Attachment 1: Independent expert review of environmental fate of 1080

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REVIEW OF PAPERS CONCERNING THE FATE OF THE MONOFLUOROACETATE ION IN THE ENVIRONMENT OF NEW ZEALAND

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Record of report finalisation

Conclusions drawn and recommendations made in this report represent the unbiased view of Peter Fisk Associates on the basis of the data presented and obtained.

Signed on behalf of Peter Fisk Associates

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Dr. Peter Fisk

Date .....

Review of papers concerning the fate of the monofluoroacetate ion in the environment of New Zealand

Introduction

Background

1 On March 8th 2007 Peter Fisk Associates (PFA) was asked by Dr. Robin Toy of ERMA New Zealand to provide a review of a number of sources describing the behaviour of the monofluoroacetate ion in the environment. Monofluoroacetate can reach the aquatic and terrestrial environments resulting from the use of sodium monofluroacetate (also known by the commercial name "1080") as a
2 mammalian pest control agent, the main target being the possum. The purpose of this review, reported herein, is to assess whether available published evidence is sufficient to assess the persistence of monofluoroacetate.

3 The sources were provided in electronic form by ERMA. No prior review other than the published sources was provided, and PFA does not know the full purpose to which this work will be applied. Therefore the conclusions of this report can be considered as a true and unbiased interpretation of the data.

PFA has relevant experience to enable the assessment of biodegradation of monofluoroacetate to be made.

The chemistry of sodium monofluoroacetate does not need to be reviewed in
4 detail. It is sufficient to know that it is highly water soluble, involatile, and stable to hydrolysis.

The biochemical aspects of the mechanism of toxicity are well known in the literature and need not be reviewed in depth. As well as the activation mechanism that yields the respiration inhibitor fluorocitrate via reaction of fluoroacetate with oxaloacetate catalysed by citrate synthase, loss of fluoride via "haloacetate hydrolase" to give glycolate has been proposed in micro-organisms and possibly plants (see below). In mammals and reptiles the major detoxification mechanism is via direct conjugation with glutathione, which ultimately yields the sulfoxide and sulfone of mercapturic acid. Conjugation of fluoroacetate with glutathione has also been shown in plants.

Definition of persistence in the environment

The present authors consider that persistence in the environment concerns degradative processes. That is, irreversible transformation of the fluoroacetate ion into some other chemical species. Therefore, removal processes from water into some other environmental compartment would not be considered as degradation. For example, adsorption onto sediment from the water column would simply change the focus onto the behaviour of the substance in the sediment compartment. Uptake by an organism might well be important in determining the overall fate of monofluroacetate in the environment, and could result in
1 subsequent degradation (metabolism) by that organism. The pathway and rate would need to be considered in order to determine whether such a process is important in determining the assessment of overall persistence.

2 Once basic pathways and rates are delineated, it is possible to use mathematical environmental models to establish whether monofluoroacetate is persistent in the total environment or individual compartments of it.

The authors have also been provided with documentation on the views of ERMA concerning degradation and its definition within regulatory contexts:

Degradability in aquatic systems

The term 'rapidly degradable' is defined in Schedule 6 of the Hazardous Substances (Minimum Degrees of Hazard) Regulations 2001 as:

> *"rapidly degradable, in relation to a substance in water, means that—*
>
> *(a) 28 days after a solution containing the substance is inoculated with micro-organisms, there is at least—*
>
> *(i) a 70% reduction in dissolved organic carbon in the solution; or*
>
> *(ii) a 60% depletion of oxygen in the solution, when compared with the maximum depletion of oxygen that would occur if the substance were completely degraded; or*
>
> *(iii) a 60% generation of carbon dioxide in the solution, when compared with the maximum generation of carbon dioxide that would occur if the substance were completely degraded; or*
>
> *(b) if only COD and BOD_5 data is available, the ratio of BOD_5 to COD is greater than or equal to 0.5:1; or*
>
> *(c) at least 70% of the substance can be degraded biotically or abiotically, in the aquatic environment within 28 days"*

Degradation in soil

The regulatory criterion for assessing the half-life in soil is:
Schedule 6 of the Hazardous Substances (Classification) Regulations 2001 refers
1 to a soil half-life (DT_{50}) as being "*the half-life in soil, which is the time required to reduce the original concentration of the substance in the soil by 50%*" and would usually be assessed using a standard test guideline (e.g. OECD 307).

ERMA interprets the DT_{50} as being a result of biodegradation, consistent with that for assigning aquatic degradation 'classification', rather than dissipation which refers to any loss from the soil whether by degradation, leaching or some other process.

Scientific papers provided by ERMA and reviewed by PFA

2 The papers are referenced in Section 2. This list is believed to have been developed following extensive literature searching by ERMA, and therefore no additional searching was carried out by PFA.

Review of sources

Source: Booth et al., 1999

Ref. 1

Method:

Degradation studies were carried out in 18 L aquaria containing either deionised water (control) or stream water containing the submerged aquatic plant *Myriophyllum triphyllum* at 21°C. Sodium fluoroacetate was applied at rates of 0.12, 2 and 5 mg/L. The water was analysed for fluoroacetate and fluorocitrate by a derivatisation GLC technique using the 2,4-dichloroaniline adducts (fluoroacetate) or TFA/BF_3 (fluorocitrate). Assays were performed up to 17 days after treatment commenced.

Results:

Fluoroacetate was stable in the control aquaria and no fluorocitrate was detected. In the tanks containing plants and micro-organisms, fluoroacetate disappeared quite rapidly. DT_{50} values are not quoted but from the graphs the present authors assess it to be ca. 8 days at the 5 mg/L dosage, 4–5 days at 2 mg/L and 1–2 days at 0.12 mg/L. This is at variance with the assertion of "degradation occurring at a higher rate in aquaria with the highest initial concentration of 1080 (P=0.21)".
3 Fluorocitrate peaked at 1, 4 and 8 days for 1.2, 2 and 5 mg/L fluoroacetate

concentrations respectively. The maximum fluorocitrate peak was 0.4, 1.2 and 1.6 mg/L at these same concentrations. Confusingly, the data are also presented as a table in the form of µmol fluorocitrate produced or fluoroacetate degraded. 1 These data are all incorrectly calculated, being 10-fold lower than actual amounts, although this does not negate the general conclusions. In general the data manipulation in this paper is very poor and should not have passed the referees' scrutiny. Notwithstanding this, the following conclusions appear to hold:

- Fluoroacetate is degraded in stream water and fluorocitrate is a metabolite.
- Higher levels of fluorocitrate were detected in aquaria dosed with higher amounts of fluoroacetate.
- 2 Both fluoroacetate and fluorocitrate were rapidly degraded so that after 17 days, levels were almost undetectable.
- It was not known which organisms are responsible for this degradation, micro-organisms, plants (or both).

This is poorly written paper but the basic conclusions appear to be supported. It is, however, the only one in which the toxic metabolite of fluoroacetate, fluorocitrate is reported with stream water and plants, rather than a defluorinating mechanism yielding glycolate and F^-.

Source: Eason et al., 1993

Ref. 2

This paper discusses the degradation of sodium fluoroacetate in water, invertebrates and mammals. Only the water degradation studies are assessed in this abstract. The article is a summary of the work carried out, as are most conference proceedings papers and not a full detailed paper, consequently a number of experimental details are lacking.

Methods.

Three 80 L aquaria, two containing submerged aquatic plants and small 3 invertebrates and the third, a control tank containing distilled water were dosed with sodium fluoroacetate (0.1 mg/L). The assay method for fluoroacetate was the same as in ref. 1. It was stated that recoveries were >90% and the limit of detection was 0.3 µg/L. Only fluoroacetate was measured. Water temperature was 20°C. It was not stated whether the tanks were aerated. Assays for fluoroacetate were performed 5 min, 1, 24, 100, 170, 330 h (13.75 days) after dosing.

Results:

Fluoroacetate disappeared rapidly from both biologically active aquaria with DT_{50} values of less that 24 h. None was detectable after 100 h. There was little degradation in the distilled water aquarium. Fluoroacetate residues were detectable in plants, the highest amount in the 1 h samples; however, none was detectable after 330 h.

Conclusions:

- Sodium fluoroacetate was rapidly degraded in stream water containing plants, invertebrates and (presumably) micro-organisms.
- Information on the metabolic fate could not be assessed, as potential metabolites were not tested for.

Source: Ellington et al., 1987

Ref 3.

Methods:

Pseudo first-order hydrolysis rates (L. $mol.^{-1}$ hr^{-1}) were measured for a number of potentially polluting chemicals at 25°C. Hydrolysis was carried out in neutral, acidic and basic media for some of the materials. For some, data were measured at different temperatures, Arrhenius plots performed and activation parameters (ΔG^*) calculated.

The detailed information for sodium fluoroacetate (p 39) and includes all the relevant purity (by IR and MS), concentration and analysis method data. The raw hydrolysis data were used to calculate neutral hydrolysis rates at 25°C assuming a value of ΔG^* of 20 Kcal/mol, which results in the rate constant increasing by a factor of 10 per 20°C increase in temperature. The analytical method used to measure the hydrolysis rates for sodium fluoroacetate was ion exchange HPLC with analysis of the fluoroacetate ion by conductivity monitor. Initial concentration was 4.8 mg/L. The duration of the experiment was not stated. The buffers used to control the pH were not stated.

Results:

The data reported are:

pH	Temp.	k_1 (hr^{-1})	$t_{1/2}$(days)	r^2
3.14	87.0	2.4E-04	120	0.425
7.25	68.7	4.0E-04	72	0.912
9.99	68.7	8.0E-05	365	0.395

The data reported in table 5 for the neutral pseudo-first order hydrolysis (k_1) rate constant was <1.7E-06 hr^{-1}.

Conclusions:

The data and data manipulation are presented in a very confusing manner. Clearly, fluoroacetate is hydrolysed in aqueous solution in a pH dependent manner with a maximum rate at near neutrality, which tends to rule out a simple SN_2 reaction with OH^- to give F^- and glycolate. The experiments at the high and low pH give poor correlation coefficients so that only the pH 7.25 value should be accepted. Using the activation parameters given, the k_1 value at 25°C would be ca. 1.8E-05 hr^{-1} or a half life of 1600 days (4.38 years).

1
- Sodium fluoroacetate is hydrolysed very slowly in water at neutral pH in the absence of biota.
- At ambient temperatures the half-life would be expected to be at least 4 years.

Source: Goldman, 1965

Ref. 4.

Methods:

2 A bacterial inoculum identified as a *Pseudomonas* species was isolated from river sediment by a process of an enrichment culture technique that could utilise fluoroacetate as the sole carbon source. An enzyme was extracted and purified 30-fold that was capable of catalysing the hydrolysis of fluoroacetate to glycolate and fluoride:

$$FCH_2CO_2^- + OH^- \rightarrow HOCH_2CO_2^- + F^-$$

Fluoroacetate and glycolate were identified and quantified by anion-exchange chromatography, paper chromatography and various colorimetric assays.

Results:

It was convincingly shown that the reaction shown above was catalysed in a strict stoichiometric ratio so that 1 mol fluoroacetate gave 1 mol glycolate and 1 mol fluoride. The enzyme also catalysed chloroacetate and iodoacetate hydrolysis, but at a much slower rate. It was inhibited competitively by small organic acids and in a time dependent manner by a number of thiol regents. The authors hypothesise that the mechanism proceeds via the formation of a carboxymethylated thiol (cysteine) at the active site, followed by hydrolysis of this thioether to release glycolate. However, iodoacetate is a much better alkylating agent of thiols than is fluoroacetate, so the access to the active site must be restricted to only allow fluoroacetate to easily access the site. This proposed mechanism is probably wrong (see Liu *et al.* ref. 7). However, it is an excellent and convincing paper.

Conclusions:

- Some soil bacteria contain enzymes capable of hydrolysing fluoroacetate to glycolate and fluoride.
- It is not possible to say how important this is for the degradation of fluoroacetate in soils and sediments as it is not an eco-toxicological paper, but it does demonstrate the process can happen.

Source: Kelly, 1965

Ref. 5.

Methods:

A gram-negative bacterium, isolated from garden soil from SE England, was capable of growing on fluoroacetate as a sole carbon source. The bacterium was grown in flask culture and fluoroacetate, fluoroacetamide and fluoride were determined by a referenced method that was not described.

Results:

The bacteria grew slowly under conditions where fluoroacetate or fluoroacetamide were the sole carbon sources but much more quickly on complete medium. They grew more quickly at 30°C than at 37°C. Bacteria conditioned to grow on only fluoroacetate would not utilise fluoroacetamide, but those adapted to fluoroacetamide would utilise both. When fluoroacetamide or fluoroacetate were utilised in a flask culture of the bacteria, fluoride was produced in tandem with the disappearance of the substrate. This is a sound paper but rather lacking in detail.

Conclusions:

- Bacteria can be isolated from soil that are capable of catalysing the degradation of fluoroacetate via a defluorination mechanism.
- It is not possible to say how important this is to the rate of fluoroacetate degradation in soil but it does demonstrate that the process occurs.

Source: King et al., 1994

Ref. 6

This paper examines the ability of soil microbes isolated from five sites from temperate western Australia. A large number of Australian plant species synthesise fluoroacetate and a number of vertebrate species have been shown to

develop increased tolerance to this toxin. Similarly, soil micro-organisms isolated from areas where fluoroacetate occurs naturally might be expected to show
1 increased ability to metabolise this compound. This is a competent paper but it is clearly a summary and a few more details would be useful.

Methods:

Both bacterial and fungal species were isolated and examined for their ability to metabolise fluoroacetate added to either autoclaved soil or aqueous solution. The extent of fluoroacetate breakdown was assessed by measuring fluoride with a fluoride electrode. The detailed method is not described but is referenced (Wong 1992, two papers, abstracted herein).

Results:

2 Micro-organisms capable of degrading fluoroacetate were only isolatable from temperate soils, but not from semi-arid tropical regions. Activity was optimal at temperatures of 11–28°C and soil moisture of 8-15% and for bacteria in neutral to alkaline soils, although fungi were most active in acid soils. The main bacterial genera were *Pseudomonas* and the fungi were mostly *Fusarium* and *Penicillium*.
3 In the degradation experiments in water and autoclaved soil, the maximum amount of fluoroacetate degraded was 65–87% and occurred in 5–49 days. Bacteria were generally better at degrading fluoroacetate than fungi. All micro-organisms degraded the material much slower at 37°C than at lower temperatures.
4 There was almost no breakdown in the autoclaved soil experiment where the soil moisture content was only 2.6%. Inoculum size had little effect on the rate, except when fluoroacetate was the sole carbon source, when a large inoculum was required to effect a significant breakdown.

Conclusions:

- Temperate Australian soils contain a large spectrum of micro-organisms capable of detoxifying fluoroacetate.
- Degradation rates obtained from this area might be expected to show faster detoxification rates as the soil biota are likely to be adapted to the natural occurrence of fluoroacetate.
- 5 Soil pH, moisture and temperature had marked effects on the rate of fluoroacetate decomposition, with high temperature, low moisture and acidic pH all being deleterious to rapid metabolism.

Source: Liu et al., 1998

Ref. 7

This is a purely mechanistic paper exploring the reaction mechanism of fluoroacetate dehalogenase from the bacterium *Moraxella* sp. B.

It was anticipated from protein homology that the nucleophile that attacks the alpha-carbon of the fluoroacetate (and other haloacetates) was Asp105 to give an intermediate ester. The hydrolysis of this intermediate is then catalysed via a histidine(272)-activated water molecule acting as the second nucleophile. Accordingly, if H272 is mutated to another amino acid, the carboxymethylated intermediate on Asp105 would be stable.

Methods:

Both native and H272N (asparagine) recombinant proteins were expressed in *E. coli*. The proteins were purified and analysed for ability to catalyse the hydrolysis of chloroacetate (a poorer substrate than fluoroacetate but chloride is easy to assay). The recombinant H272N protein that had been reacted with fluoroacetate and $H^{18}OH$ was subjected to tryptic digest and the peptides subjected to MS/MS analysis.

Results:

H272N mutant fluoroacetate dehalogenase was devoid of catalytic activity.
The peptide that had an aspartate group esterified by carboxymethyl was identified by MS. There was incorporation of ^{18}O into the tryptic peptide incorporating Asp210.

Conclusions:

- The mechanism of fluoroacetate dehalogenase in this organism involves nucleophilic attack of an aspartic acid group on the alpha carbon of the substrate and the formation of a carboxymethylated ester intermediate.
- A histidine group acting as a general base activates a water molecule as a second nucleophile, effecting the hydrolysis of the ester intermediate.
- The alternative mechanism (occurring in a *Pseudomonas* species) whereby there is direct nucleophilic attack of a base-activated water molecule was ruled out by the lack of incorporation of ^{18}O).
- There is homology of the enzyme with a haloakane dehalogenase and an epoxide hydrolase.

Comment:

Although this is an excellent mechanistic paper it does little to address the question of how quickly fluoroacetate is hydrolysed by bacteria in the soil.

Source: Lloyd-Jones et al., 1994

Ref. 8.

This report describes an attempt to isolate fluoroacetate-utilising micro-organisms from eight soil and eight water samples.

Methods:

1 Samples of soil and water were taken from eight localities in (presumably) New Zealand. There are no data in the report on the type or localities of these samples and nothing on their prior history. Nor does it state whether the water samples are from streams, rivers, ponds or lakes. The water samples were apparently devoid of sediment. Micro-organisms were cultured using a batch enrichment system by growing the cultures in liquid minimal medium containing sodium phosphate, potassium phosphate, ammonium sulphate and mineral salts with the addition of sodium fluoroacetate (10 mM) as the sole carbon source. The cultures were grown at 28°C with aeration. After 3 weeks the cultures were supplemented with an additional carbon source (yeast extract, YE). Culture supernatants were also monitored for free fluoride ions (method not defined). Serial dilutions were plated out onto minimal salts/agar containing 10 mM sodium fluorophosphates after 3, 21and 28 days or minimal agar medium containing sodium fluoroacetate. Only those cultures showing increased colony growth in the presence of fluoroacetate were considered to be fluoroacetate-utilising.

Results:

In three (out of eight) and two (out of eight) water samples it was possible to culture micro-organisms (bacteria) that could use fluoroacetate as the sole carbon source. The soil-derived cultures produce stoichiometric amounts of F^- from fluoroacetate. However, the water-derived cultures would only demonstrate defluorinating activity in the presence of YE supplement and then the conversion of fluoroacetate was not stoichiometric with only 2–5 mM F^- being produced from 10 mM fluoroacetate. It was not possible to isolate colonies capable of using fluoroacetate as sole carbon source from these cultures.

Conclusions:

- It was possible to isolate bacteria capable of utilising fluoroacetate as a sole carbon source in 3 out of 8 soil samples but none of the water samples.
- Fluoroacetate-utilising bacteria were either absent in the other samples or were not viable under the conditions used for enrichment.

Comments:

2 There are a number of flaws and omissions present in this report, especially the lack of information concerning sample identity. The lack of any sediment, bio-films or other organisms in the water samples means that the experiments did not reflect a real-life situation where fluoroacetate
3 would be degraded in fresh water (admitted by the authors). Sampling soil also presents similar problem of heterogeneity.

Source: Ogilvie et al., 1995

Ref. 9.

This paper describes the degradation of sodium fluoroacetate in tanks of stream water (source stated) containing the submerged aquatic plant *Myriophyllum triphyllum*.

Methods:

The following treatments were used: all studies were carried out in 2 L aquaria containing (a) 1.8 L of biologically-active stream water (b) 1.8 L of biologically-active stream water plus 60 g fresh weight *Myriophyllum triphyllum* (b) 1.8 L of deionised water. All treatments were carried out in quadruplicate and at 7±1°C or 23±2°C (total of 24 tanks). The tanks were aerated, stirred before testing and subjected to a 12:12 L:D regime. Fluoroacetate and fluoride were measured as described in Ref. 1 above. Analysis was carried out at 0, 1, 3, 7, 13, 17 days (water) and 0, 1, 3, 7, 13 days (plants) after dosing. Initial dosing was 0.12 mg/L (120 ppb) sodium fluoroacetate, which was stated to be 40x the highest environmental water level found in the field. All data were treated statistically (chi^2).

Results:

(a) Plants and stream water: at 23°C the degradation was rapid with barely detectable levels of fluoroacetate on day 1 (DT_{50}<1day). At 7°C the rate was slower, but by day 3 the concentrations of fluoroacetate were hardly detectable (DT_{50} ca. 2 days).

(b) Biologically-active stream water only. At both temperatures there was a marked lag phase, probably indicating the induction of a population of fluoroacetate utilising micro-organisms. At 23°C the DT_{50} was ca. 6 days and at 7°C ca. 10 days.

(c) Deionised control: unlike ref. 1 there was significant loss of fluoroacetate in the control tank after a lag phase, but much less than the biologically active treatments. The authors hypothesise this was due to either a described (with reference) decarboxylation of fluoroacetate to bicarbonate and fluoromethane or (more likely) contamination of the control tanks with micro-organisms.

(d) The concentration of fluoroacetate in the plant tissue peaked at 23 ppb on day 1 and thence rapidly declined to barely detectable levels on day 3 (23°C) or day 13 (7°C).

(e) The concentration of fluoride in the tanks containing plant material rose to 83 ppb. There was no concomitant increase of fluoride in the deionised water control tanks.

Conclusions:

- Sodium fluoroacetate is rapidly degraded via a defluorination mechanism in biologically active stream water.
- The degradation can be carried out by aquatic plants, which take it up and rapidly degrade it or by micro-organisms in the water.

- At lower temperatures it is more persistent, but at 7°C it reaches very low levels after 17 days.
- Loss of fluoroacetate from the control tanks probably indicated contamination by micro-organisms.

Comments:

This is an important paper that demonstrates that fluoroacetate is degraded quite rapidly by plants and micro-organisms under laboratory conditions.

Source: Ogilvie et al., 1996

Ref. 10.

1 This paper examines the degradation of fluoroacetate in large aquaria containing stream water and the introduced submerged aquatic plant *Elodea canadensis*.

Method:

Sodium fluoroacetate (initial concentration 0.12 mg/L) were added to 80L tanks containing stream water and 1.2Kg *Elodea canadensis*. One tank was maintained at 11°C, the other at 21°C. The experiment was carried out in duplicate at both temperatures. Analyses for fluoroacetate and fluoride (F^- electrode) were carried out by the same methods used for refs. 1 and 9. These were carried out 0, 2, 24, 48, 72, 101, 141, 192 (water samples) and 0, 2, 8, 32, 77, 192, 240 hr (plants) after dosing. pH values and dissolved oxygen concentrations were measured. Control tanks contained deionised water.

Results:

2 At 11°C the concentration of fluoroacetate declined with a DT_{50} of ca. 80–120 hours. At 192 hours there was still 23% of the fluoroacetate remaining. At 21°C the degradation was much more rapid. The DT_{50} was ca. 45 hours and the concentration of fluoroacetate was barely detectable at 101 hours. There was little degradation in the deionised water tanks (cf. ref. 9). There was a strict stoichiometry between the concentration of
3 fluoroacetate degraded and the amount of fluoride formed. In the plants, the concentration of fluoroacetate peaked at 24 hr (both temperatures) but declined at a faster rate at the higher temperature such that it was undetectable at 191 hr; at 11°C there were still detectable levels at 240 hr.

Conclusions:

4
- Sodium fluoroacetate is rapidly metabolised via a defluorination route by submerged aquatic plants and (probably) by micro-organisms present in stream water.
- The degradation is slower at lower temperatures so fluoroacetate may persist longer when applied in the winter.

Comment:
A similar paper to 1 and 9 with similar conclusions.

Source: Parfitt et al., 1994

Ref. 11

One part of this paper describes laboratory studies in which fluoroacetate was added to tanks containing stream water, plants, micro-organisms and small invertebrates in a study very similar to references 1, 9 and 10 above, with near identical results and conclusions, consequently, this part of the paper was not abstracted nor criticised. The other parts describes laboratory studies in which degradation and leaching of fluoroacetate in soils were measured and field studies in which water samples were taken from stream in which 1080 baits were spread by aerial application to control opossums or rabbits in stated NZ localities.

Methods:

Soil degradation studies:

Three types of soil from different localities were sieved. 14 g soil plus 16 ml water were incubated with sodium fluoroacetate (6.1 mg). For analysis, soil samples were centrifuged and the sodium fluoride measured by GLC. In general, the limit of detection of fluoroacate by GLC was 0.3–1 ppb. Samples were analysed up to 100 days after dosing (maximum).

Leaching studies:

A laboratory lysimeter experiment was set up using 3 soil types pH 5–6 held in 10mm (diam.) x 120 mm tubes. Sodium fluoride (4 mg) was applied to the column and 10 x 5 ml pulses of water applied to the column equivalent to 160 mm rain. The eluate was analysed by GLC.

Field analysis of water after aerial baiting for possum control:

Four aerial baiting programmes in various NZ localities for possum control in 1990 – 1993 were studied. Application rates were 5 – 14 kg/ha of 0.018% 1080 bait. Water samples totalling 288 from stream, river, surface water and ground water were taken and assayed for fluoroacetate by GLC (limit of detection 0.3–1 ppb). Sampling was spread from prior to application to 120 days after baiting. In another study in 1992, baited carrots were applied over 1050 ha for rabbit control (16-60 kg/ha of 0.023% bait). Sampling of ponds, streams, groundwater was spread up to 120 days after application. In all of these studies, rainfall was monitored and recorded.