**THE EFFECT OF THE PLANT *MYRIOPHYLLUM TRIPHYLLUM*
AND TEMPERATURE ON THE DEGRADATION OF
SODIUM MONOFLUOROACETATE (1080)
IN AN AQUATIC ECOSYSTEM**

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ABSTRACT

Sodium monofluoroacetate (1080) is a toxin used throughout New Zealand for the control of possums *Trichosurus vulpecula*. Its rate of degradation was measured in streamwater in aquaria in the presence and absence of the endemic aquatic plant *Myriophyllum triphyllum* at 7°C and 23°C. Each aquarium was spiked with 1080 to give a starting concentration of 0.12 mg/μl. Temperature and *M. triphyllum* together had a significant effect on 1080 degradation rate, with concentrations decreasing below detectable levels in 1 day at 23°C and 3 days at 7°C. *M. triphyllum* is therefore capable of playing a significant role in 1080 degradation, but 1080 introduced into the environment at colder times of the year is likely to take longer to degrade than if introduced at warmer temperatures.

Keywords: sodium monofluoroacetate, biodegradation, *Myriophyllum triphyllum*, temperature, aquatic ecosystems

INTRODUCTION

Aerial application of baits containing sodium monofluoroacetate (1080) is the principal control method for the introduced brushtail possum *Trichosurus vulpecula* in New Zealand. This pesticide is extremely soluble in water, and there is a need for research that focuses on its fate and persistence in aquatic ecosystems (Eisler 1995).

Many micro-organisms have the ability to degrade 1080 by cleaving the C-F bond and releasing inorganic fluoride ions (Goldman 1965; Walker and Bong 1981; Meyer *et al.* 1990), and 1080 is degraded in streamwater in the presence of aquatic plants (Eason *et al.* 1993; Ogilvie *et al.* in press). No studies have elucidated the relative roles of streamwater microbes and aquatic plants in this degradation of 1080. This paper presents an investigation of the role of the endemic aquatic milfoil *Myriophyllum triphyllum* (Johnson and Brooke 1989) and the influence of temperature (7°C and 23°C) on the degradation of 1080 in streamwater containing microbes.

MATERIALS AND METHODS

Streamwater and plant material were collected from the Waimakariri River, Canterbury, New Zealand. Sodium monofluoroacetate (95% purity) was obtained from the Sigma Chemical Company St. Louis, USA.

Twelve 2-litre aquaria were housed in a controlled temperature chamber at $7 \pm 1^\circ\text{C}$ with a 12:12 L:D cycle. Four of these aquaria were used for each of three treatments: 1.8 litres of biologically active streamwater; 1.8 litres of biologically active streamwater and 60 g of *M. triphyllum*; and 1.8 litres of deionised water (control). The treatments were duplicated at $23 \pm 2^\circ\text{C}$. All aquaria were bubbled with air that had passed through a filter of 0.45 μm pore size. The mean dissolved oxygen concentration for the aquaria was 90% (SE = 0.73) at 7°C and 90.4% (SE = 0.82) at 23°C.

Sufficient 1080 was added to each aquarium to give an initial concentration of 120 ppb. This is 40 times greater than the highest concentration measured in field samples after control operations (Eason 1995), and therefore represents a worst-case scenario. The contents of aquaria were thoroughly mixed with a magnetic stirrer after

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the 1080 was added, and immediately before water sampling. Water samples were taken from all aquaria at 0, 1, 3, 7, 13, and 17 days after the addition of 1080. Plant samples were taken at 0, 1, 3, 7, and 13 days. All samples were stored at -20°C and analysed for 1080 residues (dichloroaniline derivatives) using gas chromatography with electron capture detection, based on the methods of Ozawa and Tsukioka (1987). The limit of detection is 0.1 ppb in water and 1.5 ppb in plant tissue. The samples from the plant and control aquaria were analysed for fluoride ion concentration using a fluoride ion specific electrode. The fluoride ion concentration was then calculated from a standard curve.

Differences in 1080 concentration over time were compared between treatments using t-tests and analysis of variance.

RESULTS AND DISCUSSION

The overall rate of 1080 degradation was significantly faster in the presence of *M. triphyllum* at both temperatures ($P < 0.001$). At 23°C , most of the 1080 had degraded after 1 day in the presence of *M. triphyllum*, but was much slower without *M. triphyllum* (Fig. 1a). Similarly, at 7°C most of the 1080 had degraded after 3 days in the presence of the plant, but took longer than 17 days in its absence (Fig. 1b). This evidence that an aquatic plant species endemic to New Zealand may play a more significant role than streamwater microbes in the degradation of 1080 extends the more general understanding of the role of aquatic plants established by Ogilvie *et al.* (in press).

Some 1080 loss was observed for up to 17 days in the control aquaria (Fig. 1). Although this loss was not statistically significant, it is possible that the effect was real. The water may have been contaminated by microbes from the air or from the other aquaria. It is also possible that spontaneous degradation occurred. Aqueous solutions of 1080 can decrease in toxicity over time through spontaneous decarboxylation to sodium bicarbonate and methyl fluoride (Eisler 1995). Chenoweth (1949) reported that an aqueous solution of 1080 stored at 5°C lost about 54% of its toxicity to rats after 24 days. However, there have also been reports of 1080 being stable in solution, for example, McIlroy (1981) stored it in distilled water for 10 yr without any significant breakdown. We feel that the key contributing factors to these apparently opposing observations are the lack of microbial activity and the initial concentration of 1080 in solution. Where an initial concentration is sufficient to inhibit microbial activity, it is less likely that 1080 will be degraded.

FIGURE 1: Persistence of 1080 in aquaria at 23°C and 7°C . Error bars are 1 standard error.

FIGURE 2: Persistence of 1080 in plant material at 7°C and 23°C. Error bars are 1 standard error.

Temperature had a significant effect on 1080 degradation. In the presence of plant material, there was significantly less 1080 on day 1 in the aquaria at 23°C than in those at 7°C ($P=0.009$) (Fig. 1). In the aquaria with streamwater only, there was significantly less 1080 on day 7 at 23°C than at 7°C ($P=0.015$). The 1080 concentration in plant material reached a peak at both temperatures after 1 day (Fig. 2). The mean concentration fell to below the detection limit after 3 days at 23°C, and after 13 days at 7°C. It is therefore likely that 1080 applied during winter months will take longer to degrade than if it was applied at warmer temperatures.

Mean initial fluoride ion concentration immediately after the addition of 1080 in the four aquaria containing plant material was 0.062 µg/ml (SE = 0.0015), and the mean final concentration was 0.083 µg/ml (SE = 0.009). This observed increase was closely correlated to that expected from the defluorination of the 1080. The initial fluoride ion concentrations in the control aquaria were 0.01 - 0.02 µg/ml and there was no significant change in concentration over time. The close relationship between the decrease of 1080 and the increase of fluoride ions formed confirms that the mechanism of 1080 degradation in this system involves the cleavage of the C-F bond of fluoroacetate. It is therefore likely that there were micro-organisms present in the streamwater, and associated with *M. triphyllum*, which have the ability to produce the enzyme haloacetate halohydrolase (Goldman *et al.* 1968), which catalyses the cleavage of the C-F bond. It is unlikely that the study ecosystem had been in prior contact with 1080, so it appears that these micro-organisms have the ability to develop 1080-degrading enzyme systems when exposed to 1080 as a substrate.

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REFERENCES

- Chenoweth, M.B., 1949. Monofluoroacetic acid and related compounds. *Pharmacol. Rev.* 1: 383-424.
- Eason, C.T., Gooneratne, R., Wright, G.T., Pierce R., and Frampton C.M., 1993. The fate of sodium monofluoroacetate (1080) in water, mammals, and invertebrates. *Proc. 46th N.Z. Plant Protection Conf.*: 297-301.

- Eason, C.T., 1995. Sodium monofluoroacetate (1080): an update on recent environmental toxicology data and community concerns. *Proc. 10th Aust. Vertebr. Pest Conf.* (in press).
- Eisler, R., 1995. Sodium monofluoroacetate (1080) hazards to fish, wildlife, and invertebrates: a synoptic review. *U.S. Department for the Interior Contaminant Hazard Reviews, Report 30*. 47 p.
- Goldman, P., 1965. The enzymatic cleavage of the carbon-fluorine bond in fluoroacetate. *J. Biol. Chem.* 240: 3434-3438.
- Goldman, P., Milne, G.W.A., and Keister, D.B., 1968. Carbon-halogen cleavage -III. Studies on bacterial halohydrases. *J. Biol. Chem.* 243: 428-438.
- Johnson, P.N., and Brooke, P.A., 1989. Wetland Plants in New Zealand. DSIR Publishing, Wellington. 319 p.
- McIlroy, J.C., 1981. The sensitivity of Australian animals to 1080 poison. I. Intraspecific variation and factors affecting acute toxicity. *Aust. Wildl. Res.* 8: 369-383.
- Meyer J.J., Grobbelaar N., and Steyn P.L., 1990. Fluoroacetate-metabolizing pseudomonad isolated from *Dichapetalum cymosum*. *Appl. Environ. Microbiol.* 56(7): 2152-2155.
- Ogilvie, S.C., Hetzel, F., and Eason, C.T., 1995. Effect of temperature on the biodegradation of sodium monofluoroacetate (1080) in water and in *Elodea canadensis*. *Bull. Environ. Contam. Toxicol.* (in press).
- Ozawa H., and Tsukioka T., 1987. Gas chromatographic determination of sodium monofluoroacetate in water by derivatization with dicyclohexylcarbodiimide. *Anal. Chem.* 59: 2914-2917.
- Walker J.R.L., and Bong C.L., 1981. Metabolism of fluoroacetate by a soil *Pseudomonas* and *Fusarium solani*. *Soil. Biol. Biochem.* 13: 231-235.