Guidelines for the Safe Use of Sodium Fluoroacetate (1080)

OSH occupational safety & health service te ratonga oranga

DEPARTMENT OF LABOUR TE TARI MAHI

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Introduction

The major purpose of these guidelines is to provide advice on the safe occupational use of sodium monofluoroacetate (1080) in its various formulations. The primary intention is to provide practical guidelines for assisting users to develop working practices of a standard consistent with the requirements of the Health and Safety in Employment Act (HSE Act) 1992 and the Hazardous Substances and New Organisms Act (HSNO Act) 1996.

At the time of preparing these guidelines, 1080 was covered by the transitional provisions of the HSNO Act that carried over controls set under the Toxic Substances Act and the Pesticides Act 1979. As part of a group of controlled vertebrate pesticides, 1080 is due to be transferred into the HSNO regime in July 2003. In March 2002, a decision was made by ERMA New Zealand that grounds exist for reassessment of 1080. The application is being prepared by the Animal Health Board and the Department of Conservation. These processes may result in changes to the existing 1080 controls and/or additional controls being added.

In 2002, OSH adopted a Biological Exposure Index (BEI) for 1080 in urine. This was made possible by recent investigations into the effects of long-term exposures in experimental animals that shed more light on the possible chronic, as opposed to the better known acute, toxicity of 1080. In addition, a urine test for 1080 has now become more widely available and utilised to assess the degree of exposure occurring in formulators and users of this pesticide. Therefore, biological monitoring with reference to the BEI has become a useful component of health surveillance activities.

The Guidelines include information of relevance to all parties involved, including bait distributors, their immediate supervisors, and management. Less emphasis has been placed on the formulation processes, which involve relatively small numbers of staff. However, ongoing human exposure studies (including in the formulating factories) have helped to identify particular tasks and individual behaviours that contribute to the hazard. These findings should enable further recommendations regarding suitable procedures and practice.

As the overall objective is the enhancement of safety and health, other hazards of a non-chemical nature are also considered. More detailed advice on such hazards is available elsewhere. Issues of disposal and assessment of environmental effects have been considered elsewhere and are beyond the scope of these guidelines.

It is intended that these guidelines will be reviewed in 2 years' time or following the adoption of changes to the controls that are placed on 1080 by HSNO legislation.

Acknowledgement

These guidelines were prepared with the assistance of Michael Beasley of the National Poisons Centre, University of Otago, Dunedin.

What is 1080?

Sodium (mono)fluoroacetate is the chemical name for 1080. It was first patented as a rodenticide in the late 1930s, with further research being conducted in the United States in the 1940s due to a shortage of other rodenticides during the war.

A wildlife research centre gave it the acquisition number of "1080" and this identifying number has become its popular name. It began commercial use in 1944, and it was only at about this time that fluoroacetate was also found to occur in nature, as a constituent of some plants. The first trials were carried out in New Zealand in 1954, and by 1957 its use had become widespread. Its use in the United States has since become much more restricted as the US Environmental Protection Agency (EPA) has now required more information on environmental effects before permitting extensive usage. However, no US companies have been prepared to take on the enormous costs involved in undertaking the stringent research requirements. In New Zealand, however, further animal research has been commissioned, and exposure studies are ongoing. Detailed review is beyond the scope of these guidelines.

In pure form, sodium fluoroacetate is a light, fine white powder, similar in appearance to flour. It is odourless and virtually tasteless. Commercial formulations may, however, have a faint vinegary odour due to residual contaminants from its manufacture (although the imported powder has a purity of at least 98%). It has high water-solubility and can absorb water from the atmosphere, to develop a more sticky consistency. It has a very low solubility in organic products such as fats, oils or solvents. It is nonvolatile and is stable to heat up to about 100°C.

1080 preparations used in the field include coated carrot pieces, cereal pellet baits, pastes and gels. Formulations commonly used in New Zealand are discussed in Appendix C.

Properties of 1080

Synonym	Sodium fluoroacetate
Formula	$CH_2FCOONa$
Molecular weight	100.02
Appearance	Colourless or white fluffy powder
Solubility	Soluble in water, insoluble in most organic solvents
Vapour pressure	Negligible
Melting point	200^0C
Odour	Odourless
Workplace Exposure Standard	TWA 0.05 mg/m^3
Biological Exposure Index	15µg/litre 1080 in urine

Routes of Contact

Potential routes of exposure and absorption in occupational situations include inhalation, skin contact and ingestion (usually inadvertent). In the context of 1080 usage, caution has been particularly advised for certain operations.

For example, exposure to residual 1080 solution not absorbed by the carrot or oats may happen, even though the spraying itself occurs within an enclosed system. Exposure can occur during transfer of the freshly prepared baits from the mixing machine to the aircraft or loader bucket. The freshly cut carrot surfaces may be moist and not completely absorb all the 1080 solution. The baits can drip quite readily, and further, the concentration over the outside of the bait is generally more than the intended average concentration. It is possible that any free liquid could be almost at the concentrations initially applied, i.e. 2% or 4% or even 15%.

A second potential 1080 hazard is the airborne dust generated when emptying the bags of dry pellets, often at face-level, into the aircraft or loader bucket. The proximity of the hopper to the aircraft propeller or helicopter rotor blade may increase the dispersion of dust or contaminated soil particles, due to induced air currents.

There may also be the possibility of inadvertent oral intake from hands contaminated either directly or indirectly from clothing.

It is hoped that research can be undertaken to more fully identify — and particularly assess — the hazards of 1080 use, not only regarding field and aerial operations, but also during its formulation at the factories.

Recommendations for Safe Use of 1080

The HSE Act requires employers to identify, assess and control hazards encountered in the workplace. With regard to chemicals, the hazard management steps are set out in more detail in the OSH publication the *Approved Code of Practice for the Management of Substances Hazardous to Health (MOSHH)*. The MOSHH code should be read in conjunction with the following recommendations for the safe use of 1080. A precautionary approach is promoted in the MOSHH code, with a requirement to reduce exposure to all hazardous substances to the lowest practicable level.

Pre-employment Assessments

There are no medical conditions clearly proven to make persons more susceptible to sodium fluoroacetate. Cardiovascular disease, epilepsy and probably diabetes are potential risk factors, although unlikely to be significant at typical exposure levels, or at least those measured to date. Significant dermatitis could result in increased skin absorption, but only severe forms resistant to treatment and protective measures present a high risk. Assessment of mental and psychological status is important.

Education and Training

Sodium monofluoroacetate is a "controlled" pesticide under provisions of the Pesticides Act that have carried over into the transitional provisions of the HSNO Act. Currently, user licences are issued on a "permanent" basis to those successfully completing an examination. While many organisations provide practical on-the-job training, this knowledge is not assessed in a formal way prior to granting a licence and private operators may have had little practical instruction, even after successful completion of the examination.

This situation will change when 1080 comes under the full provisions of the HSNO Act, as users will require a test certificate as an approved handler, as will any person handling substances containing 1080, unless they are under the supervision of an approved handler. To achieve the approved handler status, the applicant will be required to complete a suitable course to satisfy the qualifications specified by HSNO regulations and then obtain a test certificate from a test certifier. A test certificate may be issued to a current user who has yet to obtain the qualifications if they have been working with 1080 in accordance with the Pesticide Act requirements in the previous 2 years (grandparenting provisions). Approved handler test certificates will have to be renewed every 5 years, with the grandparented test certificate lasting for a maximum of 2 years.

Transport and Storage

Sodium monofluoroacetate is a Class 6.1 "Poisonous Substance" in the system for Classification of Hazardous Substances for Transportation on Land. 1080 belongs to

the packing group I, and as such the "skull and cross-bones" depiction is required on the label. Depending on the data used to calculate the toxicity and the formulation of the product, a range of packing groups can be derived applying the classifications set out in the Land Transport Rule. HSNO controls derived from classifications of formulated products will include PG II. Note that the HSNO Classifications of formulated products are based on data for the dog LD_{50} 0.06 mg/kg as this results in more precautionary outcomes than rat data LD_{50} 0.2 mg/kg.

The general and more specific precautions applicable to this Class, and hence to 1080, are outlined in the *Code of Practice for the Transport of Hazardous Substances on Land* (NZS 5433: 1999), available from the Standards Association of New Zealand, and the Toxic Substances Regulations 1983. In particular, 1080 should not be transported or stored with explosives, including oxidising agents, organic peroxides and food or food containers. Transport vehicles should be covered and always attended unless fully lockable. The stock solution should be in shatterproof containers. Final storage facilities should be lockable.

Other useful precautions are:

- do not smoke in or around storage area;
- store away from ignition sources;
- place containers on surface with raised edges to contain spills.

Packaging and storage requirements are contained in section 190 of the HSNO Act and NZS 5433.

Labelling

Currently the requirements are those that were specified under the Pesticides Act 1979 (section 38) and the Toxic Substances Act 1970 and Regulations 1983 (section 23); the latter classified 1080 (all formulations) into the First Schedule as Deadly Poisons. Where practicable, all containers should state "**Deadly Poison. Available to authorised persons only. Keep out of reach of children.**" In addition, with containers of capacity over 100 ml there should be brief statements regarding the following:

- hazards of poison;
- appropriate precautions;
- likely symptoms of poisoning;
- appropriate first aid;
- purpose of use.

Containers of over 100 ml capacity also require a statement on the actions in the event of a spill. All of these requirements apply to current containers of 1080 as these easily exceed the above volume.

Further more specific controls are likely to be applied when 1080 comes under the full provisions of the HSNO Act. (Controls will vary depending on the classification of the substance which will range from 6.1A to 6.1C.)

Safety Data Sheets

A good safety data sheet provides a convenient way for users to obtain the type of information essential for optimal safe usage. It should cover the following items:

- details of supplying company;
- identifying information and physico-chemical description and properties;
- health hazard information, including toxic effects and first aid measures;
- precautions for use, which should consider where relevant the following:
  - personal protection
  - technical/engineering controls
  - exposure standards;
- safe handling information, which should include instruction on:
  - storage and transport
  - fire/explosion hazard
  - spills and disposal.

The Department of Labour (OSH) has produced a publication *Guidelines for the Preparation of Material Safety Data Sheets*. This publication is being updated to reflect the information that will be required by the HSNO controls and will be issued as an Approved Code of Practice under the HSNO Act.

Safe Work Practices and Personal Protective Equipment

In all cases, steps should be taken to minimise exposure to 1080 by adopting sound work practices and wearing suitable personal protective equipment where necessary. Protective clothing needs to be of adequate fit and replaced when necessary. Instructions should be provided on maintenance, storage and cleaning. Protective clothing and equipment must be removed and the hands and face washed before eating, drinking or smoking. It remote areas a bucket of water can be used, with the water being changed at regular intervals. Towels should be provided. Overalls and boots should be cleaned at the end of the day and securely stored. Used overall and boots should never be taken home.

While the degree of protection required would depend on the task being performed, the following general recommendations are made:

Handling Liquid Concentrates

The following PPE is recommended:

- elbow-length rubber or plastic gloves;
- gumboots;
- overalls;
- eye protection;
- respirator*.

Waterproof clothing is desirable wherever severe splashing of solution can occur. For example, a waterproof apron is recommended when operating a carrot cutter.

*A respirator is recommended in situations where large quantities of pellets are being handled or dust containing 1080 can be generated.

(Burst high-pressure hoses occasionally occur). At the least, overalls and gumboots should be worn when preparing carrot or oat baits from the solution.

Handling Prepared Baits: Ground Operations

The following PPE is recommended:

- gloves;
- long sleeves;
- boots;
- respirator*.

With pasting operations, care is required when ground baiting. Special care is required when swinging a grubber towards the body. Serious leg injuries from incorrect use are not unknown. Don't overfill the paste gun and check that the lid is tightly fitted. Clean the outside of gun at finish to prevent risks to young children, domestic animals or pets.

Handling Prepared Baits: Aerial Operations

The following PPE is recommended:

- gloves;
- overalls;
- gumboots;
- respirator*;
- eye protection;
- hearing protection.

A respirator should be worn by staff directly involved in loading aircraft hoppers and is recommended for others involved in the operation.

Staff working under a helicopter must wear high-visibility safety helmets. Only people directly involved in the operation should be allowed in the vicinity. Where practical, loading areas should be cordoned off.

Loaders should listen for any changes in helicopter motor output. When not being loaded, opened 1080 bags should be removed from the vicinity of the operation. Care must be taken to ensure empty bags are not left to blow around when the helicopters are being used.

Other Controls

A process for the storage and disposal of unwanted baits and empty containers is required to ensure that the risk to the community is minimised. Tracking and disposal will be covered specifically under the controls imposed by the HSNO legislation.

*A half-facepiece respirator with P2 particulate (dust) filters or a P2 disposable respirator is recommended. Employees must be instructed in the correct fitting and maintenance of respirators.

In this industry non-chemical hazards may also require control particularly physical or ergonomic hazards. Important issues to consider are:

- *machine safety*: carrot cutting machinery must have adequate guarding;
- *manual handling issues*: frequent lifting activities may need to be eliminated or minimised.

Issues of machine guarding and manual handling are discussed in the following OSH documents and elsewhere:

- *Guidelines for the Guarding of Machinery;*
- *Guarding of Portable Grain Augers;*
- *Ergonomics of Machine Guarding;*
- *Manual Handling: Guidelines for the Workplace;*
- *Manual Handling: A Workbook.*

A clear general principle is that dangerous machine parts should not be within reach of the operator.

Environmental Monitoring

This refers to measurement of airborne levels of a chemical, either in the operator's personal breathing zone or the surrounding ("ambient") air. This type of monitoring is not considered necessary as a regular routine in the great majority of situations, particularly where exposure to 1080 dust or droplets is likely to be sporadic and low. (However, it has been a useful tool in recent research work on 1080 exposures). The current Workplace Exposure Standard for 1080 is 0.05mg/m^3.

Health Surveillance

This activity can include biological monitoring of 1080 exposure, biological monitoring of 1080 effects, and direct medical assessment (health monitoring).

Biological Monitoring

Testing for 1080 in urine is the favoured method for biological monitoring of exposure. Samples can currently be analysed by Landcare Research New Zealand Ltd, Lincoln (phone (03) 325 6700; facsimile (03) 325 2418). Other laboratories may also be able to provide this service. Further details on sample collection, storage and transport are available from Landcare.

Turnaround times for analysis of urine samples will vary, so planning and early notification of sample submissions to Landcare Research is advisable.

Consent must be obtained from the employee prior to testing, and individual results treated as confidential.

It is recommended that sampling be done at the end of the work day and ideally also on the last working day of a "series", in order to increase the chances of detecting the maximum levels. In order to minimise the possibility of contamination, the person should change out of their working clothes and wash their hands thoroughly before submitting a sample.

The measured urinary concentrations can be evaluated by reference to the newly established biological exposure index (BEI) for 1080, of 15 µg/L (*Workplace Exposure Standards Effective from 2002*, Occupational Safety and Health Service, Department of Labour). This standard is partly derived from the very low doses that were found not to be toxic in recent laboratory animal studies.

Concentrations above this level are unacceptable. Furthermore, while this standard takes into account the *possibility* of significantly greater human sensitivity to the chronic toxic effects of 1080 than that found in test animals, by the incorporation of "safety factors", there remains a *very small* possibility that humans could be even more susceptible in a relative sense than what has been allowed for in the calculation of the BEI. Therefore, due to this lack of absolute certainty, it is recommended that efforts be made to minimise urinary levels to as low as possible.

The are no hard and fast "rules" regarding the frequency of urine testing. Decisions should be flexible, and guided by the results of the previous tests (if any), as well as by the presence or otherwise of potentially higher-risk circumstances, including:

- new applicators (or new modes of application where less exposure data exist);
- substandard protective equipment or work practices (though this should NOT occur);
- post-incident testing in the event of mishap.

Emergence of specific, potentially relevant health concerns might also be an indication.

A general recommendation is to test at least twice during the first year (in those not already tested as part of the ongoing exposure studies). These two tests could be done relatively early and late in the "application season" respectively, both ideally during or immediately after a period of comparatively intense application work. In the event of results well within the BEI, monitoring could be reduced to once per year, and could be discontinued after a few years in the event of such consistently low results. On the other hand, more frequent testing is indicated for levels in excess of, or approaching the BEI.

Action required if BEI is exceeded

If urine levels are found to exceed the BEI for the first time, evaluate and correct where deficient the current controls and individual work practices. Repeat the test in 1 week. If the repeat measurement is still above the BEI, the worker should be suspended from work, for 1 week, during which time they should undergo medical assessment (see health monitoring) and be involved in a comprehensive review of control measures.

The longer term aim of control measures is to achieve a urinary level not just below the BEI, but as far below the BEI as possible.

Workers should not continue to work with 1080 while their urine levels remain above the BEI.

Biological Effect Monitoring

There are currently no well-accepted biological effect monitoring strategies available for the assessment of risks from 1080 exposure.

Health Monitoring

Medical assessment and examination should occur as part of preplacement, and also in the event of two successive urine tests exceeding the BEI.

The integrity and barrier function of the skin should be reviewed, with special attention to severe dermatitis, broken or abraded skin. Absorption may also be increased through moist skin, such as from excessive sweating with hot or strenuous circumstances (the latter could also increase respiratory intake).

An important component of health monitoring is to obtain information shedding light on male reproductive function, pregnancy outcomes (where relevant), and cardiovascular health status. In the event of abnormalities, 1080 should be *considered* as a possible influence, though this is considered extremely unlikely with exposure levels associated with urine concentrations below the BEI.

Other aspects of health monitoring, particularly in the wider context of pest destruction work, could include screening for skin cancer and periodic hearing tests. The latter applies particularly for field staff involved in aerial operations or working near other noisy machinery, or using firearms regularly, particularly shotguns.

It is noted that under the HSE Act, the employer must obtain informed consent before monitoring the health of employees. All medical information must be kept confidential.

First Aid Measures

Skin Exposures

These are unlikely to be acutely hazardous. However *prolonged* skin contact with concentrated solution must be avoided particularly where cuts and abrasions exist (see Personal Protective Equipment). Irrigate the skin with water for 10-15 minutes if clothes become heavily soaked, and change any wet clothes.

Ingestion

Currently there are no very effective decontamination treatments or antidotes for 1080.

In live animal models, it does not appear to be effectively adsorbed to activated charcoal. The emetic, syrup of ipecac, is no longer available. In any case, induction of vomiting by use of an emetic generally removes only half of a toxin at most, and can cause complications, should coma or convulsions due to 1080 develop while vomiting is still occurring.

"Water to dilute" is unlikely to be effective, and indeed could increase absorption. Food may be slightly effective only. A finger inserted down the throat is not a reliable method to induce vomiting.

Colestipol is one of several anion exchange resins recently investigated as a binding agent for 1080. A small number of tests have suggested more effectiveness than activated charcoal; however data are few and supportive evidence nonexistent in humans.

The only current field antidote available for oral administration is ethanol (alcohol); conveniently available in concentrated forms such as whisky or other spirits. While there is some theoretical support for a beneficial role, there is no real evidence of effect and it cannot be relied upon.

With 1080, prevention is better than cure.

ACCIDENTAL INGESTION MUST BE PREVENTED!

Should inadvertent or deliberate ingestion occur:

- attempt to induce a single vomit with a finger inserted down the throat (this is not a reliable method);
- give alcohol to drink if available;
- SEEK MEDICAL ATTENTION URGENTLY.

Do not be delayed by prolonged attempts at inducing vomiting/giving alcohol which are not very effective.

- Definitive treatment involves intensive monitoring of the patient with symptomatic and supportive management, including use of oxygen.
- Veterinarians have had success from treating dogs with emetic (apomorphine) and anaesthesia with pentothal and a halothane/oxygen mixture.

Public Health Considerations

Operators should be aware of the restrictions imposed on how and where controlled pesticides can be used. These are outlined in the Pesticides (Vertebrate Pest Control) Regulations 1983. Section 12 defines various restricted areas within which 1080 cannot be applied, without either prior permission of or consultation with the Medical Officer of Health of the district, or an appropriate authority. Such areas include:

- public roads and other places of public access or within 60 meters thereof;
- catchment areas from which water is drawn for human consumption;
- inside or within 400 meters of areas controlled by local authorities or other defined communities.

Further, all aerial applications require permission from the Medical Officer of Health of the district.

Note the HSNO controls that will be assigned to 1080 are likely to change the notification and consultation requirements.

Review and Evaluation

The practice of occupational health and safety is an ongoing business. There should be systems in place to encourage the reporting, recording and evaluation of incidents, accidents or illnesses occurring during pest destruction work, or of hazards noted during this work.

Appendix A: Toxicity of 1080

Pure (i.e. 100%) 1080 is a highly toxic chemical. The oral dose sufficient to be lethal to most humans is thought to fall between 2-10 milligrams of 1080 per kilogram of body weight. This corresponds to at least 20mg in a 10kg toddler, to 100-200 mg in adults. In a young 15kg child, it may take at least 7 or 8 pellets of 5 grams and 0.08% strength to be fatal. However, it is thought that as little as 0.5 mg/kg could cause symptoms, so that even as few as 2 or 3 pellets could be hazardous, certainly if the larger variety of 8 grams and 0.15% strength. In adults, as little as 1ml of 20% solution is potentially fatal if swallowed.

Animal experiments estimating LD_{50} values, or the dose likely to be lethal to 50% of those tested, reinforce that pure 1080 is in the super-toxic class. Dogs are particularly susceptible, with an estimated median single lethal dose (LD_{50}) of about 0.06 mg/kg, a sensitivity perhaps twenty times greater than that of humans.

However, confusion should not arise between the very high toxicity of pure 1080, and the much lesser toxicities of the formulated products, depending on the exact concentration of 1080 in them. For example, low-strength (0.04 – 0.08%) formulations are categorised as HSNO 6.1C only.

There is a moderate amount of information on the adverse effects on humans from relatively high one-off doses arising from accidental or intentional ingestion of relatively concentrated formulations. However, data are scanty regarding repetitive, low-level inhalational and skin exposures, so the level of risk in this context is not well defined. There are very few well-documented and proven cases of 1080 toxicity arising during pest destruction work, although the full-strength powder itself has caused problems.

Given this situation, to some degree, as with many pesticides, animal studies need to be utilised to help assess the likely human risks from low-level repetitive exposures. The relatively few studies of lethality risks following dermal application suggest skin absorption of 1080 is quite low (though this will be enhanced in the presence of severe dermatitis, cuts or abrasions, and possibly moist skin). The major line of evidence is that it takes a great deal more 1080 to be fatal when applied to the skin for several hours than when dosed orally. Furthermore, the animal experiments show that 1080 is broken down and/or eliminated from the body quite promptly (within a few days, though this varies somewhat between mammalian species). Therefore high accumulation of 1080 in living animals is unlikely.

Sodium fluoroacetate is not toxic in itself, but some is converted in the body to fluorocitrate, and this chemical blocks an essential body process called the “Krebs” (or tricarboxylic acid) Cycle. This is a recycling process present in each cell which plays an essential part in a chain of events in which the energy content of foodstuffs or other body stores is used to continuously produce key chemicals which are essential because of their high energy content present in a chemical form more directly utilisable for vital cellular functions. Only a minority of absorbed fluoroacetate is converted to the toxic fluorocitrate. About one-third is excreted

unchanged (most within a few days), and the rest as a range of metabolites or breakdown products.

The organs most affected are those most dependent on continuing supplies of utilisable energy. Thus the key target organs are the heart and brain, with the exact balance varying between species. In humans, symptoms can include nausea, vomiting, apprehension, perspiration, tremors, increased heart rate, elevated blood pressure, and drowsiness leading to coma and convulsions. Death may result from either cardiac or respiratory failure. There is a delay of at least half an hour and often several hours before the onset of symptoms following swallowing. This is largely due to the time required to form fluorocitrate.

Antidotes have been designed to provide high levels of acetate, in the hope of its competing with fluoroacetate for the same specific chemical, which plays a part in the "toxic" conversion of fluoroacetate to fluorocitrate. While antidotes are difficult to thoroughly evaluate in humans, the animal evidence suggests that the antidotes are not reliably successful and need to be given very early to have much effect at all.

The question arises as to whether either a milder acute illness or more gradual long-term effects may occur from very slight but recurrent exposures. Certainly, toxic effects have been noted in regular repeat dosing of small amounts in animals, by injection or orally. These include adverse effects on heart muscle and the testes. The studies suggest that such effects may arise from cumulative damage (so long as daily exposure continues) rather than accumulation of 1080 itself, which is not high.

Due to low skin absorption, good excretion, and relatively brief and/or low inhalation exposures, such effects seem unlikely in human users (though the possibility of myocarditis was raised in one case involving a manufacturing chemist). However, new research has helped to clarify the minimum doses required to produce these effects in test animals, so that the risks to humans (depending on their estimated dose) can be better predicted. This research also has included studies on the possibility of birth defects.

Appendix B: 1080 Risk Assessment

Risks can be assessed from theoretical considerations or the more direct empirical approach of reviewing the evidence available. The latter type of information suggests a relatively low hazard from 1080 operations, with very few well-documented cases of acute illness. (An overseas report of serious illnesses following use of a 0.1% mixture in a steel mill, and anecdotal reports of suicidal ingestions are not directly relevant.) An older published NZ case of chronic kidney and other disease attributed to 1080 exposure some weeks previously was considered doubtful by several reviewers.

There have been two serious cases on the files of the National Poisons Centre, both describing symptoms consistent with 1080 poisoning but not providing any indication as to what the mishap might have been (suicide attempts seemed unlikely explanations at the time but could not be excluded in the latter case). One case involved brief loss of consciousness while distributing carrot baits mixed with 1080 about 6 hours previously. Evidence for cause and effect was stronger in the other case, which had a fatal outcome. Levels of the chemical in skeletal muscle were considerably higher than those generally found in test animals dying from 1080 dosing. There have been only isolated reports in more recent times, involving milder symptoms, not clearly linkable to 1080.

Animal data strongly suggest that skin absorption is low, as much higher doses are required in order to be fatal when applied to the skin (for at least 4 hours) than when given orally. (The difference is over a hundredfold on some rodent species.) Therefore, from a theoretical point of view, while skin absorption cannot be ignored completely, the risk of ingestion or inhalation is of more concern.

It is theoretically possible that accidental swallowing of even less than 5ml of a 4% solution, such as that used to prepare carrot baits, could be serious or even fatal. On the other hand, accidental ingestion of treated baits, even at the highest strength of 0.15%, is much less of a hazard to workers, although 20gm (less than one ounce) could be fatal to a toddler. The likelihood of a direct splash is low given the enclosed nature of the carroting process, but face shields are a justifiable precaution.

Inhalation risks are less, as 1080 does not form a vapour. Based on usual rates of air intake, it is likely that airborne dusts would need to be present at around the high limits set for nuisance dusts (10mg/m^3 of inspirable particles) for the best part of a working day to present a risk of life-threatening *acute* effects.

There is relatively little accumulation of fluoroacetate in the body and no direct evidence of long-term adverse effects in humans. However, some animal studies have demonstrated sensitivity of certain organs to repeated low doses. It is not known how sensitive humans might be to such effects relative to the animal species tested. In setting of the BEI for 1080 in urine, a “safety factor”, allowing for the worse case scenario of possibly substantially greater human susceptibility, has in effect been built in to the calculations. Certainly it is sensible to minimise exposure to 1080 in all situations, and this may necessitate the use of PPE.

Appendix C: Formulations and Methods of Use

New Zealand is the largest user of 1080 in the world. It is imported as a relatively pure (at least 98%) powder, from which various formulations are prepared at specialist factories. It is then distributed to user organisations, by far the major ones being the Regional Councils, government departments such as DOC and MAF, and on a more limited scale, other research institutions. All of these must have approved operators to order the product.

There are three major types of 1080 preparation: the stock solution (20%), 1080 pellets, and various pastes and gels. The stock solution is used at the factories in the production of pastes and pellet baits, but can also be sold directly to clients for application to field-prepared baits based on carrot or oats.

Paste or "jam" baits often comprise apple pulp as the major constituent to which is added preservative, a "lure oil", green dye and 1080 solution, giving a final strength of 0.06%, 0.08% or 0.15%.

The pellet baits incorporate various types of cereal, dye and 1080 in concentrations ranging from 0.02% for rabbits and to 0.15% (and possibly even 0.3%) for deer. For possums, the usual strengths used are 0.08% and, increasingly, 0.15%. Baits can range between 1 – 20 grams in weight.

The paste preparations are often applied with a so-called "jam gun" to pastoral areas, often to a sod upturned by an implement generally known as a grubber. "Mastic guns" can also be used to apply paste either to bait stations (often placed horizontally for weather protection) or more directly to trees.

Gels at 5 and 10% 1080 are applied directly to foliage; gel bait blocks 0.15% are placed in bait stations. There is also a fish-based paste 1% 1080 registered by DoC for use against wasps — though it hasn't be used for quite some time, the registration is still current while safer alternatives are explored.

The great majority of pellets are used in aerial applications. At the landing strip the 25kg bags are cut open and the pellets tipped into a container, from which they are loaded into the aircraft hopper, this procedure often occurring at about face level. At this stage the pellets are dry with usually some debris at the bottom of the bag, which can form an airborne dust when it is upended. Pellets are also used in bait stations.

Field-prepared baits involve application of appropriate dilutions of 20% stock solution to a known weight of carrot. Preparations include 1 to 9 or 2 to 8 dilutions with water, giving 2% or 4% solutions. Ten litres is then sprayed onto 1 tonne (1000kg) of carrot, giving a final average level in carrot of 0.02% or 0.04%. Occasionally a 0.15% bait strength may be produced from application of a 15% solution, and 0.08% strength is also used. Large operations may involve any of four types of carrot cutter: the Bental, Gibson, Haldee and Reliance. The spraying operation is an enclosed process. Concrete mixers may be used for small amounts.

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