Review of Aquatic Weed Control Methods in New Zealand

William P. Chisholm[1]

[1] C/- Aquatic Weed Control Ltd, PO Box 11-014, Dunedin, New Zealand.

Summary: Aquatic weed control techniques used for managing New Zealand's waterways are discussed, along with their strengths, weaknesses and costs. Most non-chemical methods have been of limited value in controlling or eradicating aquatic weeds. Even with aquatic herbicides, it is difficult to effectively control submerged species, due to inadequate plant exposure and uptake. A new technique for applying the aquatic herbicide diquat for controlling submerged aquatics has been developed in New Zealand. There is scope for significant expansion of using the diquat/gel- Hydrogel® technique to control aquatic weeds, and protect waterways.

Keywords: Aquatic weeds, *Lagarosiphon major, Ceratophyllum demersum,* Diquat, Hydrogel.

INTRODUCTION

A number of exotic aquatic weed species have colonized New Zealand's waterways, assisted mainly by human activities (Johnstone 1986).

Despite this, many of New Zealand's waterways remain uninfected by aquatic weeds, and there have been considerable efforts to keep them weed-free. Over the past 45 years many techniques have been tried for aquatic weed eradication, or to manage their adverse effects on aesthetic, recreational and economic values of waterways.

The objectives of this paper are to review how aquatic weeds have been managed in New Zealand and to discuss the potential of a relatively new technique for applying aquatic herbicides in a gel form for aquatic weed control.

REVIEW OF AQUATIC WEED MANAGEMENT METHODS

An extensive literature review on aquatic macrophyte management was carried out. Information was also gathered from aquatic weed control contractors and field managers, information on up-to-date costing and logistics issues.

Some information on aquatic weed control methods is available in the published literature. However, a considerable amount of information remains unpublished and scattered throughout various management files, planning documents and reports.

The following is a summary of methods used in New Zealand. All costs are in NZ dollars.

Hand Weeding. This is useful for controlling small, localised aquatic weed infestations, where plants are sporadic and patches do not exceed 1 m^2. Hand weeding is labour intensive and costly, which can often exceed $10,000 per hectare. Once colonisation of a waterway has significantly advanced, hand-weeding ceases to be a viable option, and its effectiveness in removing extensive weed infestations is minimal.

Mechanical digger Mechanical diggers have most value in artificial canals and areas that are shallow and close enough to lake shorelines to allow access for a digger. Costs can vary, depending on the width of canals and extent of weed infestation. Wells & Clayton (2005) mention "$2500 per hectare", although this varies depending on the type of machinery used.

Disadvantages of this method include removal of large amounts of benthic fauna and fish, particularly eels, and causing high turbidity and sometimes anoxia. In addition, machines widen and deepen drains, which may encourage weed growth. They may also spread weeds from one waterway to another (Wells & Clayton 2005).

Rototiller Rototilling of the bottom sediments has been used to uproot Lagarosiphon in water depths of between 1.5 and 4 metres (Clayton *et al* 2000, Wells & Clayton 2005). The depth of sediment penetration affects the results. Deep rototilling (to ca. 3–5 cm sediment depth) of the lakebed sediment is more costly ($5000 per hectare) than shallow rototilling ($1000 – 2000 per hectare), but provides a greater duration of control (1-2 years vs. 6 months). Rocks, or other lakebed obstacles can prevent the effective use of a rototiller.

Regrowth of aquatic weeds from disturbed lakebeds can be widespread. Rototilling acts somewhat like a plough, creating a more suitable habitat for rooted aquatic weeds to grow. In managing Lagarosiphon, Clayton *et al.* (2000) concluded that rototilling was too costly and ineffective compared to other control methods.

Mechanical Weed Cutter These can target a specified area and cut to a nominated depth. This can also have the benefit of removing nutrients from the waterway. Weed cutting and disposal is priced at $2,000–4,000 per hectare, although costs can vary considerably, depending on the density of aquatic weeds and the distance to a disposal site. A disadvantage is the quick re-growth to nuisance levels, because cutting stimulates the plant to re-grow. Cutting may have to be repeated two or three times in a growing season. A further disadvantage is the potential spread of aquatic weeds, even when fragments are collected and bagged, as some viable plant fragments inevitably escape.

Suction dredging Suction dredging, using a venturi suction pump, uproots the aquatic weeds and discharges them into a collection bag. This can give effective control for up to three years in Lagarosiphon beds. However, re-establishment can be as short as two months for hornwort (Clayton *et al* 2000), and the method does not easily achieve eradication. It also cannot be easily used in hard-bottomed or rocky substrates. Clayton *et al* (2000) describe costs of using this method in the Rotorua lakes at $15-20,000 per hectare.

Nutrient Control Reduction of nutrients entering a water body can be achieved by catchment-wide nutrient management (e.g. de-stocking), riparian buffering, inflow diversion and by nutrient removal, such as flocculation. Flocculation materials such as Phoslock® are currently being tested for use in the Rotorua Lakes. The costs of Phoslock application is $6,000-10,000 per hectare, depending on the amount of phosphate to be removed and the nature of the lakebed substrate.

Water level drawdown This has been practiced in New Zealand hydro-electric lakes over a number of years (Johnstone 1986), but has relevance only for those lakes with controlled outlets. This method is not always effective in controlling aquatic weeds, as weed re-growth can be rapid when the water level is restored. Other problems are high cost (through lost hydro-generation potential) and adverse environmental effects such as shoreline erosion and slumping.

Shading and substrate lining Dyes, such as aqua shade® and nigrosine, suppress aquatic plant growth by attenuating light, which passes through the water. Their application is largely limited to smaller water bodies.

Various covers including polyethylene, PVC, polypropylene, nylon, synthetic rubber materials and fibreglass screens have also been used. Covers are usually placed on the bottom, as opposed to surface-floating. Costs of shading or substrate modification vary widely from $5000-15,000/ha.

Biological Control Of the biological control agents available, the Grass Carp *Ctynopharyngodon idella* (Valenciennes) is most widely used as an aquatic weed control agent. It feeds on a range of submerged and floating weeds, but prefers soft plant tissues.

Grass Carp are unlikely to breed in New Zealand waterways, and as such, are unlikely to become a pest. However, they do pose problems for native aquatic plant conservation, as they are not selective in the plants that they eat (Clayton & Wells 2005).

In larger lakes and open canals, success has been variable, because of fish losses through escape and predation. Grass Carp cost around $25 per fish. In Lake Hood, it was estimated that approximately 30 fish per hectare were required to provide adequate weed control, which equates to a control cost of $750 per hectare.

Herbicides Use of herbicides is easier and cheaper, when compared to mechanical methods, and many are harmless to aquatic organisms at concentrations required for aquatic weed control. The main disadvantage is that a chemical is in water as residue for a period of time. Therefore, not all herbicides can be used in aquatic environments.

Ideally, an aquatic herbicide should have a high degree of phytotoxicity to kill weeds fast, and should rapidly degrade from water after the action on weeds. Technology should be available for their application in static or flowing water systems. They also require a high environmental safety profile for humans, fish and other aquatic fauna.

The herbicides approved for aquatic use in New Zealand include diquat and endothal. Glyphosate use is limited for controlling some emergent aquatic plants, but may not directly discharged into water.

Diquat dibromide (Reglone® Reward®) has been used for over 40 years in New Zealand, principally in Rotorua lakes for submerged macrophyte control (Clayton 1986). Diquat does little harm to non-nuisance native species, such as charophytes, and native potamogetons, and milfoils recover rapidly after treatment (Wells & Clayton 2005).

Endothal (Aquathol® and Aquathol Super K®) has only recently been registered for use in New Zealand, and significant restrictions remain on its use. Endothal is superior to diquat for controlling *Hydrilla* (Hofstra & Clayton 2001, Hofstra *et al* 2001). Diquat is less effective in turbid waters than endothal (Hoefstra *et al* 2001)

Experience in New Zealand reveals that the mode of delivery of herbicides is very important to the effectiveness of aquatic weed control. Various gel adjuvants have been mixed with diquat, such as alginate gum (Torpedo®, Accugel®), guar gum (Hydrogel®, Aquagel®) and methocel (hydroxypropyl methylcellulose, marketed as Depth Charge®). All are formulated to mix with diquat, and applied at 60 - 80 L ha $^{-1}$. When applied as a steady stream, the mixtures sink and attach onto submerged weeds. Diquat is released into the surrounding water, causing desiccation of the plant tissue.

The most widely used gel adjuvant is Aquagel, marketed as Hydrogel in Australia. Hydrogel is made of guar gum, which is a non-toxic polysaccharide starch. It is more popular in New Zealand than methocel, as it comes in powder form, can be mixed on site, and can be mixed to any desired viscosity. It is also considered superior to alginate gum (marketed in Australia as Accugel®), as it retains a consistent viscosity at any temperature. Hydrogel allows diquat to be accurately and rapidly delivered into water from a knapsack, gun and hose, boat-mounted boom or helicopter-mounted boom. The gel reduces aerial and in-water spray drift to near zero.

Comparative costs Comparative costing of the various aquatic weed control methods used in New Zealand (Table 1) indicates the cost advantage of using a gel formulation.

Table 1. Comparative costing of aquatic weed control techniques in New Zealand.

Method	Approx. Cost/ha ($NZ)
Hand weeding	7,000 - 10,000
Mechanical digger	1,000 - 3,500
Rototiller	2,000 - 5,000
Weed cutter	2,000 - 4,000
Suction dredging	15,000 - 20,000
Nutrient control	6,000 - 10,000
Shading	5,000 - 15,000
Grass Carp	750
Herbicide	1,400

Case study - Moutere Stream, Nelson. Hornwort *(Ceratophyllum demersum)* had been illegally introduced into this stream. This aquatic weed was previously not present in New Zealand's South Island. Attempts were made by the Department of Conservation to eradicate hornwort, using Hydrogel (Rees 2005), with the first treatments applied in March 2002. Hydrogel was applied in strips approximately 600 mm wide, over 775 m of stream; about 195 L of Hydrogel covered 0.68 ha. The cost of this treatment was $4500.

After 12 months, no hornwort could be found in the stream. Two further Hydrogel treatments were carried out over the next 12 months, and no hornwort was found in subsequent surveys, indicating considerable success of the Hydrogel treatments in eradicating hornwort from site.

Monitoring Environmental Impacts of Hydrogel use. In other studies, Wells & Clayton (1996) studied the effects of continued use of diquat on freshwater mussels, but did not find any adverse effects. Research carried out more recently (HortResearch 2001) found zero accumulation of diquat in the sediment at sites that have been regularly treated.

Samples from long-finned eels captured immediately after herbicide treatments in Lake Benmore showed no significant diquat residues in the eel stomach contents or tissues. In addition, studies of the effects of diquat on native eels in the Avon River showed no observable signs of acute toxicity in the short-fin eel (Tremblay 2004).

DISCUSSION

Herbicides have the advantage of being able to suppress extensive areas of aquatic weeds quickly at a relatively low cost. There is significant body of evidence of from New Zealand that diquat and endothal are both effective tools available for management of critical infestations of aquatic weeds in major water bodies.

Application techniques are critical for herbicides to be successful in controlling aquatic weeds. Applications should include a gel adjuvant such as Hydrogel, with equipment able to accurately deliver the required dosage over the treatment area.

Although herbicides have been the most cost-effective method of aquatic weed control, there is an understandable general aversion in society for the discharge of chemicals into water. This aversion can often prevent the use of herbicides over large areas. In this situation, the social acceptability of herbicide treatments can be considerably improved through the use of Hydrogel, which allows for specific targeting, reducing chemical wastage and offsite drift.

The development of new techniques for aquatic weed control has been glacial. The reasons for this are principally because of the relatively small "market" in aquatic weed control, and the social unacceptability of many of the available methods. Despite these problems, new techniques in herbicide delivery have been developed in New Zealand, and are now widely used, often with superior results.

The use of diquat/gel (Hydrogel) for aquatic weed control is now widespread throughout New Zealand's waterways. Its social acceptance is rapidly improving, as evidenced by most territorial authorities allowing its use as a permitted activity (i.e. no Council discharge permit required).

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REFERENCES

Clayton, J.S. 1986. Review of diquat use in New Zealand for aquatic weed control. *International Symposium on Aquatic Weeds* 7: 73-79.

Clayton, J.S.; Wells, R.D.S. 1999. Some issues in risk assessment reports on grass carp and silver carp. *Conservation Advisory Science Notes* 257. Clayton, J., Wells, R., Champion, P. & Blair, N. 2000. Rototilling and alternative options for control of *Lagarosiphon major* in Paddock Bay, Lake Wanaka. NIWA Report 78, 12 pp.

Hofstra, D.E.; Clayton, J.S. (2001). Evaluation of selected herbicides for the control of exotic submerged weeds in New Zealand: I. The use of endothall, triclopyr and dichlobenil. *Journal of Aquatic Plant Management* 39: 20–24.

Hofstra, D.E.; Clayton, J.S.; Getsinger, K. D. (2001). Evaluation of selected herbicides for the control of exotic submerged weeds in New Zealand: II. The effects of turbidity on diquat and endothall efficacy. *Journal of Aquatic Plant Management* 39: 25–27.

HortResearch 2001. *Pesticide Residue Report No. 186,* National Institute of Water and Atmospheric Science (NIWA) Technical Report.

Johnstone, I. M. 1986. Mancrophyte management: An integrated perspective. *New Zealand Journal of Marine and Freshwater Research* 20: 599-614.

Tremblay, L.A. 2004. Biomarkers in eel to evaluate effects of diquat in a Christchurch river. *Australasian Journal of Ecotoxicology* 10: 53-56.

Wells & Clayton (1996). The Impacts of Weed Beds and Diquat Spraying of the Freshwater Mussel, *Hydrilla menziesi*. National Institute of Water and Atmospheric Science (NIWA) Technical Report.

Wells, R.D.S.; Clayton, J.S. 2005. Mechanical and Chemical Control of Aquatic Weeds: Costs and Benefits. In: Encyclopedia of Pest Management DOI: 10.1081/E-EPM-120024643. Copyright # 2005 by Taylor & Francis.

Wells, R.D.S.; Bannon, H.J.; Hicks, B.J. 2003: Control of macrophytes by grass carp *(Ctenopharyngodon idell*a) in a Waikato drain, New Zealand. *New Zealand Journal of Marine and Freshwater Research 3*7: 85Œ93.