The Status of Potassium for Use in Zebra Mussel Control: Summary of Data—August 1994

OHIO SEA GRANT COLLEGE PROGRAM

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This is an update of an Ohio Sea Grant research project by Drs. Susan W. Fisher and Paul C. Stromberg, *The use of potassium in control of the zebra mussel,* Dreissena polymorpha *Pallas* (project R/ZM-11 under grant NA90AA-D-SG496).

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[1]Indicates that work is still in progress.

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1. Toxicity of Potassium and Halide Salts to Adult Zebra Mussels

a. Relative toxicity of halide salts to adult zebra mussels

The use of potassium as a zebra mussel control agent depends on the satisfactory demonstration of its efficacy. The potassium salt selected for use in these experiments was KCl. Potassium chloride was chosen because it is relatively inexpensive, is relatively innocuous to other forms of aquatic life, and because it has high water solubility. Concentrations of KCl listed in this report are based on KCl, not on K^+, the active ingredient.

Table 1 shows the toxicity of KCl and salts from the same class in the periodic table to adult zebra mussels of two size classes (large = 20-25 mm; small = 5-8mm).

Table 1. Toxicity of K^+ and Analogs to Adult Zebra Mussels

Compound	Size Class	LC_{50} (ppm)	95% Confidence Limits
KCl	20-25 mm	102	(81-129)
	5-8 mm	138	(120-156)
LiCl	20-25 mm	232	(172-313)
	5-8 mm	185	(123-280)
KI	20-25 mm	226	(220-313)
RbCl	20-25 mm	>1,000	
	5-8 mm	1,101	(594-8106)

Tests were conducted at 17°C, pH 7.5 in hard standard reference water.

Of the salts tested, potassium was most toxic. Although the LC_{50}s for KCl and LiCl to small mussels were not significantly different, LiCl is more expensive than KCl and thus would not be as cost effective in commercial use. Rubidium chloride was significantly less toxic than either KCl or LiCl. Given the low toxicity of RbCl, it was decided that testing of larger salts was pointless.

b. Toxicity of KCl to adult zebra mussels as a function of pH and temperature

If potassium chloride were to be used to control zebra mussels, it might be employed in a variety of settings which vary significantly in water quality. Thus, it is important to demonstrate that the efficacy is maintained even though conditions vary. The toxicity of KCl to adult zebra mussels was thus assessed under varying conditions of pH and temperature (Table 2).

Table 2. Toxicity of KH_2PO_4 to Adult Zebra Mussels Under Various pH Temperature Regimes

pH	Temperature° C	LC_{50} (ppm)	95% Confidence Limits
5	25	227	98-402
6	25	92	80-105
7	25	169	147-194
8	25	88	82-95
5	10	228	195-263
6	10	165	135-212
7	10	137	116-159
8	10	140	89-194

Monobasic potassium phosphate was toxic to adult zebra mussels (20-25 mm) under a variety of environmental conditions. In general, temperature was more influential than pH in determining toxicity with higher toxicity occurring at 25°C than at 10°C.

c. Toxicity of KCl in Distilled Water (Ram)

Salts of potassium are clearly lethal to the adult zebra mussel (Tables 1, 2). However, if potassium salts are to be used in zebra mussel control, and if potassium salts are to be competitive with conventional molluscicides, the concentration applied to effect control must be as low as possible. Recently, Ram (personal communication) discovered that purified water can synergize the toxicity of potassium salts and other compounds that seem to inhibit respiration as their mode of action. In the presence of purified water, the LC_{50} of KCl drops by a factor of ten. Thus, KCl may be cost effective and environmentally compatible for industries that generate large quantities of purified water.

2. Toxicity of KCl to Juvenile Zebra Mussels

a. Toxicity to veligers and plantigrade mussels in static toxicity tests

Many industries target juvenile zebra mussels in their control strategies in an effort to prevent infestation and the attendant problems associated with the presence of adult zebra mussels. Thus, it is essential to demonstrate that KCl is toxic to juvenile mussels. Methods were developed for conducting toxicity tests on the veliger and plantigrade stages. Results for static toxicity tests are presented in Table 3.

Table 3. Toxicity of KCl to Juvenile Zebra Mussels in Static Toxicity Tests

Life Stage	LC_{50} (ppm)	95% Confidence Limits
3-Day-Old Veliger	124	(109-140)
Plantigrade	198	(195-200)

Tests were conducted in hard standard reference water, pH 8.3, 17°C for 24 hr.

The toxicity of KCl to early stage veligers was not significantly different from its toxicity to adult zebra mussels. Plantigrade mussels were significantly more resistant to KCl than any other stage. These data are similar to data generated for other molluscicides for which data on several life stages have been generated (See Fisher et al. 1994, for example).

b. Toxicity of KCl to Juveniles in Studies with Fish Therapeutants

One sizeable potential market for potassium in zebra mussel control is for use as a molluscicide in commercial fish shipments when those shipments are made from areas infested by zebra mussels. KCl could be added to the water in which the fish are being transported to kill any veligers which might be present. Importantly, KCl has already been approved as a fish therapeutant by the FDA, thus circumventing the usual problems with FIFRA registration. KCl was tested on zebra mussel veligers according to treatment regimes allowed for commercial fish shipments. These data are summarized in Table 4.

Table 4. Toxicity of KCl to 3-Day-Old Veligers

Concentration of KCl (%)	Exposure Time	Developmental Stage	% Mortality 24hr*	48 hr**
0.25	24 hr	plantigrade	94.3	98.1
0.50	6 hr	plantigrade	4.8	20.2
1.00	1 hr	plantigrade	0.8	9.7
0.25	24 hr	3-day veliger	100.0***	
0.50	6 hr	3-day veliger	100.0***	
1.00	1 hr	3-day veliger	91.9***	

* Mussels were exposed to the toxicant for 1-24 hr as indicated.

** Plantigrade mussels were held in clean water for 24 hr following exposure; mortality was again recorded at the conclusion of the 24 hr recovery period in clean water.

*** No post-exposure recovery period was possible with veligers due to mortality incurred in transferring from exposure water to clean water.

Administration of 0.25% KCl for 24 hr and 0.50% for 6 hr killed all 3-day-old veligers. The 1.00% KCl treatment may also result in the death of all veligers during the post treatment phase, although it was not possible to examine this possibility since veligers cannot be transferred from treatment vessels to uncontaminated water without significant mortality due to handling. The plantigrade mussels were clearly more resistant to KCl than the veligers. However, the 24 hr treatment with 0.25% KCl may provide sufficient control of this form of the mussel. Clearly, KCl has potential, not only for controlling fungi in commercial fish, but for controlling zebra mussels as well.

c. Toxicity of KCl to Juveniles in Field Studies

Field tests of the efficacy of KCl in preventing settling of veligers were conducted at the Consumer's Electric Power Plant, Monroe, MI during the summers of 1992 and 1993 using a specialized apparatus for detecting settling (Fisher et al. 1993). Various treatment regimes of KCl (25, 50 ppm as K^+) were tested in continuous and intermittent treatments. Delivery of 50 ppm of K^+ was effective in deterring 85% of settling seen in controls. In addition, intermittent injection of 50 ppm K^+ using two hours on/two hours off appeared to be effective in preventing settling. LC_{50}s were determined for 3-day-old veligers and plantigrade mussels as 124 and 198 ppm of KCl. Thus, it is likely that invading mussels were not killed but simply prevented from attaching. The activity of KCl in this system should thus be considered molluscistatic rather than molluscicidal.

Studies were repeated at Monroe during the summer of 1993. The treatment regimes varied from 50 ppm to 100 ppm and the time of administration varied from continuous to 1 hr on, 3 hrs off. The data are summarized in Table 5.

Table 5. Total Settled Veligers for Monroe, 1993

Treatment	Total Number of Veligers Settled
Control	34
Still Water	240
1 (100 ppm, 1/3)	25
2 (75 ppm. 1/3)	21
3 (50 ppm continuous)	2
4 (50 ppm, 1/2)	20
5 (75 ppm. 1/2)	8

The data suggest that treatments 3 and 5 were effective in reducing settling. However, to verify this finding, it will be necessary to repeat the tests during a time of maximal settling in the controls.

3. Toxicity of KCl to Nontarget Organisms

a. Toxicity of KCl to other molluscs

The toxicity of KCl has been determined using several nontarget molluscs due to concern for endangered molluscs. These data are summarized in Table 6.

Table 6. Toxicity of KCl to Nontarget Molluscs

Species	LC_{50} (ppm)	95% Confidence Limits
Snail (*Helisoma* spp.)	>186*	
Anodonta imbecilis juvenile in sediment	>100*	
Anodonta imbecilis juvenile without sediment	76	(54-112)
Corbicula	>2,000*	
Threehorn Wartyback	>100	

* Highest concentration tested; no mortality was observed.

KCl was nontoxic to three species of nontarget molluscs. KCl was observed to be toxic to juvenile *Anodonta imbecilis*. However, toxicity occurred only in the absence of sediment, their natural substrate. Thus, mortality was probably caused by stress induced by removal from their substrate in addition to that attributable to KCl.

b. Toxicity of KCl to nontarget fish

Any molluscicide that is significantly toxic to fish cannot be widely used for zebra mussel control. Thus, studies are ongoing to determine the toxicity of KCl to important fish species. The results of 3 experiments are reported in Table 7. Other fish species listed in the summary (pg 1 of this report) will be tested this spring.

Table 7. Toxicity of KCl to Nontarget Fish Species

Fish Species	LC_{50}(ppm)	95% Confidence Limits
Fathead minnow	2,465	2,132-2,850
Channel catfish	7,338	6,975-7,757
Rainbow trout	1,191	923-1,536
Hybrid Striped Bass	3,499	2,911-4,206
Golden Shiner	816	715-932

The data show that KCl is, on average, an order of magnitude less toxic to fish than to the zebra mussel. The tests on rainbow trout are being repeated because the confidence limits are unusually wide and it is anticipated that the resulting LC_{50} will be higher than the one reported in Table 7. However, the data available clearly demonstrate the selectivity of KCl.

References

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Kelly Kershner, Ohio Sea Grant Communications

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