A circular pond has a diameter of 10 in. The average depth is 150 cm. How much product is needed to treat the entire pond at a rate of application of 20 g per 1000 m^3?

4. A ditch measuring 1000 m long by 2 m wide is completely covered with cattail. It will take 2000 L of spray solution to completely soak the vegetation. At a mixture ratio of 2 kg of product per 100 L of water, how much product is needed to treat the cattails?

5. A travelling speed of 10 km per hour is used by a sprayer treating a ditch bank. The width being sprayed is 2 in. The length of ditch bank to be treated is 3 km, while the width of ditch bank is 2 in. At a rate of application of 20 L product in 100 L of water per hectare, what would the output (in L/min) of the sprayer be adjusted to so that the entire ditch bank is treated in one pass?

6. A rectangular patch of cattail measures 20 m wide by 50 m long. Walking at a speed of 1 km per hour an applicator can cover a width of 5 m with a spray gun and be able to soak all of the vegetation. The prescribed spray solution contains 3 kg of product per 100 L of water. With a sprayer output of 10 L per minute, how much product is needed to treat the entire patch of cattails?

7. A boat bailer delivers 10 L of a chemical solution per minute over an effective swath width of 3 m. In order to treat a 4 ha lake at a rate of 10 L of product in 100 L of water, a total of 400 L of spray solution is required. The spray tank mounted in the boat will hold only 100 L of solution; therefore, only 1/4 of the lake area can be treated per tank load. How fast would one drive the boat in order to treat that one quarter of the lake area?

Solutions

1. Q = R x A
   $= \frac{6L \times 2ha}{ha}$
   = 12 L

2. Determine area A = L x W
   = 100mx70m
   = 7000 m^2

   Determine water volume in ha-m

   V = A x D(avg) = 7000 m^2
   = 28000 m^3

   10,000 m^3 = 1 ha-m
   28,000 m^3 = 2.8 ha-m

   Determine quantity of product to apply

   Q = R x V
   $= \frac{5\ kg}{ha\text{-}m} \times 0.28\ ha\text{-}m$
   =14 kg

3. Determine area

   A = r^2 x 3.14
   = 5^2x 3.14
   = 78.5 m^2

   Determine water volume in m^3

   V = A x D (avg)
   = 78.5 m^2x 1.5 m
   = 117.75 m^3

Determine quantity of product to apply

$$\begin{aligned} Q &= R \times V \\ &= \frac{20\text{ g}_s}{1000\text{ lt}^s} \times 117.75\text{ m}^3 \\ &= 2.35\text{ g} \end{aligned}$$

4.

$$\frac{2\text{ kg}}{100\text{ L}} = \frac{x\text{ kg}}{2000\text{ L}}$$

$$x = 40\text{ kg}$$

5. Determine area to be treated (in hectares)

$$\begin{aligned} A &= L \times W \\ &= 3000\text{ m} \times 2\text{ m} \\ &= 6000\text{ m}^2 \end{aligned}$$

$$\begin{aligned} 10{,}000\text{ m}^2 &= 1\text{ ha} \\ 6{,}000\text{ m}^2 &= 0.6\text{ ha} \end{aligned}$$

Determine quantity of spray solution

$$\begin{aligned} Qs &= R_w \times A \\ &= \frac{100}{\text{ha}} \times 0.6\text{ ha} \\ &= 60\text{ L} \end{aligned}$$

Determine sprayer output

$$\begin{aligned} O &= \frac{S \times W \times Os}{A \times 600} \\ &= \frac{10\text{ km/hr} \times 2\text{ m} \times 60\text{ L}}{0.6\text{ ha} \times 600} \\ &= 3.3\text{ L/min} \end{aligned}$$

6. Determine area to be treated (in hectares)

$$\begin{aligned} A &= L \times W \\ &= 20\text{ m} \times 50\text{ m} \\ &= 1000\text{ m}^2 \end{aligned}$$

$10{,}000\ m^2 = 1\ ha$
$1{,}000\ m^2 = 0.1\ ha$

Determine quantity of spray solution required

$$Q = \frac{O \times A \times 600}{W \times S}$$

$$= \frac{10 L/min \times 0.1\ ha \times 600}{5m \times 1\ km/hr}$$

$$= 120\ L$$

Determine quantity of product required

$$\frac{3\ kg}{100\ L} = \frac{x\ kg}{120\ L}$$

$$x = 3.6\ kg$$

7.

$$S = \frac{O \times A \times 600}{W \times Q}$$

$$= \frac{10\ L/min \times 1ha \times 600}{3\ m \times 100\ L}$$

$$= 20\ km/hr$$