Invasive Mussel Collaborative

Preventing the Spread of Invasive Zebra and Quagga Mussels: A Reference Guide for Methods of Decontaminating Gear and Equipment

Remember to Clean, Drain and Dry!

When working on the water, take the following preventative measures **before** moving to a new water body:

- Inspect and **clean** off any visible aquatic plants, animals, and mud from all equipment *before* leaving water access.
- **Drain** motor, bilge, livewell, and other water containing devices *before* leaving water access.
- **Dry** everything for five days or more or wipe with a towel *before* reuse.

In situations where it is possible and/or necessary to disinfect watercraft and gear, the table below summarizes available options for the treatment of zebra and quagga mussels. Undertake decontamination efforts only after surfaces are visibly clean, drained, and dry.

- **Not all methods are appropriate** or feasible for all gear types and/or all situations.
- **State and local agencies may recommend, require, or permit specific methods** of decontamination for specific gear types or locations.
- **Some decontamination methods can be scaled** to meet specific needs.
- **States may regulate decontamination runoff as wastewater** and additional action may be needed to properly dispose of runoff water.
- **Surrounding plants and soils could be harmed** if decontamination is done improperly.
- **Know your local, state, and federal regulations** before use of any of the methods.

***This table is intended for reference use only**. For more information, contact your state invasive species program (https://invasivemusselcollaborative.net/contact-an-expert/) or visit http://invasivemusselcollaborative.net/prevention/.*

This table is intended for reference use only. The Invasive Mussel Collaborative does not endorse use of or recommend any specific product, method, or application. Always ensure that you are complying with local, state, and federal regulations before, after, and during decontamination.

Method	Preparation//Contact Time	Applications	Other Considerations
Hot water	≥60°C (140°F) // 10 seconds[1,2]	• Surfaces of watercraft and trailers • Motor flushing • Sampling nets and equipment • Wet suits, masks, snorkels, and fins • Waders/boots • Clothing	Most self-serve car washes do not meet the temperature requirement. To verify that the hot water spray is effectively heating the contact area, a non-contact infrared thermometer can be used. Water loses approximately 15-20 degrees F per foot of distance when sprayed from a power nozzle; an increase in initial temperature can be used to account for this heat loss to the point of contact. Personal protective equipment (PPE) is needed to avoid burns.
Steam cleaning[3]	Live steam from a steamer	• Surfaces of watercraft and trailers • Motor flushing • Sampling nets and equipment • Clothing	High steam temperatures can melt bonds and adhesives. Inflatable PFDs, technical fabrics, and wader/boot seams can also be melted by steam. Quick strokes instead of lingering in one place with a steam cleaner will decrease the likelihood of causing damage to equipment. Read all manufacturer's guidelines to determine if steam will harm equipment.

[1] Comeau, S., Rainville, S., Baldwin, W., Austin, E., Gerstenberger, S., Cross, C., and W.H. Wong. 2011. Susceptibility of quagga mussels (*Dreissena rostriformis bugensis*) to hot-water sprays as a means of watercraft decontamination. Biofouling 27(3): 267-274.

[2] Morse, J.T. Assessing the effects of application time and temperature on the efficacy of hot-water sprays to mitigate fouling by *Dreissena polymorpha* (zebra mussels Pallas). Biofouling 25(7): 605-610.

[3] Wisconsin Department of Natural Resources. Best management practices for boat, gear and equipment decontamination. 25 pp.

Method	Preparation//Contact Time	Applications	Other Considerations
Freezing	Freezer with temperatures ≤ 20°F (-5°C)//Until frozen solid, at least 5 hours[4]	• Sampling nets and equipment • Wet suits, masks, snorkels, and fins • Waders/boots • Clothing	Exposure to freezing temperatures could damage some gear. Not all gear will fit in all freezers (depending on size).
Salt water	Table salt (NaCl) solution of 3.5% (35 ppt)//30 minutes[5]	• Sampling nets and equipment • Wet suits, masks, snorkels, and fins	Treatment with saltwater is only effective as a disinfectant method for quagga/zebra mussel veligers.
Vinegar	Undiluted white vinegar//20 minutes[5]	• Disinfecting bilge • Sampling nets and equipment • Wet suits, masks, snorkels, and fins • Waders/boots	Vinegar dissolves quagga/zebra mussel veliger shells and can be used on nets or gear that are used to collect samples for dreissenid mussel analysis after sampling to prevent false positive detections in uninfected lakes. Vinegar is corrosive to metal and toxic to fish at undiluted concentrations; rinsing gear with tap water after vinegar treatment may minimize these impacts. If gear has been used in hard water, a vinegar bath may be less effective, as hard water has a higher buffer capacity.
Virkon	2% solution//20 minutes[6]	• Sampling nets and equipment • Wet suits, masks, snorkels, and fins • Waders/boots	**Virkon Aquatic is labeled for use only as a bactericide and virucide**. Recent studies have shown that a bath immersion of 20 grams per liter (g/L) Virkon Aquatic is effective as a disinfectant method for quagga mussels (adults and veligers)[6]. Appropriate PPE must always be worn to avoid personal injury when using chemicals.
Quaternary ammonium compounds *These compounds are labelled for use as disinfectants, fungicides, and virucides, but have also been shown as effective molluscicides[7].*	Sparquat 256®: 3.1% solution//10-15 minutes[7]	• Sampling nets and equipment • Wet suits, masks, snorkels, and fins • Waders/boots	Effective as a disinfectant method for quagga mussels veligers only. Appropriate PPE must always be worn to avoid personal injury when using chemicals.
	Green Solutions High Dilution 256®: 1.8% solution//10 minutes[7]		Effective as a disinfectant method for quagga mussels veligers only. Appropriate PPE must always be worn to avoid personal injury when using chemicals.
Bleach/Chlorine	0.5%-2% (250 ppm – 1000 ppm) bleach solution//10 minutes	• Sampling nets and equipment • Wet suits, masks, snorkels, and fins • Waders/boots	Bleach is corrosive, use with caution. Read and follow all product labels, equipment manuals and any associated documents. Appropriate PPE must always be worn to avoid personal injury when using chemicals.

[4] McMahon, R. F., Ussery, T. A., and M. Clarke. 1993. Use of emersion as a zebra mussel control method. Contract Report EL-93-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
[5] Michigan Quality of Life Departments. 2014. Policy and Procedure document: Invasive Species Decontamination for Field Operations in Michigan. 25 pp.
[6] Stockton, K.A. 2011. Methods to assess control and manage risks for two invasive mollusks in fish hatcheries. M.S. Thesis, University of Idaho.
[7] Britton, D.K., and S. Dingman. 2011. Use of quaternary ammonium to control the spread of aquatic invasive species by wildland fire equipment. Aquatic Invasions 6(2): 169-173.

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Appendix: Potential Applications for Other Aquatic Invasive Species

The aforementioned methods may also be used for decontaminating gear infested with other invasive species. Where decontamination guidance documents and/or scientific literature suggests that a treatment method may be used against species other than invasive mussels, we have provided a reference guide below.

Method	Preparation//Contact Time	Applications for Other Invasive Species		
Hot water	≥60°C (140°F) // varies according to species[8,9]	• Asian clam: 30 minutes • New Zealand mudsnail: 15 seconds • Malaysian trumpet snail: 5 minutes • Oriental mystery snail: 5 minutes	• Faucet snail: ≥ 1 minute • Spiny waterflea: ≥ 1 minute • Didymo: 1 minute	• Whirling disease: ≥90°C for 10 minutes • VHS: 10 minutes • Spring Viremia of Carp: 30 minutes
Steam cleaning	Live steam from a steamer[9]	• Asian clam • New Zealand mudsnail	• Faucet Snail • Spiny waterflea	• Spring Viremia of Carp • Whirling disease • VHS
Freezing	Freezer with temperatures ≤ 20°F (-6°C)//Until frozen solid[8,9]	• New Zealand mudsnail • Malaysian trumpet snail	• Faucet snail • Spiny waterflea	• Didymo: 4 hours • Whirling disease: ≤ -20°C for 7 days[10]
Virkon	2% solution// varies according to species	• New Zealand mudsnail: 20 minutes[11] • Didymo: 1-5 minutes for 80% mortality[12]	• Asian clam: 5 minutes[13] • VHS: 10 minutes[9]	• Spiny waterflea: 20 minutes[9] • Spring Viremia of Carp: 10 minutes[9]
Quaternary ammonium compounds *These compounds are labelled for use as disinfectants, fungicides, and virucides, but have also been shown as effective treatments[14,15] for certain species.*	Quat 128®: 4.6% solution//10-15 minutes	• Didymo[8]	• Whirling disease[8]	
	Sparquat 256®: 3.1% solution//10-15 minutes[14]	• New Zealand mudsnail[14]	• Didymo[8]	• Whirling disease[8]
	Green Solutions High Dilution 256®: 1.8% solution//10 minutes[15]	• New Zealand mudsnail[15]	• Didymo[8]	• Whirling disease[15]
	Super HDQ©: 1% solution//5 minutes	• New Zealand mudsnail[15]	• Whirling disease[15]	
	Formula 409® – must be antibacterial: 100% solution//10 minutes	• New Zealand mudsnail[14]	• Whirling disease[10]	
Bleach/Chlorine	1% (500 ppm) bleach solution// Varies according to species	• Spiny water flea (adults): 10 minutes • Didymo: 2% solution for 1 minute for ≥90% mortality[12]	• Whirling disease: 15 minutes[10] • Spring Viremia of Carp: 10 minutes • VHS: 5 minutes	

[8] U.S. Forest Service. 2016. Aquatic Invasive Species Guide to Preventing Transport by Wildland Fire Operations. Appendix B. 34 pp.

[9] Wisconsin Department of Natural Resources. Best management practices for boat, gear and equipment decontamination. 25 pp.

[10] Hedrick, R.P., McDowell, T.S., and K. Mukkatira. 2008. Effects of freezing, drying, ultraviolet irradiation, chlorine, and quaternary ammonium treatments on the infectivity of myxospores of *Myxobolus cerebralis* for *Tubifex tubifex*.

[11] Stockton, K.A., and C.M. Moffitt. 2013. Disinfection of Three Wading Boot Surfaces Infested with New Zealand Mudsnails. North American Journal of Fisheries Management (33)3: 529-538.

[12] Root, S., and C.M. O'Reilly. 2012. Didymo control: increasing the effectiveness of decontamination strategies and reducing spread. Fisheries 37(10): 440-448.

[13] Barbour, J.H., McMenamin, S., Dick, J.T.A., Alexander, M.E., and J. Caffrey. 2013. Biosecurity measures to reduce secondary spread of the invasive freshwater Asian clam, *Corbicula fluminea* (Müller, 1774). Management of Biological Invasions (4)3: 219–230.

[14] Schisler, G.J., Vieira, N.K.M., and P.G. Walker. 2008. Application of household disinfectants to control New Zealand mudsnails. North American Journal of Fisheries Management 28: 1172-1176.

[15] Stout, J.B., Avila, B.W., and E.R. Featherman. 2015. Efficacy of commercially available quaternary ammonium compounds for controlling New Zealand mudsnails *Potamopyrgus antipodarum*. North American Journal of Fisheries Management 36(2): 277-284.