# FINAL REPORT

# Aquatic Animal Health Subprogram: AQUAVETPLAN Operational Procedures Manual Decontamination


**Kevin Ellard**



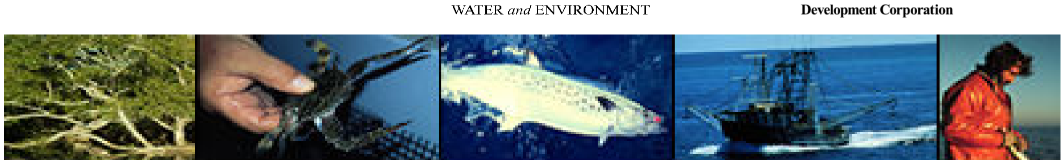
**January 2006**

**FRDC Project No. 2002/653**

Australian Government
Department of Agriculture, Fisheries and Forestry

Tasmania
DEPARTMENT *of* PRIMARY INDUSTRIES, WATER *and* ENVIRONMENT

Australian Government
Fisheries Research and Development Corporation

Kevin Ellard

Aquatic Animal Health Subprogram: AQUAVETPLAN Operational Procedures Manual - Decontamination

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## NON-TECHNICAL SUMMARY

| 2002/653 | Aquatic Animal Health Subprogram: AQUAVETPLAN Operational Procedures Manual - Decontamination |
|---|---|

**PRINCIPAL INVESTIGATOR:** Kevin Ellard

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### OBJECTIVES:

1. To produce a technical manual outlining disinfection procedures for aquatic animal pathogens
2. To present the technical information in a format that can be easily accessed and understood by a wide range of personnel in the event of an aquatic animal disease emergency
3. To complement existing manuals currently in place for AQUAVETPLAN.

### NON-TECHNICAL SUMMARY:

The output of this project, Aquatic Animal Health Subprogram: AQUAVETPLAN Operational Procedures Manual – Decontamination, provides a resource outlining decontamination procedures suitable for use during aquatic animal disease emergency response procedures.

In order to provide a document suitable for use in a range of aquaculture and fishing industries throughout Australia, significant emphasis has been placed on processes involved in decontamination rather than simply recommending a range of disinfectants and concentrations. As a result the manual has been divided into two major sections.

*Part A* of the manual describes the basic principles relating to decontamination procedures for aquaculture or fishing industry establishments, presenting these within the three major areas of planning, cleaning and disinfection.

*Part B* contains a series of tables and job sheets summarising procedures and providing recommendations for specific enterprise types, tasks and disinfectant techniques. Various parts of this section are suitable for use as individual technical advice sheets during aquatic animal emergency disease events.

The project has used a wide range of published and unpublished literature on decontamination procedures and extensive consultation with key government and industry personnel to finalise manual content.

Draft versions of the manual were distributed to personnel involved in aquatic animal disease emergency response in all States and Territories of Australia. Where appropriate, recommendations have been incorporated into the final document.

The manual has been prepared for formal endorsement by Australia's National Aquatic Animal Health Technical Working Group and the Aquatic Animal Health Committee. Copies of the final manual will be distributed to all government agencies throughout Australia involved in emergency animal disease response and preparedness.

OUTCOMES ACHIEVED TO DATE

As a result of the completion and distribution of the document, AUSVETPLAN Operational Procedures Manual- Decontamination, anticipated outcomes include:

- Improved access to information relating to decontamination procedures for aquatic animal disease
- Improved response capabilities during aquatic animal disease emergency events
- Greater awareness of the need for appropriate decontamination procedures by personnel employed in government and industry sectors
- The implementation of specific decontamination procedures as part of standard operating practice by industry and government to maintain regional biosecurity and emergency disease preparedness.

**KEYWORDS:** **Decontamination, AQUAVETPLAN, aquatic animal disease, fisheries aquaculture, cleaning and disinfection.**

## ACKNOWLEDGEMENTS:

The author would like to thank all those who reviewed and commented on the draft versions of the AQUAVETPLAN Operational Procedures Manual – Decontamination.

Special thanks are also extended to the co-investigators Dr Frances Stephens (Western Australian Department of Fisheries) and Dr Joanne Sadler (private consultant), for their input into initial drafts of the document.

Primary reviewers included:
Dr Brian Jones, Western Australian Department of Fisheries
Dr Nick Moody, Queensland Department of Primary Industries and Fisheries
Dr Ian Anderson, Queensland Department of Primary Industries and Fisheries
Dr Marty Deveney, Department of Primary Industries and Resources, South Australia
Mathew Landos, University of Sydney (previously NSW Fisheries)
Dr Ken McColl, CSIRO - Australian Animal Health Laboratories
Dr Jeremy Carson, Tasmanian Department of Primary Industries Water and Environment
Dr Judith Handlinger, Tasmanian Department of Primary Industries Water and Environment
Belinda Wright and other members of the Office of the Chief Veterinary Officer, Australian Government Department of Agriculture, Fisheries and Forestry.


## BACKGROUND:

This joint FRDC and Tasmanian Department of Primary Industries Water and Environment funded project was undertaken in response to an identified need to provide a series of technical manuals addressing aquatic animal disease preparedness and response as part of AQUAVETPLAN. Industry and government stakeholders together with the FRDC Aquatic Animal Health Subprogram have identified the production of such documents as a priority.

At their meeting on 15 February 2002 the AQUAPLAN Business Group (ABG) discussed a range of proposed needs as part of the process for building a national approach to animal and plant health. Amongst the items discussed, emergency management and the need for a series of technical manuals relating to emergency preparedness and response were identified as priorities. The preparation of a manual outlining decontamination procedures suitable for use during aquatic animal disease events, could be used for training purposes and as an emergency procedures guide, was identified as a specific need by the Tasmanian Department of Primary Industries Water and Environment

A successful research and development application to the FRDC Aquatic Animal Health Subprogram secured limited funding for the project in November 2002. The Tasmanian Department of Primary Industries Water and Environment, Animal Health and Welfare Branch provided significant additional support, allowing the project to be completed.

## NEED:

Program 4 of AQUAPLAN is a planned series of technical response manuals that describes the proposed Australian approach to an aquatic animal disease emergency event. The decontamination manual within this series is a key document required during the early stages of any exotic disease incursion and complements existing operational procedure manuals[1].

## OBJECTIVES:

1. To produce a technical manual outlining disinfection procedures for aquatic animal pathogens
2. To present the technical information in a format that can be easily accessed and understood by a wide range of personnel in the event of an aquatic animal emergency disease event
3. To complement existing manuals currently in place for AQUAVETPLAN.

## METHODS:

This project is largely a review of existing and emerging scientific literature pertaining to disinfection and decontamination of disease causing organisms. Information obtained from the review was then used to develop operational procedures suitable for decontamination of aquaculture and fisheries facilities.

Methodology was undertaken according to the following format.

1. Review of published literature relating to disinfection and decontamination techniques
2. Preparation of a document outline in accordance with the AQUAVETPLAN document format for comment by reviewers
3. An assessment of government and industry needs relating to decontamination during an aquatic animal emergency disease response
4. The preparation of a draft document for comment
5. Preparation of a final document for review by the National Aquatic Animal Health Technical Working Group and Aquatic Animal Health Committee.

## RESULTS/DISCUSSION:

Within the final document significant emphasis has been placed on processes involved in decontamination rather than simply recommending a range of disinfectants and concentrations. As a result, the manual has been divided into two major sections.

*Part A* describes the basic principles relating to decontamination procedures for aquaculture and fishing establishments and presents these within the chapters of planning, cleaning and disinfection.

*Part B* contains a series of job sheets summarising procedures and providing recommendations for specific enterprise types and tasks. In an effort to make information readily accessible and easily interpreted, tables have been used throughout the document to summarise recommendations and technical information contained within the text.

1: AQUAVETPLAN Operational Procedures Manual – Disposal,
AQUAVETPLAN Operational Procedures Manual - Destruction

Following a detailed literature review, a document outline was prepared and circulated for comment during 2003. The FRDC AAH Sub-program Steering Committee approved this document outline in July 2003. The project then undertook an assessment of industry and government requirements to finalise specific details to be outlined within the manual.

A draft copy of the decontamination manual was circulated to State and Territory government experts during July 2005. Comments have been incorporated into the final draft document, as appropriate.

## BENEFITS AND ADOPTION:

Major beneficiaries of this manual will be State and Territory agencies involved in emergency response to aquatic animal disease and those engaged in regional aquatic animal biosecurity.

Farm managers, industry representatives and aquatic health training establishments are considered secondary beneficiaries that may also utilise the manual.

## PLANNED OUTCOMES:

The output of this project, in the form of the AQUAVETPLAN Operational Procedures - Decontamination Manual, will contribute to planned outcomes by having:

1. Produced a technical manual outlining disinfection procedures for aquatic animal pathogens
2. Presented the technical information in a format that can be easily accessed and understood by a wide range of personnel in the event of an aquatic animal disease emergency event
3. Complemented existing manuals currently in place within AQUAVETPLAN.

As a result, planned outcomes are anticipated to include:

- Improved access to information on decontamination procedures for diseases of aquatic animals
- Improved response capabilities during aquatic animal disease emergency events
- A greater awareness of the need for appropriate decontamination procedures by personnel employed in both government and industry sectors
- The implementation of specific decontamination procedures as part of standard operating practice by industry and government to maintain acceptable regional biosecurity.

## CONCLUSION:

The objectives of this project have been achieved following the production of a draft document suitable for use as the AQUAVETPLAN Operational Procedures Manual – Decontamination.

## REFERENCES:

A full list of the references used during this project is contained within Attachment 1: AQUAVETPLAN Operational Procedures Manual – Decontamination Manual (page 91 of the manual).

## APPENDIX 1:

This project has not developed any intellectual property that requires legal protection. The nature of the project output, AQUAVETPLAN Operational Procedures Manual – Decontamination, is designed to provide guidance during aquatic animal emergency disease events.

## APPENDIX 2:

| | |
|---|---|
| Principal investigator | Kevin Ellard |
| Co-investigators | Dr Frances Stephens |
| | Dr Joanne Sadler |

## ATTACHMENT 1:

AQUAVETPLAN Operational Procedures Manual – Decontamination Manual

**AUSTRALIAN AQUATIC ANIMAL DISEASES**
**VETERINARY EMERGENCY PLAN**

# AQUAVETPLAN

**Operational Procedures Manual**

# *DECONTAMINATION*

***(Draft version for NAAH-TWG and AAHC endorsement: December 2005)***

AQUAVETPLAN is a series of technical response plans that describe the proposed Australian approach to an aquatic animal emergency disease event. The documents provide guidance based on sound analysis, linking policy, strategies, implementation, coordination and emergency management plans.

**Primary Industries Standing Council**

**Operational Procedures Manual: Decontamination (Version 1.0) forms part of:**
**AQUAVETPLAN Edition 1**

**This document will be reviewed regularly. Suggestions and recommendations for amendments should be forwarded to:**
The AQUAVETPLAN Coordinator
Office of the Chief Veterinary Officer
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GPO Box 858, Canberra ACT 2601
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**Publication record:**

**AQUAVETPLAN is available on the internet at:**
**http://www.daff.gov.au/aquavetplan**

**AQUAVETPLAN Operational Procedures Manual – Decontamination**

Ellard, K., Stephens, F. and Sadler, J.

Published by the Tasmanian Department of Primary Industries Water and Environment.

# Preface

This Operational Procedures Manual outlining decontamination procedures for use in emergency aquatic animal disease incidents forms part of the Australian Aquatic Animal Disease Emergency Plan, or AQUAVETPLAN (Edition 1)[1].

AQUAVETPLAN is a series of technical response plans that describe the proposed Australian approach to an aquatic animal disease emergency. These documents provide guidance based on sound analysis, linking policy, strategies, implementation, coordination and emergency management plans.

The primary reason for decontamination of infected premises or equipment is to prevent the spread of disease. Detailed instructions for the field implementation of AQUAVETPLAN are contained within disease strategy manuals, operational procedure manuals and management manuals. Industry-specific information is given in the enterprise manual. The full list of AQUAVETPLAN manuals that may need to be accessed in an emergency is shown below:

**Disease strategies**
Individual strategies for each disease

**Operational procedures manuals**
Disposal
Destruction
Decontamination

**Management manuals**
Control centres management

**Enterprise manual**
Including sections on:
– open systems
– semi-open systems
– semi-closed systems
– closed systems

Terminology of this manual parallels that of the AQUAVETPLAN Enterprise Manual[1] by dividing aquaculture into four systems based on the ability to control the water and stock involved in particular establishments. When designing and implementing any decontamination program, several factors need to be considered. These include the type of pathogen, the type of system (open, semi-open, semi-closed or closed), the degree of organic soilage, quality of water supply and avenues for safe disposal of waste.

This decontamination manual is aimed at both government and industry personnel who may be involved in emergency disease preparedness and response. It is designed to provide decision-makers with access to sufficient information on decontamination procedures to enable informed decisions. The manual does not replace State, Territory, industry or farm emergency plans, which may have a more specific operational focus. Instead it is designed to complement such plans and documents.

Relevant State or Commonwealth legislation governing the use of chemicals, occupational health and safety and environmental impact must also be considered. All decontamination procedures need to be conducted in accordance with agricultural and veterinary chemical guidelines as well as environmental legislation, which may vary between States and Territories.

1: www.daff.gov.au/aquaticanimalhealth

To facilitate access to relevant information, certain sections or tables have been reproduced from other documents. The reader is also referred to relevant sections within AUSVETPLAN[1].

Summary tables and job sheets relating to diseases and production enterprises have been used wherever possible.

1: www.animalhealthaustralia.com.au

# Membership of writing group

This manual has been prepared by;

Kevin Ellard, Tasmanian Department of Primary Industry Water & Environment.

Although the author was responsible for drafting this manual, some parts of the text have been amended at various stages during the consultation/approval process. Policies expressed in this version do not necessarily reflect the views of all contributors.

The assistance of the following contributors is gratefully acknowledged:

Dr Fances Stephens, Veterinary Fish Pathologist, Department of Fisheries,
Government of Western Australia

and

Dr Joanne Sadler, formerly Fish Health/ Research & Development, Nortas Pty Ltd, Tasmania

# Contents

# List of figures and tables

## PART A



## PART B

# List of caution notes

# About this manual

This manual provides specific information applicable to the control of disease agents during an emergency disease response. It is primarily concerned with the decontamination of the production environment following disease incursion rather than routine hygiene procedures necessary for the production of healthy stock.

The manual should also be regarded as a potential training resource. Significant emphasis has been placed on the processes involved in decontamination rather than simply recommending a range of disinfectants and concentrations. It is for this reason that the document is divided into two major sections. *Part A* provides information on the basic principles and planning of a decontamination program, whilst *Part B* is a collection of specific recommendations for a range of common tasks. Information considered by the author to be significant may be included in both sections.

It is assumed that during the initial stages of an emergency disease event stock will be either culled or emergency harvested and disposed of according to the directions of regulatory authorities. Consequently, the procedures outlined in this manual do not consider the safety of aquatic animal stock held on infected premises.

For the purposes of this document 'decontamination' refers to the complex process involving cleaning, destruction of the infective agent and disposal of contaminated materials.

## Part A: General Principles

*Part A* describes basic principles relating to decontamination procedures for aquaculture establishments. It is strongly recommended that this section be consulted when undertaking preparations for emergency disease response, training of personnel or during the planning stage of any decontamination program.

*Part A* has three major chapters.

- **Planning**- describes aspects that must be taken into consideration when designing and planning decontamination programs.
- **Cleaning**- describes key aspects of the cleaning process.
- **Disinfection**- describes key aspects of the disinfection process and a listing of common disinfection agents together with their advantages and disadvantages.

## Part B: Recommendations for specific procedures

*Part B* contains a series of tables and job sheets summarising procedures and providing recommendations for specific enterprise types and tasks. These have been divided into the following groups.

- **Recommendations for enterprise types**- provides an overview of the restrictions and limitations with regard to decontamination for each of the major enterprise types (as described in the AQUAVETPLAN Enterprise Manual[1]).

1: www.daff.gov.au/aquaticanimalhealth

- **Recommendations for common disinfecting agents**- provides technical information on common agents used for disinfection.
- **Recommendations for decontamination of site infrastructure-** outlines procedures that should be considered when attempting to decontaminate equipment or material commonly found on aquaculture or fishing enterprises.
- **Decontamination procedures for personnel**- this section outlines decontamination procedures for personnel moving between facilities and working on decontamination programs.

Since the effectiveness of any decontamination process is dependent upon the conditions under which it is used, persons using recommendations made within *Part B* should also take into account factors outlined within *Part A* of the document.

# Part A: General Principles

## A 1. The decontamination process

The process of decontamination involves a combination of both physical and chemical procedures that are used to remove soiling[1] and inactivate the target pathogenic organism. The process should also take into account appropriate disposal of waste products.

An effective decontamination program is vital during all stages of any emergency disease response. Appropriate procedures are required to allow personnel, machinery and equipment to move safely between properties during surveillance, destocking or clean-up stages of the operation. Decontamination procedures will also reduce the period between initial destocking and the re-introduction of healthy fish stocks to a previously contaminated site.

The planning and design of decontamination procedures incorporate a number of stages that include the identification and assessment of risks, design of efficient and effective procedures, training of personnel, implementation of the procedures and testing for effectiveness.

In the case of aquatic animal disease, implementation of effective decontamination procedures presents unique challenges that usually involve the containment and disinfection of large quantities water as well the disposal of waste material. There are also specific difficulties associated with decontaminating large equipment such as biofilter towers and marine vessels.

Although this manual is primarily designed for use during an aquatic animal emergency disease event, appropriate sanitation procedures should also form part of routine husbandry practices for any aquaculture or processing establishment. Decontamination strategies used for the regular maintenance of sanitary operating procedures and emergency disease response measures differ only in terms of the selection, application and allocation of specific resources. The general principles of decontamination remain the same in each case and are summarised within Figure A1.

### A 1.1 Stages of the decontamination process

To be effective, the decontamination process should be broken down into a series of specific procedures that address identified risks. Figure A2 illustrates how each procedure is related to a specific task (eg. decontamination of dive equipment or the treatment of discharge water) and how these procedures combine to form the final decontamination program.

Individual procedures will vary in complexity depending on the size of the task and type of equipment involved. For example, tasks required could include relatively straightforward decontamination procedures for personnel moving between sites, through to more complex procedures for decontamination of hatchery recirculation systems.

These individual procedures also consist of a number of stages. For the purposes of this document these stages have been identified as planning, cleaning, decontamination and assessment.

1: Refer to section A 3.2 for an appropriate definition of ‘soil’ and ‘soiling’

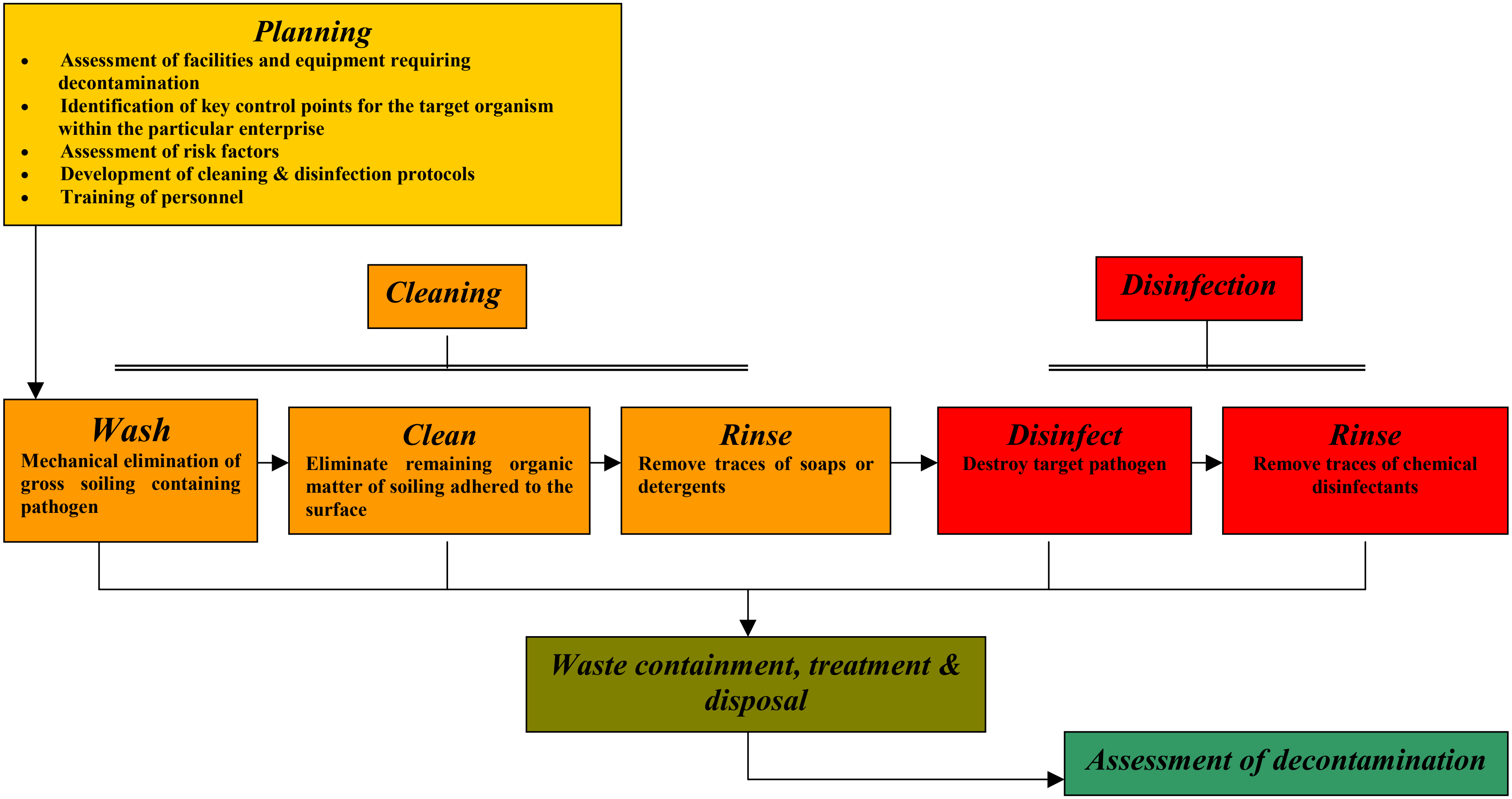



**Figure A1: The decontamination process**
**(Adapted from principles described in Le Breton, 2001a)**

## *A* 1.2 Risks & pitfalls

It is a surprisingly common misconception that disinfection procedures require only cursory application of chemical disinfectants to be effective. Unfortunately this can result in practices that are both ineffective and provide a false sense of security, ultimately allowing personnel, machinery or equipment to travel between sites while still contaminated. It is therefore important to be aware of the points listed within Table A1 when designing and implementing programs.

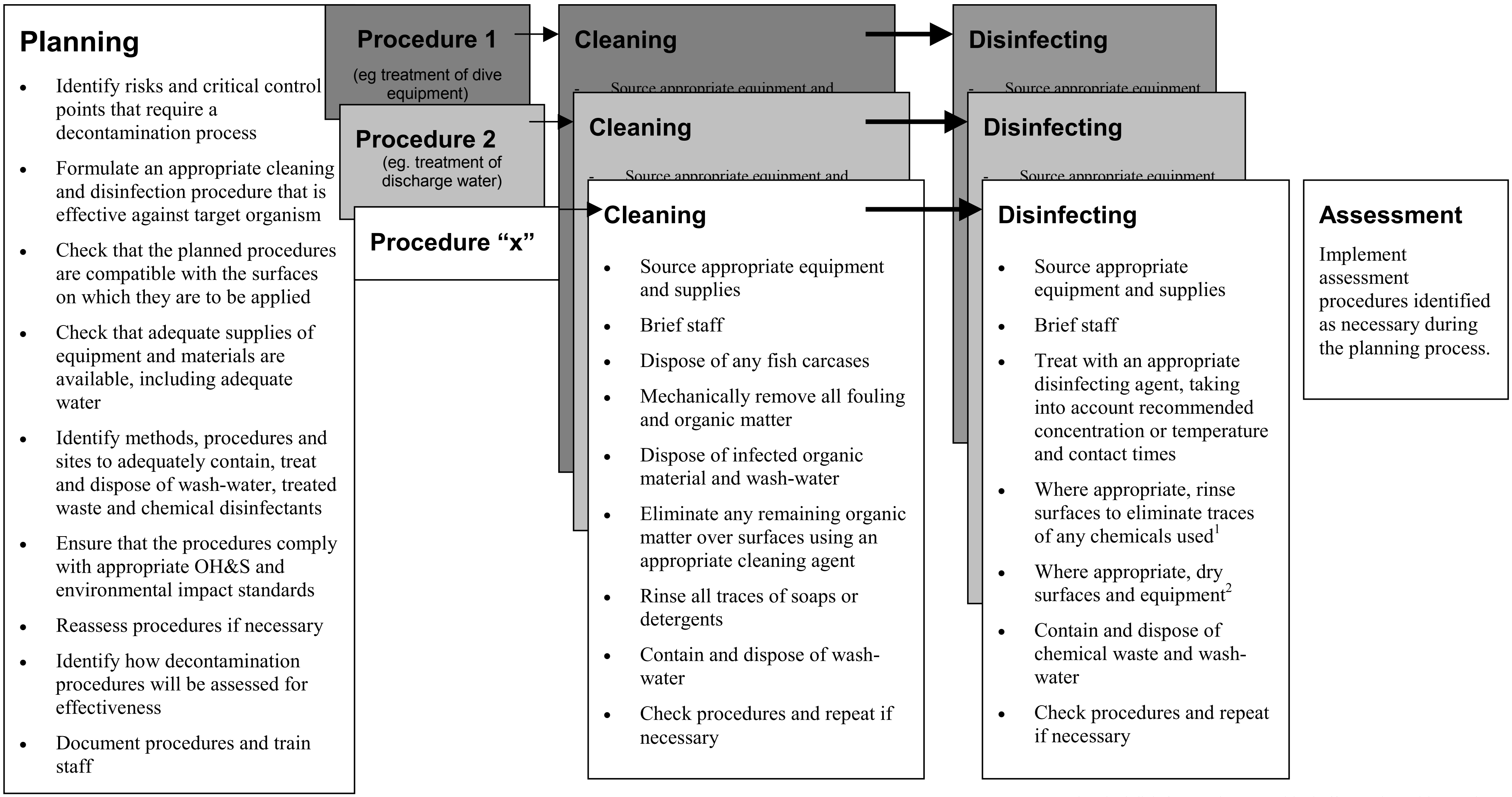
Ineffective decontamination generally fails to include adequate cleaning as part of the process; uses inappropriate disinfecting agents; or does not take into account adequate contact time. For example, footbaths that are replenished infrequently or have staff walking through them without pausing to clean footwear are of limited value. Similarly, divers working on farms removing mortalities from cages sometimes reassure themselves with a cursory application of sanitising solution that is insufficient to deal with the accumulation of fish slime or oils that can rapidly build up on suits, decks and equipment. Under such circumstances the chemical disinfectant is merely treating the surface of accumulations, leaving the infective agent protected within an envelope of organic matter.

Decontamination procedures, whether being used during an emergency response or as part of routine management, must be effective in order to be worthwhile, but they should also be straightforward since overly cumbersome or complex procedures tend to be either ignored or undertaken in a cursory fashion.

**Table A1: Ten points to remember when planning and undertaking a decontamination program**

1. **Effective cleaning should be considered responsible for more than 90% of the success of a decontamination program**
2. **Accumulations of soil, dirt, or organic matter provide an effective barrier, protecting pathogens from disinfecting agents**
3. **Organic matter rapidly inactivates a number of chemical disinfectants**
4. **Certain cleaning agents can inactivate specific types of chemical disinfectants**
5. **The effectiveness of certain cleaning compounds and disinfectants is reliant on the quality and hardness of the water used**
6. **The effectiveness of chemical disinfectants depends on the concentration used as well as the contact time**
7. **The relative effectiveness of many chemical disinfectants is depends on temperature and pH**
8. **Many disinfectants are corrosive to equipment and most are irritant to people and toxic to aquatic life**
9. **Washwater may still contain viable pathogenic organisms or polluting chemicals and should be disposed of appropriately**
10. **Many chemical disinfectants are not effective against spores, and some are only mildly effective against mycobacteria or non-lipid viruses**

**Figure A2: Stages of decontamination.**




1: Some chemical disinfectants have a residual effect and provide ongoing benefits if not rinsed. Rinsing is generally not required following physical disinfectant processes.
2. The need to dry surfaces and equipment is dependent upon the type of equipment and the chemical used.

# A 2. Planning

During any aquatic animal emergency disease event the objectives of decontamination should be to:

- allow staff and equipment used for inspection duties to move safely between sites
- allow staff and equipment located on known infected premises to safely move off the site without risk of spreading infection
- reduce the level pathogen loading on the infected premises, and
- allow the property to be released from quarantine.

Each of the objectives listed above has increasing complexity and logistical difficulty. It is important to consider a number of key issues during the planning stage. These issues are most likely to include the following:

1. What is the organism or pathogen of concern and how is it most effectively inactivated?
2. What is the type of enterprise involved?
3. What types of material or equipment require decontamination?
4. Is the available water supply of sufficient quality and quantity?
5. What options are available for disinfection?
6. What are the risks to the safety of personnel?
7. Are there environmental pollution risks?
8. What is the relevant legislation that must be complied with?

## A 2.1 Nature of the pathogen

The pathogens of aquatic animals that are listed as reportable within Australia are predominantly viral, but also include several non-spore forming bacteria, protozoa and an oomycete (fungus-like pathogen). Understanding the properties of each type and the disinfection processes that are likely to be effective is the first step in any disinfection program (Rutala, 1996)

Infective pathogens vary greatly in their susceptibility to various disinfection strategies and chemical agents. Table A2 summarises the relative susceptibility of various pathogen types, whilst Tables A11 and A12 (page 36) indicate the susceptibility of each group to common disinfecting agents.

The appropriate AQUAVETPLAN disease strategy manual[1] should be consulted to obtain epidemiological information on the pathogen of concern. This information is necessary to identify critical diseasecontrol points for each enterprise.

**Table A2: Relative susceptibility of pathogen types to disinfection**

| ***Susceptibility pattern to chemical disinfectants & UV radiation*** | ***Microorganism*** |
|---|---|
| **Highly susceptible** | • **Mycoplasmas** |
| **Susceptible** | • **Gram-positive bacteria**<br>• **Enveloped viruses**<br>• **Gram-negative bacteria**<br>• **Fungal spores** |
| **Resistant** | • **Non-enveloped viruses**<br>• **Mycobacteria** |
| **Highly resistant** | • **Bacterial endospores**<br>• **Protozoal oocysts**<br>• **Protozoal-like spores** |
| **Extremely resistant** | • **Prions** |

Adapted from Quinn & Markey, 2001.

## A 2.2 Type of enterprise

As outlined within the AQUAVETPLAN Enterprise Manual[1], aquaculture enterprises and industries may be classified according to one of four types:

**Open systems** Systems where there is no control of either host movement or water flow eg. wild caught fisheries

**Semi-open systems** Systems where there is control of host movement but no control of water flow eg. net pen culture

**Semi-closed systems** Systems where there is control of host movement and some control of water flow eg. pond culture, race culture

**Closed systems** Systems where there is good control of both host movement and water flow eg. aquaria, recirculation facilities

Since the ability to control host movement and water flow from infected premises are major factors that determine the success of any decontamination program, each enterprise type has specific characteristics that affect the type of program that may be undertaken. Further details on enterprise types and how they affect decontamination programs may be found in section B1. of this document.

1:www.daff.gov.au/aquaticanimalhealth

## A 2.3 Type of material requiring decontamination

The planning stage should assess the physical characteristics of material and equipment requiring decontamination. An inventory of all equipment requiring decontamination should be formulated and include an assessment of materials used in construction, surface porosity, access to areas and resistance to damage.

The level of cleaning required prior to disinfection for each type of equipment should also be assessed. If heavy soiling is present extra attention will need to be given to the cleaning process and the tools required. The type of cleaning product used during these initial stages should either be compatible with the disinfectant chosen or thoroughly rinsed off surfaces prior to the application of disinfectants.

The type of material requiring decontamination plays a significant role in how effective decontamination will be. Hard non-porous materials such as polished metal surfaces, plastics or painted concrete are considered relatively easy to clean and disinfect because there is little opportunity for infective material to lodge in crevices. This ease of decontamination reduces where the surface is corroded, pitted or paint is flaking.

Absorbent materials such as rope, wood, or uncoated concrete are much more difficult to treat. For such material the cleaning stage must be more rigorous whilst the disinfection contact times considerably longer. In many cases it may be more cost effective to dispose of such items rather than attempting to disinfect for re-use.

Machinery and equipment used in aquaculture is often bulky and requires specialist equipment for safe handling. Tanks, biofilters and pipe-work can also have limited access making work difficult and possibly hazardous. Consultation with the facility manager or equipment manufacturer about safe handling of heavy equipment, access to enclosed spaces or the process of dismantling should be undertaken during the planning stage. Such specialised tasks should always be left to suitably qualified personnel.

Depending on the enterprise type, there may also be significant volumes of water that requires decontamination. It is only practical to contain and disinfect contaminated water under specific situations. In open water enterprises this will not be possible, but can be achieved in closed systems and may be possible in flow through systems (semi-open or semi-closed) if the water flow can be diverted.

On most sites there is likely to be a significant amount of fish carcases and organic waste requiring disposal as part of the decontamination process. Such material generally carries a very high infective load and is difficult to disinfect. The safe disposal of all organic material should form a major part of the planning process. Further details on the safe disposal of biological material may be found within section B 3.9 of this document, and within the AQUAVETPLAN Disposal Manual[1].

1: www.daff.gov.au/aquaticanimalhealth

## A 2.4 Available water supply

Adequate supplies of water are necessary for all washing, cleaning, disinfection and rinsing aspects of the decontamination process. Where possible, water should be clean (low in suspended solids), soft (low in mineral solutes) and of sufficient volume to complete the task required.

The quality of the water supply has significant impact on the efficacy of both chemical disinfectants and cleaning compounds. Water that contains high organic loads quickly inactivate chemicals such as chlorine and iodine, whilst hard waters containing high levels of dissolved ions can also reduce the activity of some detergents and disinfectants (refer to sections A 3.2 and A 3.3 for additional details).

Due to its potential to reduce the effectiveness of chemical detergents and disinfectants, seawater should not be used as a diluent for chemical agents, but may be useful for initial removal of gross fouling or some rinsing procedures. Where adequate supplies of clean freshwater are not available on-site, consideration should be given to shipping in supplies for critical cleaning and disinfection tasks.

The selection of appropriate water handling facilities should also form part of the planning stage. This usually includes the supply of pumps, hoses, pressure cleaners and storage facilities. Planning should also include containment, temporary storage and possible treatment of water used during decontamination.

## A 2.5 Choice of the disinfecting process

When the disinfection process is first considered, it is common to limit planning primarily to only chemical disinfectants but disinfecting processes may also utilise physical, and in some cases, biological processes.

While there are a number of physical disinfection processes used in medical establishments and industry, the most practical physical processes that could be used during an aquatic animal emergency disease event include the use of dry heat, wet heat, UV radiation and sedimentation/filtration.

Potential biological disinfection processes include burial, ensilage or composting. These three methods are more commonly used for the disposal of solids rather than during disinfection, however complex biological processes occur during decomposition resulting in enzymatic degradation as well as changes in oxygen, moisture content, pH, and temperature. All of these processes act to inactivate pathogens within infected material.

The range of chemical disinfectants currently on the market is daunting and anyone investigating this issue for the first time is likely to be overwhelmed by the numerous brands and combinations available. Many of the commercial preparations are a combination of chemicals that can include more than one disinfectant as well as stabilising agents, buffers, wetting and cleaning agents and compounds that assist penetration.

Some disinfectant agents are especially corrosive to metals, rubber or fabrics and may considerably shorten the lifespan of equipment. Oxidising chemicals, alkaline compounds, acids and even extremes of heat are all corrosive. Table A10 (page 32) gives a brief summary of the corrosive characteristics of a number of the more common chemicals used during decontamination. Where there is any doubt, a small section of material should be tested first. In many cases the corrosive nature of chemicals can be minimised by thorough rinsing after cleaning or disinfection.

The concentration or intensity of the disinfectant and the time of exposure needed vary with the type of pathogen, the level of contamination, the nature of the items to be disinfected and the process being used. It is therefore imperative that the characteristics and limitations of each product or active ingredient are understood before a disinfection program is implemented. The consequences of inappropriate selection are not only serious from the disease control point of view, but are expensive in terms of labour and materials.

The following checklist of questions should be considered when selecting a disinfecting process.

- Is the agent and procedure effective against the pathogen in question?
- Does the handling procedure satisfy the acceptable safety standards?
- Is the agent and procedure safe for equipment?
- Is it environmentally acceptable? If the agent is not environmentally acceptable - can it be contained and neutralised?
- Can the agent be used with the available water supply (ie. in freshwater, hardwater or seawater)?
- Is the agent and procedure cost effective?
- Is the agent and equipment available and in sufficient quantities?
- Is formal authority needed to use the agent or undertake the procedure?
- What are the available alternatives?

### A 2.6 Workplace safety

It is beyond the scope of this document to provide detailed information on the requirement for workplace safety apart from reminding those undertaking or supervising decontamination procedures that it is the responsibility of all persons involved to ensure that all reasonable measures are undertaken to maintain a safe working environment.

The decontamination process has a number of aspects that would be considered as hazardous operations. Such hazards include, but are not restricted to:

- the handling of corrosive or irritant chemicals

- the use of steam or hot water cleaners
- the use of high pressure water cleaners
- the need to lift heavy equipment during cleaning and disinfection operations
- the need to work in confined spaces
- diving operations, and
- the need to work on or around water wearing heavy protective clothing.

The planning stage should include a risk assessment of all activities to be undertaken. Where risks are considered to be unacceptable, procedures **must** be put in place to reduce risks to appropriate levels or an alternative process implemented.

Material safety data sheets should be readily available for all chemical agents used on site, as should appropriately trained first aid officers and medical equipment. A safety officer responsible for ensuring that appropriate standards are met should also be appointed on all sites.

## A 2.7 Environmental considerations

Although selection of the disinfection method will be undertaken primarily on effectiveness against the target organism, disinfectants used in disease control programs are potentially noxious substances and may have adverse impact on the environment. The planning process needs to consider in advance the potential environmental impact from decontamination procedures and assess whether methods for the containment or neutralisation are viable and acceptable. Consultation with appropriate State or Territory authorities responsible for environmental management should always occur at this stage.

The volumes of water requiring disposal will need to be considered during planning. In some cases, water may be able to be released into waterways following treatment to inactivate chemical disinfectants (for example treatment of oxidising disinfectants with thiosulphate) or following a prescribed period of time that allows chemicals dissipate to acceptable levels (for example hypochlorite and chlorine dioxide). Other options could include discharge onto approved wasteland sites. Approval from relevant authorities should always be sought before disposing of treated material.

Thorough cleaning prior to disinfection, the use of protective clothing and equipment, the use of temporary drains to trap and divert waste, and lined ponds or tanks for temporary storage are all options to reduce the effect of decontamination activities on the environment.

## A 2.8 Relevant Legislation

Legislation relating to decontamination procedures falls largely within three categories:

- ***Legislation relating to the control of use of agricultural or veterinary chemicals***

By definition, any chemical that is used directly or indirectly for the control of an animal disease is governed in its use by relevant 'control of use' legislation. Such legislation requires that chemicals must be used for the purpose in which they are registered and appropriate instructions given on the label for their safe use.

During emergency disease response situations, chemicals may need to be used for 'off-label' purposes. In such situations the relevant State or Territory authority (in most cases this is the veterinary registrar within the relevant state department of primary industry or agriculture) and/or the Australian Pesticides & Veterinary Medicines Authority[1] should be consulted for advice prior to their use.

- ***Legislation relating to the control of discharge of pollutants into waterways***

It is a common requirement in all States and Territories that activities should not have significant detrimental impact on the natural environment. As such, the discharge of chemicals, silt, organic matter or carcases into natural waterways or other environments may be deemed an offence. It is essential that authorities are consulted when designing the decontamination process and that appropriate disposal of waste materials is undertaken.

- ***Regulations relating to workplace safety***

As discussed in section A 2.6, legislation relating to workplace safety requires that persons undertaking duties receive appropriate training in the use of equipment, chemicals and procedures. It also requires that appropriate protective equipment and resources be provided to ensure that such activities are undertaken safely.

1: www.apvma.gov.au

# A 3. Cleaning prior to disinfection

Effective cleaning must always precede disinfection. If completed correctly this step may remove in excess of 90% of the pathogen loading (Fotheringham, 1995a; Lewis, 1980).

Cleaning is designed to:

- remove organic matter that reduces activity of many chemical disinfectants
- remove gross contamination that may shield the action of disinfectants, and
- remove traces of chemical residues.

The basic steps to be followed during cleaning operations will vary according to the enterprise type but should generally be as follows:

1. Tanks and ponds should be drained and the contaminated water treated in an appropriate manner prior to discharge or disposal. Refer to *Part B* for further details on the treatment of infected water.
2. Carcases should be removed and disposed of in an appropriate manner (refer to the AQUAVETPLAN Disposal Manual[1] for further details). Appropriate disposal methods may include deep burial, ensilage, composting or rendering.
3. Organic material in the form of faeces, uneaten feed and sediments at the base of ponds or tanks should be collected and disposed of in a similar fashion to carcases. The treatment and disposal of slurry is discussed in section B 3.9.
4. Effluent such as solid wastes and infected water must be contained and treated in an appropriate manner.
5. Residual stocks of feed should be disposed of.
6. Any material such as wooden planks or highly porous material that cannot be thoroughly disinfected should be removed for incineration or burial.
7. Before cleaning commences, suitably qualified personnel should disconnect electrical supplies to all equipment requiring cleaning. Cables carrying electrical power to washing equipment should also be fitted with residual current devices.
8. Equipment that can be removed should be rinsed of dust and soaked in detergent prior to disinfection.
9. Pipe-work, biofilters, net-pens and other structures should be dismantled for cleaning and disinfection.
10. Interior surfaces of tanks, pipe-work, filters, buildings and cages must be thoroughly cleaned using appropriate physical abrasion, heat or strong detergents.
11. Detergents should be rinsed off all surfaces and equipment. Washwater should be contained for later disposal as this may still contain viable pathogens.

1: www.daff.gov.au/aquaticanimalhealth

12. All machinery and tools used in the removal of soiling must also be washed and disinfected.

## A 3.1 Gross soiling

Soil is defined here as any material, be it mineral or organic, which accumulates on equipment or within facilities. For the purposes of this document, the types of soil or soiling have been classified into five basic types.

***Type 1: Oily build-ups and protein accumulations***

This type of soiling is common in facilities and equipment used in the processing or handling of fish[1] or fish material. Oils and fats form highly resistant layers that are difficult to remove and provide an environment that enhances survival of the pathogen.

Examples of where this type of soiling may occur include:
- decks of boats or jetties used in handling fish
- equipment within processing facilities
- diving suits when removing mortalities from cages
- containers used to transport fish and fish products.

***Type 2: Sediment accumulations***

This soil type is usually associated with the build–up of particulate matter on equipment, but water containing high loads of sediment in suspension also falls into this category.

Examples of situations where this type of soiling commonly occurs include:
- earth accumulations on earthmoving equipment
- mud accumulations over the underside of vehicles
- sediments at the base of ponds or tanks
- suspended solids within water
- dust accumulations over the surface of machinery and equipment.

***Type 3: Biofilms***

Biofilms are defined as a collection of bacteria or fungi that exist in a community form within an exopolysaccharide matrix adhered to the surface of equipment (Morck *et al.* 2001). Within aquaculture, biofilms are known to accumulate over the internal surface of tanks and associated pipe-work, within biofilters and on nets. The extracellular matrix creates a protective environment that resists the action of disinfectants and provides a nidus for potential reinfection.

This type of soiling is of particular importance in closed or semi-closed aquaculture establishments where complex pipe-work provides a suitable environment for the establishment of biofilms and presents significant difficulties in cleaning. The build-up of biofilms within hatcheries has commonly been postulated as the cause of

1: Fish is defined here as any aquatic animal and may include finfish, molluscs or crustaceans increased disease issues in those establishments that do not undertake annual dry out of their systems.

***Type 4: Organic fouling***

This category refers to the growth of organisms, such as algae and invertebrate animals, over the surface of tanks, cages or equipment. These growths and the associated debris may provide a protective barrier to the pathogen as well as inactivating some chemical agents. In specific cases, fouling organisms may also provide an intermediate host for pathogens.

Organic fouling commonly occurs:
- on boat hulls
- attached to net pens and associated structures
- within pumps and pipe-work on boats or marine sites
- over the internal surfaces of tanks
- as cohabitants of pond systems.

***Type 5: Mineral accumulations***

Mineral deposits are generally due to calcium or salts in water precipitating onto surfaces. Although such deposits are generally benign, they do provide a physical barrier to disinfectants. Mineral accumulations occur as a build-up on the inside of pipes, tanks or biological filters and over the surface of equipment used in marine environments.

## A 3.2 Increasing water efficiency

Water will be required to rinse chemicals and soil from surfaces and to act as a diluent for detergents and disinfectants. It may also be used as an abrasive during pressure cleaning operations and as a medium to apply heat to surfaces.

In the ideal situation, water should be clean, free of pathogens or chemical contaminants and have a low level of dissolved ions. In reality this is rarely the case, but wherever possible clean freshwater should be used in preference to seawater and freshwater with a high organic or mineral loading.

Outlined within this section are factors that affect water quality for cleaning and disinfection operations.

### *A 3.2.1 Water temperature*

Water cleaning efficiency may be improved by increasing water temperature and mechanical force with which it is applied. The effects of chemical cleaning and disinfecting agents also tend to increase with temperature and approximately double for every $10^{o}$ C rise in temperature (Holah, 1995b).

Table A3 gives recommendations for optimum water temperatures during various stages of cleaning. Methods for increasing the mechanical cleaning force of water is discussed further in section A 3.4.

**Table A3: Recommended temperatures for cleaning procedures**

| | Ideal water temperature | Comments |
|---|---|---|
| **Preliminary rinsing** | 38-46°C | Generally done with low water pressure. |
| **Cleaning stage** | 49-77°C | Some detergents, in particular alkaline cleaners, are unstable at higher temperatures |
| **Rinse** | 7-13°C | Colder waters assist rinsing by reducing the formation of foams. |

Recommendations adapted from Salvat & Colin (1995)

### *A 3.2.2 Water Hardness*

Water hardness is most commonly caused by the presence of calcium and magnesium compounds as either bicarbonates or chlorides (Bitton, 1994). Hardness is responsible for increased consumption of anionic detergents and bicarbonate based cleaners (Lewis, 1980). It reduces the efficiency of a number of disinfectants, leads to the formation of scale (type 5 soiling) and makes it difficult to rinse residues when used with some detergents.

Hard water may be softened by:

- the addition of sequestering agents (eg. sodium tripolyphosphate)
- adding ion exchange resins (also known as the zeolite process) or,
- the more complicated lime-soda process (Bitton, 1980).

Water softening using lime-soda results in high water pH that must be taken into account when choosing chemical disinfectants, but has the advantage of reducing microbial loading through inactivation (via high pH) and precipitation (Bitton, 1994).

For reasons of convenience and availability, the use of sequestering agents or ion exchange resins is recommended in preference to the lime-soda process.

### *A 3.2.3 pH*

Extremely acid or alkaline waters can affect the action of chemical disinfectants. As a general rule, seawater tends to be buffered by dissolved salts to pH 8, but freshwater may have a much wider pH range. Waters associated with acid sulphate soils will tend to be highly acidic, whilst freshwater in limestone areas or from bores is often alkaline.

It is useful to test water if using chemical disinfectants that may be affected by extremes in pH. Test kits for determining water pH and hardness are readily available from laboratory suppliers, swimming pool supply shops and pet stores specialising in aquarium fish.

### *A 3.2.4 Turbidity*

Water turbidity plays a key role in the inactivation of pathogenic organisms by ultraviolet irradiation (UV), including that produced by solar radiation. If UV disinfection is to be utilised, special consideration needs to be given to ensuring water clarity is as high as possible, usually through the use of filtration. UV radiation is reported to require at least a six-fold increase in intensity in unfiltered water compared to filtered water when used to control vibrio and aeromonad bacterial pathogens (Torgersen & Hastein, 1995; Bullock & Stucky, 1977).

In some cases, water with a high colloidal load caused by minerals, clay particles and organic matter may be treated with a flocculant, causing small particles to join together until they are large enough to settle out of the water column. Flocculants can improve water clarity but also have the added benefit of removing significant numbers of pathogens, in particular viruses, which adhere to colloidal particles. Bitton (1994) states that up to 99% of viruses and 90% of bacteria are removed from water treated with flocculants under laboratory conditions. Flocculants act by transferring pathogenic microorganisms from the water suspension to a bottom layer of sludge that must be disposed of properly. This characteristic may also be utilised for the pre-treatment of wastewater from infected properties prior to secondary treatment or release into the environment.

Common flocculants are alum, ferric chloride and ferric sulphate. Bitton (1994) recommends the use of alum at a rate of 10-25ml/L, ferric sulfate at 40ml/L and ferric chloride at 60ml/L.

A final point to note is that solar radiation plays a key role in the decline of pathogenic organisms in water (Torrentera *et al.* 1994). Dark or turbid waters that are often found in freshwater or estuarine ecosystems can protect pathogens from the effects of solar radiation, particularly if these systems are static or stratified. Environmental viability of pathogens is greatly reduced in clear marine ecosystems since these tend to have much greater penetration of solar radiation. This factor should be taken into consideration when determining the appropriate period before restocking, especially in 'open' enterprise types.

## A 3.3 Cleaning compounds

The purpose of cleaning compounds is to reduce the surface tension of water and allow lifting and flushing away of soils.

They generally act by:
- wetting
- reacting with both the soil and the cleaning surface to emulsify fats, peptonise proteins, dissolve minerals or organic material and disperse solids

- assisting in preventing re-deposition onto cleansed surfaces.

Choice can often be confusing because cleaning compounds (detergents) are rarely sold as single compounds. Instead they are complex mixtures of surfactants (surface active agents), dispersants, solvents and sequestering or chelating agents (Myers, 1992).

For the purpose of this document, the base components of cleaning agents can be classified into three major groups; alkaline detergents; acidic cleaning compounds; and surface wetting agents. The relevant characteristics of each group is outlined below and also summarised in Table A4 on page 20.

### *A 3.3.1 Alkaline detergents*

Alkaline detergents have good saponifying qualities and are able to dissolve many organic solids but their alkaline nature means that they corrode some metals and can also be irritating to skin or mucus membranes. Alkaline detergents are used for heavy duty cleaning and include products containing sodium hydroxide, sodium carbonate and sodium silicates.

Detergents containing sodium hydroxide are commonly used in the food processing industry. These detergents are relatively cheap and very effective in removing protein and fat residues (Troller, 1983). They are suitable for initial cleaning of most hard surfaces and can be used on steel, most plastics, glass, ceramics and concrete. Alkaline detergents are generally not suitable for cleaning wood, galvanised iron, aluminium or delicate fabrics. For these applications, neutral detergents, weakly alkaline or acidic surface active agents can be used.

In some cases alkaline detergents have chlorine added, which aids in removing protein deposits. It is important to note that chlorine-liberating compounds lose much of their biocidal action above pH 7.5 (refer to section A 4.3.1 for further details) as would occur when mixed with alkaline detergents (Holah, 1995a). In such cases the chlorine is added to enhance the products cleaning action rather than as a disinfectant.

Alkaline cleaning compounds have a tendency to precipitate ions from hardwater resulting in a surface scum that can be difficult to rinse off equipment. This may be overcome by restricting the temperature at which alkaline cleaners are used to less than 65$^{o}$C, or by using an acid rinse following cleaning procedures (Cancellotti, 1995).

### *A 3.3.2 Acidic cleaning compounds*

Acidic detergents are particularly useful in removing mineral deposits caused by hard waters and marine environments. They are also useful in removing heavy build-ups of proteinaceous material and can be used with salt water. Acids also assist in water penetration and softening when combined with other compatible agents, are easily rinsed from surfaces and have some residual biocidal capacity.

The organic acids are generally less corrosive and irritant than the inorganic acid or alkaline cleaners. Acids should generally be used with cold water to avoid the production of fumes and reduce corrosive effects.

### *A 3.3.3 Surface wetting agents or surfactants*

Surfactants act by emulsifying fat deposits but also have dispersion and wetting properties. They are generally non-corrosive and non-irritating. Surfactants are key components of most cleaning agents and often incorporated with the acid or alkali preparations mentioned above.

There are four types of surfactants (Myers 1992):

1. Anionic surfactants. These are by far the most commonly used and are salts of complex organic acids.
2. Non-ionic surfactants. These are polar molecules but have no electrical charge. They exist as organic compounds rather than salts and are useful in hardwater or marine environments.
3. Cationic surfactants. These are relatively poor cleaners but have sanitising properties. Cationic surfactants occur as salts of organic bases. Surfactants within this group are better known for their disinfecting capabilities and generally do not have the capacity for heavy duty cleaning required in aquaculture facilities or processing plants. Quaternary ammonium compounds are commonly used cationic surfactants
4. Amphoteric surfactants. These alkaline amino acids enhance water penetration, are good emulsifiers and are compatible with anionic, ionic or cationic surfactants.

### *A 3.3.4 Sequestering agents*

Sequestering agents are important in ensuring that cleaning efficiency is maintained in hard water that contains calcium ($Ca^{++}$) or magnesium ($Mg^{++}$) ions. Sequestrants are an important component of any detergent that is exposed to, or used with, seawater or particularly hard freshwater. Examples of sequestering agents include sodium tripolyphosphate and ethylenediamnetetraacetic acid (Morris, 1994; Lewis, 1980).

### *A 3.3.5 Other cleaning agents*

Other cleaning agents that may be of use under specific circumstances include amphoteric compounds (used to loosen charred residues from surfaces), proteolytic enzymes (digest protiens and other complex organic soils) and abrasive compounds (Lewis, 1980).

**Table A4: Comparative characteristics of common cleaning and wetting compounds.**

| *Cleaning Compound* | *Applications* | *Advantages* | *Disadvantages* | *Common examples* |
|---|---|---|---|---|
| **Mild alkaline detergents** | Primarily type 2 soiling, but also useful type 1 soiling | Useful a general detergent<br>May have chlorine added to enhance protein breakdown capability<br>Produces pH of 8.4 | High concentrations can be irritant<br>Mildly corrosive<br>May be difficult to rinse | Sodium carbonate<br>Sodium sesquicarbonate |
| **Strong Alkaline detergents** | Excellent for type 1 and type 3 soiling<br>Also useful for type 2 soiling | Provide good saponification<br>Have good foaming characteristics, which may be used to prolong contact time on vertical surfaces<br>High pH aids soil removal and has some biocidal characteristics<br>May have chlorine added to enhance protein breakdown | Corrosive to some metals, in particular sot alloys and aluminium<br>Irritant to skin and mucus membranes<br>Interact with $Mg^{++}$ and $Ca^{++}$ ions in hard waters to produce soap scums that may be difficult to rinse.<br>Inefficient at deflocculation and emulsification | Sodium hydroxide<br>Sodium orthosilicate<br>Sodium sespuisilicate |
| **Organic acid compounds** | Type 5 soiling and other inorganic acid soluble substances | Removes inorganic precipitates and other acid soluble substances<br>Less corrosive than alkalines<br>Easily rinsed from surfaces | Mildly corrosive<br>Inhibited by various organic nitrogen compounds | Acetic acid<br>Citric acid<br>Oxalic acid |
| **Inorganic acid compounds** | Type 5 soiling | Highly efficient at removing mineral deposits produced by marine or hard waters<br>Some biocidal effect through low pH<br>Effective at softening water<br>Can be combined with other agents to enhance penetrating ability<br>Easily rinsed from surfaces | Corrosive to metals<br>Irritant to eyes, skin and mucus membranes | Phosphoric acid<br>Sulphamic acid<br>Nitric acid |
| **Non-ionic surfactants** | Excellent detergents for oils, therefore effective on some type 1 soils<br>Useful for type 2 soils | Compatible with most other cleaning compounds<br>Very good wetting characteristics<br>Good dispersing and detergent action | May be sensitive to acids | Polyethen-oxyethers |
| **Cationic surfactants** | Some wetting effect but not recommended for general cleaning purposes | Good biocidal characteristics | Relatively poor penetration capability<br>Must not be used with anionic compounds | Quaternary ammonium compounds |
| **Anionic surfactants** | Some type 1 soils, effective against oils, fats and waxes<br>Also useful on absorbent or pitted material | Can be used under acid or alkaline conditions<br>Good penetration characteristics<br>Compatible with acid or alkaline cleaners and may have a synergistic effect | Some types foam excessively<br>Must not be used with cationic compounds | Soaps<br>Sulfated alchohols<br>Sulfated hydrocarbons |

Table compiled from information within Holdah (1995a); Salvat and Colin (1995); Lewis (1980); and Fotheringham (1995).

## A 3.4 Equipment requirements

Equipment used in the removal of gross soiling may be as simple as scrapers or brushes, but may also include a wide range of specialist equipment such as transportable vehicle wash systems. Outlined below is a brief summary of equipment commonly used.

### *A 3.4.1 Brushes & scrapers*

Although the use of brushes and scrapers requires little explanation, the importance of this basic equipment should not be overlooked. Any decontamination program must have adequate supplies of good quality scrubbers, brushes and scrapers to removed thick deposits of soil.

This equipment should, where possible, be sourced from commercial cleaning wholesalers that carry a wide range of products suitable for heavy cleaning purposes. Personnel will often have to use this equipment for extended periods and equipment and allowing staff to carry out work while standing is preferable.

Scrapers are useful to mechanically lift and dislodge heavy accumulations, in particular types 1 & 4 soiling. Equipment available from boat chandleries used to clean hulls is often most suitable for this purpose. Boot cleaners are also available for use in conjunction with footbaths to remove gross soiling prior to chemical disinfection and are highly recommended.

### *A 3.4.2 Misters and low pressure sprayers*

The use of hand or backpack sprayers is a convenient method of applying detergents and disinfectants to surfaces. These units operate at very low pressures and are not effective at dislodging soils and must be accompanied by mechanical action (either as brushing or high pressure water) to effectively clean. Such units are probably most useful in applying disinfectants over surfaces following cleaning.

Mechanically driven misters are commonly used for the application of chemicals in horticulture and broad scale agriculture. Their great advantage is that they produce a mist that disperses to all surfaces, and thus have applications in decontamination programs where areas and equipment are difficult to access or have complex structures.

Misters are available in a range of sizes from small petrol driven models to large tractor mounted units.

### *A 3.5.3 Pumps*

High volume pumps, such as those used in firefighting units, are useful for removing loose accumulations associated with type 2 soiling, but have limited value for other soil types. Their main value is the ability to thoroughly wet equipment and therefore are extremely useful during rinsing stages of the operation. These pumps are also essential for transferring water between storage facilities or for the removal of wastewater. High volume pumps are readily available from most agricultural or irrigation equipment suppliers.

Where liquids containing high levels of solids are present, for example faecal waste slurries, specialised sludge or diaphragm pumps may be required to transfer and agitate such wastes.

### *A 3.4.4 High pressure water cleaners (HPWC's)*

HPWC's are considered a key piece of equipment for all stages of cleaning and disinfection. They are highly efficient at dislodging most types of gross soiling.

Within the range of HPWC's available, water pressure output may be fixed or variable. These units may be used to apply detergents and disinfecting chemicals via venturi injection systems available on most models when used at low pressure (refer to caution note A5 below). Although they are commonly electrically powered, petrol driven units suitable for use in isolated locations are also available.

There are several types of pressure water cleaner readily available on the market.

- Pressure water cleaners use a high-pressure water jet to dislodge soiling. Smaller units generally have a working water pressure below 125 bar (1800psi) and larger units can apply water up to 240 bar (3500psi). Most also have the capacity to use preheated water (usually < 60°C) to enhance cleaning. See caution notes A1 and A3 (page 23).
- Heated pressure water cleaners have a mechanism within the unit to increase water temperatures (60-90°C) and apply this heated water to the site at pressure. Pressure capacities vary according to the model chosen but are generally similar to non-heated units described above. Although more expensive than unheated HPWC's, cleaning efficiency is significantly increased, especially when dealing with type 1 soiling. Refer to Table A3 (page 15) for optimum cleaning temperatures and caution notes A2, A3 and A4 (page 23).
- Steam cleaners heat water within the unit to produce a jet of very hot water and steam (up to 140°C). These cleaners are extremely efficient at loosening fat and oil deposits (type 1 soiling) during the initial stage of cleaning but their combined use with chemical cleaners is generally not possible or recommended. Refer to caution notes A2 and A4 (page 23). Due to the high temperatures produced, steam cleaners can also be used for disinfection purposes on some surfaces.

### *A 3.4.5 Net washers*

Nets from pens present particular challenges in cleaning effectively. They are generally bulky and difficult to handle as well as being made of absorbent material that is usually heavily fouled with type 3 and type 4 soiling.

Nets may be cleaned via two basic methods, spreading out on a slab then using HPWC's to blast off gross soiling (refer to caution note A3, page 23), or using specialised net-washers.

Net-washers work in a similar fashion to the domestic washing machine and have a large rotating drum in which the net is agitated whilst being rinsed with clean water. Although this mechanical action is highly efficient at dislodging soil, net washers are unlikely to be available during emergency events unless already installed as part of the farm infrastructure.

Where net washers are used, consideration must be given to diverting the washwater for appropriate disposal.

### *A 3.5.6 Foam projectile pipe cleaning systems*

Foam projectile pipe cleaning systems, also referred to as 'pigging systems', are routinely used by the oil industry and by food or beverage manufacturers to remove build-ups on the inside of pipes without the need for dismantling. They are considered to be highly effective in removing biofilms. The system can also be utilised to remove residual chemicals and dry the inside of pipelines following disinfection.

These systems use a range of foam projectiles that are forced through pipelines using compressed air. The projectiles come in a range of sizes, densities and abrasive surface textures that can be used to either scour, wipe or dry the internal surface of pipelines.

For decontamination purposes, pigging systems are most useful in facilities such as hatcheries where complex pipe systems occur. These cleaning systems have already gained some acceptance in abalone hatcheries and grow-out facilities within Australia as part of normal maintenance procedures.

The capital cost of these systems is dependent upon the size of the piping requiring cleaning, but is relatively cost effective. Used under appropriate circumstances they are considered to have significant advantages, especially when risks associated with disease breakdown through residual biofilms and time saved is taken into account.

**Caution notes:**

A1. Care should be taken to ensure that pressure applied by HPWC units does not damage the surface of equipment and tanks. It is advisable to test a small area first. Concrete tanks are particularly susceptible to pitting and erosion by HPWC's. This problem may be overcome by choosing a wider spray pattern rather than a concentrated jet or lowering the pressure output.

A2. Although cleaning agents are often more effective when used hot, temperatures should not exceed 65$^{o}$. The emulsions formed with the detergent are destroyed at high temperatures (Holah, 1995). This temperature restriction also applies to some alkaline detergents when used with hard water. Acidic cleaners are normally used cold.

A3. Pressure water cleaners have a tendency to spread dirt and water over an area surrounding the immediate work site. Operators wear appropriate protective clothing and should ensure that they are not contaminating other equipment with the spray.

A4. HPWC's have the potential to cause injury or burns. Operators should be supplied with appropriate protective equipment, including face shields and waterproof clothing.

A5. When using HPWC's to apply chemicals for disinfection purposes, the water/chemical mix may vary depending on viscosity and venturi pressure. Where a prescribed disinfection concentration is required, simple calculations are necessary to determine the application rate.

# A 4. Disinfection

A key element of disinfection is the choice of a suitable disinfecting agent. Disinfecting agents are selected according to the following criteria:

- the nature of the target pathogen/s
- the nature of the items to be disinfected
- the toxicity and dangers involved in using the disinfectant
- persistence and environmental impact of disinfectant residues
- solubility, stability, corrosiveness and penetration of the disinfectant
- price, handling characteristics and availability.

## A 4.1 Nature of the target pathogen

### *A 4.1.1 Viruses*

Viruses vary in their susceptibility to inactivation by disinfectants. For disinfection purposes, viruses fall into three basic groups:

- ***Category A:*** These viruses contain a lipid envelope and are of intermediate to large size. Category A viruses are the easiest group to inactivate since the lipid envelope is sensitive to many lipophilic compounds, including soaps, detergents and quaternary ammonium compounds.

- ***Category B:*** These viruses are the most difficult to inactivate. They are small non-lipid containing viruses or those protected within occlusions. Baculoviroses have been included within this group because they are embedded in protein matrix, or occlusion, that provides protection to the viral particle (Spann *et al.,*1993).

  The most effective disinfectant products for use against category B viruses include strong alkalis or aldehydes. Oxidising agents are also considered effective under most circumstances but require higher concentrations and longer contact times than those included in category C.

- ***Category C:*** These viruses are intermediate in their ease of inactivation by chemical agents. They do not contain lipid but are usually larger than the viruses in Category B.

  These viruses may be inactivated using a range of disinfectants, the most effective of which are strong alkalis, aldehydes and peroxygen products.

Table A6 lists those viral agents of aquatic animals currently reportable within Australia and assigns each disinfection category.

**Table A6: Disinfection categories of viral disease agents of aquatic animals listed as reportable within Australia.**

| *Disease* | *Viral Group* | *Disinfection Category* |
|---|---|---|
| **Finfish** | | |
| Epizootic haematopoietic necrosis | **Iridovirus** | **C** |
| Infectious haematopoietic necrosis | **Rhabdovirus** | **A** |
| *Oncorhynchus masou* virus disease | **Herpesvirus** | **A** |
| Spring viraemia of carp | **Rhabdovirus** | **A** |
| Viral haemorrhagic septicaemia | **Rhabdovirus** | **A** |
| Channel catfish virus disease | **Herpesvirus** | **A** |
| Viral encephalopathy and retinopathy | **Nodavirus** | **B** |
| Infectious pancreatic necrosis | **Birnavirus** | **C** |
| Infectious salmon anaemia | **Orthomyxovirus** | **A** |
| Iridoviral diseases of finfish | **Iridovirus** | **C** |
| Koi herpesvirus | **Herpesvirus*** | **A** |
| **Molluscs** | | |
| Akoya oyster disease | **Unknown*** | **Unknown*** |
| Iridoviroses | **Iridovirus** | **C** |
| **Crustaceans** | | |
| Taura syndrome | **Dicistroviridae** | **B** |
| White spot disease | **Nemaviridae** | **A** |
| Yellowhead disease | **Roniviridae** | **A** |
| Gill-associated virus | **Roniviridae** | **A** |
| *Tetrahedral baculovirosis* (Baculovirus penaei) | **Baculovirus** | **B** |
| Spherical baculovirosis (*Penaeus monodon*-type baculovirus) | **Baculovirus** | **B** |
| Infectious hypodermal and haematopoietic necrosis | **Parvovirus** | **B** |
| Spawner-isolated mortality virus disease | **Parvovirus** | **B** |
| Baculoviral midgut gland necrosis | **Baculovirus** | **B** |

Information obtained from Bondad-Reantaso *et al*. (2001), Hatori *et al,* (2003), and Spann *et al.* (1993).
* True aetiological agent yet to be identified

### *A 4.1.2 Bacteria*

Like the viruses, bacterial pathogens can be classified according to their  susceptibility to disinfecting agents (Russel, 2001).

- Gram-positive vegetative bacteria tend to be most susceptible to disinfection, especially chemical disinfectants
- Gram-negative bacilli are comparatively more resistant to disinfecting agents than gram-negative cocci (Russel, 2001)
- Mycobacteria tend to occupy an intermediate place between vegetative bacteria and bacterial spores
- Amongst bacterial agents, bacterial spores are most resistant to the action of disinfectants.

Table A7 lists bacterial pathogens of aquatic species reportable within Australia and gives a summary of gram reaction, structure and possible spore formation. These characteristics are used to indicate disinfection susceptibility.

Among fish bacterial pathogens, Torgersen and Hastein (1995) report that *Aeromonas salmonicida* and a number of the vibrio species are able to produce respiring non-culturable cells that can survive for several months in free water or sediments. *Renibacterium salmoninarum*, the cause of bacterial kidney disease, has been shown to be comparatively resistant to inactivation by heat (Humphries *et al*. 1991)

**Table A7: Bacterial disease agents of aquatic animals listed as reportable within Australia**

| Disease (Bacterial Agent) | Gram reaction | Structure | Formation of resistant spores |
|---|---|---|---|
| ***Finfish*** | | | |
| Bacterial kidney disease (*Renibacterium salmoninarum*) | Gram positive | Bacilli | Non-spore forming |
| Enteric septicaemia of catfish (*Edwardsiella ictaluri*) | Gram negative | Bacilli | Non-spore forming |
| Piscirickettsiosis (*Piscirickettsia salmonis*) | Gram-negative Rickettsia | Pleomorphic /coccoid | Non-spore forming |
| Furunculosis (*Aeromonas salmonicida* subsp. *Salmonicida*) | Gram negative | Bacilli | Non-spore forming |
| *Aeromonas salmonicida* – atypical strains | Gram negative | Bacilli | Non-spore forming |
| Enteric redmouth disease (*Yersinia ruckeri* – Hagerman strain) | Gram negative | Bacilli | Non-spore forming |
| ***Molluscs*** | | | |
| Infection with *Candidatus Xenohaliotis californiensis* | Gram-negative Rickettsia-like | Pleomorphic /coccoid | Non-spore forming |
| ***Crustaceans*** | | | |
| Necrotising hepatopancreatitis | Gram negative | Alpha-proteobacteria | Non-spore forming |

Information adapted from Inglis *et al.* (1993); and Carson (2005)

### *A 4.1.3 Protozoa and protozoal-like parasites*[1]

The complete lifecycle should be considered for any pathogen within this group before any decontamination procedure is undertaken. Since reservoir populations may lead to reinfection, the presence of intermediate hosts or resistant spores are important factors to consider during decontamination.

Among the protozoal parasites listed as reportable within Australia, most are microcell parasites of molluscs and the life cycle of many are poorly understood. As such, few control programs have been attempted to limit their spread (Bondad-Reantaso *et al.,* 2001). A number of these are also considered to have resistant spore stages within the lifecycle (refer to Table A8 for summary information) but research on the efficacy of various disinfectants against these types of spores may be limited.

Weche *et al.* (1999) suggests that spores produced by *Martelia sydneyii* were significantly inactivated using 200ppm chlorine for a period of 2 hours, with complete inactivation after 4 hours exposure. Bushek (1996) also reported that 400ppm chlorine and a contact time of 4 hours was required to kill *Perkinsus marinus* parasites in seawater. These high residual chlorine levels

1: Those microcell parasites belonging to the proctistan group, including *Bonamia spp., Mikrocytos ssp., Martelia spp, Perkinsus spp*. and *Haplosporidium spp*.

and long contact times suggest that, in the absence if specific information to the contrary, anyone attempting decontamination programs should consider protistan spores to be highly resistant to disinfection techniques.

The AQUAVETPLAN Disease Control Manual – Whirling Disease[1] states that within the life cycle of *Myxobolus cerebralis*, the myxospore stage is also the most resistant to disinfectant strategies and water entering freshwater habitats has the potential to contain viable myxospores if not adequately disinfected. Recommended methods for inactivation of myxospores within this disease control manual include the use of calcium hydroxide (0.5% for 24 hours), calcium oxide (0.25% for 24 hours), chlorine at 1600 ppm for 24 hours (or 500 ppm for 10 minutes) and heating to in excess of $90^{o}$ C for at least 10 minutes (DAFF, 2005c).

Other protists such as ciliates and flagellates are comparatively easy to inactivate using a variety of disinfectant products.

**Table A8: Protozoal and protazoal-like disease agents of aquatic animals listed as reportable within Australia**

| *Notifiable Disease (Protozoal/Protozoa-like Agent)* | *Formation of resistant spores* | *Lifecycle* |
|---|---|---|
| ***Finfish*** | | |
| Whirling disease *(Myxobolus cerebralis)* | Spores extremely long lived in pond sediments. Indirect lifecycle with salmonids and a widespread freshwater oligochaete worm as hosts[3]. | Indirect life cycle |
| ***Molluscs*** | | |
| Infection with *Bonamia* species including *B. ostreae & B. exitiosa* | No spores demonstrated[2] | No intermediate host known |
| Infection with *Mikrocytos roughleyi* | No spores demonstrated[2] | Direct life cycle suspected |
| Infection with *Mikrocytos mackini* | Unknown | Direct life cycle suspected |
| Infection with *Martelia refringens* | Spore forming[5] | Complete life-cycle unknown Intermediate host strongly suspected |
| Infection with *Martelia sydneyi* | Spore forming, survive up to 35 days outside of host[4] | Complete life-cycle unknown Intermediate host strongly suspected |
| Infection with *Perkinsus* species | Spore forming[1,2] | Direct transmission demonstrated. Host range for some species may be broad |
| Infection with *Haplosporidium nelsoni* | Spore forming | Indirect lifecycle suspected[2] |
| Infection with *Haplosporidium costale* | Spore producers | Indirect lifecycle suspected[2] |

1: Bondad-Reantaso *et al*. (2001); 2: Delany *et al.* (2003); 3: DAFF (2005b); 4: Wesche *et al.* (1999); 5: Berthe *et al.* (1998)

1:www.daff.gov.au/aquaticanimalhealth

### *A 4.1.4 Fungi*

The fungal diseases of aquatic organisms listed as notifiable within Australia are epizootic ulcerative syndrome (causative agent *Aphanomyces invadans*) in finfish and crayfish plague (causative agent *Aphanomyces astaci*).

The fungi within the oomycete group[1] are primarily pathogens of freshwater or estuarine systems, but infection of marine species can also occur. This group produces motile zoospores that, apart from a brief period of encystment, are relatively susceptible to most disinfectants.

The AQUAVETPLAN Disease Strategy Manual- Crayfish Plague[2] recommends the use of iodophors, peracid solutions or sodium hypochlorite as the most appropriate chemical disinfectants for this group. Lilly and Inglis (1997) reported that *Aphanomyces indvadans* was found to be susceptible to 100ppm available iodine following a contact time of at least 1 minute, whilst sodium hypochlorite and a commercial peracid solution required 20 minutes contact time to produce inactivation at the same concentration. This disease control manual also recommends the use of heat (>$50^0$C) and desiccation (drying for a minimum of 48 hours) as alternatives (DAFF, 2005c).

## A 4.2 Choice of disinfecting agents

Types of disinfecting agents that might be used during an outbreak of disease in aquatic animals include the following.

1. Oxidising agents
2. Alkalis
3. Aldehydes
4. Acids
5. Biguanides and quaternary ammonium compounds
6. Ultraviolet irradiation
7. Drying
8. High temperatures

It is beyond the scope of this document to discuss all possible types and combinations and has been limited to those considered most likely to be used during an emergency disease event. Tables A11 and A12 (page 36) indicate the comparative efficacy of common disinfecting agents whilst Tables A13 and A14 (page 37 and 38) provide a summary of the working characteristics of common chemical agents. Further details on the practical applications of each type are contained within *Part B* of this document.

It is common practice to use a variety of effective disinfecting agents within the decontamination program. For example, more expensive products are often used for critical tasks or the disinfection of personnel, but it may be more appropriate to disinfect of large volumes of water using cheaper compounds that are also available in sufficient quantities.

The shortcomings of each chemical type of disinfectant can often be improved by adjusting working concentrations and modifying physical parameters of water used. For example the antimicrobial effect of iodophors, carboxylic acids and chlorine may be improved by lowering the solution pH. With the exception of iodophors and alcohols, increasing concentration generally improves antimicrobial efficacy. Similarly, increased temperature (within a defined range) and contact time also increases the effectiveness of disinfecting agents.

## A 4.3 Oxidising agents

The majority of oxidising agents are comparatively fast acting and very effective disinfectants for a large range of micro-organisms when they are used under appropriate conditions, at a suitable concentration and acceptable contact times.

Most oxidising agents are corrosive to soft metals such as aluminium, brass and copper and can damage rubber items such as gumboots and vehicle tyres, the main exception to this being iodophor compounds. All oxidising agents can be neutralised through treatment with a reducing agent such as sodium thiosulphate (refer to section B 2.9 for further details).

### *A 4.3.1 Chlorine liberating compounds*

Chlorine liberating compounds are the most widely used chemicals for disinfection purposes. As indicated in Table A9, those chlorine compounds considered most suitable for use during decontamination programs fall into three basic categories; hypochlorite compounds; organic chloramines and chlorine dioxide liberators.

**Table A9: Common types of chlorine liberating compounds**

| *Chemical Group* | *Common Examples* | *Physical state (concentrate)* | *Available chlorine (concentrate)* |
|---|---|---|---|
| ***Inorganic chlorine compounds*** | *Sodium hypochlorite* | Liquid | 1-15% |
| | *Potassium hypochlorite* | Liquid | 12-14% |
| | *Calcium hypochlorite* | Powder | 65-70% |
| | *Lithium hypochlorite* | Powder | 30-35% |
| | *Chlorinated TSP* | Powder | 3.25% + detergent action |
| ***Organic compounds*** | *Chloramine-T* | Powder | 24-26% |
| ***Chlorine dioxide*** | *Sodium chlorite* + acid | Liquid | 17% |

Adapted from Dychdala (2001).

**Hypochlorite solutions** release chlorine in the form of hypochlorite ions and hypochlorous acid, which are the active disinfecting agents. However hypochlorite ions have much weaker biocidal activity than hypochlorous acid.

Hypochlorous acid and hypochlorite ions occur in equilibrium in solution with the relative concentration of each determined by either temperature or pH. As the water pH and temperature increase, so to does the concentration of hypochlorite ions. It is therefore necessary to maintain water pH at or below 7 (a pH range of 6-8.5 for working solutions is recommended) in order to maximise the effectiveness of these disinfecting solutions. In hot environments (above $25^{o}$C) the

1: Fungus-like pathogen
2: www.daff.au/aquaticanimalhealth

increase in hypochlorite ions may need to be compensated through the use of higher hypochlorite concentrations.

**Chloramine-T** is the most commonly used organic chloramine, being used as a veterinary disinfectant and therapeutic in both terrestrial and aquatic livestock.

Opinion about the chemistry of chloramine-T is the subject some debate, but it is generally accepted that, like the hypochlorites, chloramine-T decomposes in water to hypochlorite ions and hypochlorous acid. Degradation of the organic anion within chloramine-T occurs at a much slower rate than hypochlorites and this slow degradation makes solutions more stable, less corrosive and less irritant. Chloramine-T is also less affected by the presence of organic matter.

**Chlorine dioxide** has been used for the treatment of drinking water for many years. Although normally a highly reactive gas at room temperature requiring complex infrastructure for its generation, products have recently been introduced onto the market that allow chlorine dioxide to be utilised for a range of small-scale disinfection applications. These products commonly use sodium chlorite (also referred to as 'stabilised chlorine dioxide') solutions that are treated with an acid 'activator solution' to generate chlorine dioxide in solution. Chlorine dioxide does not ionise to form hypochlorite or hypochlorous acid and thus is not subject to the constraints of temperature or pH described above.

Chlorine dioxide has a number of significant advantages over hypochlorite solutions. It is less affected by the presence of organic matter and is unaffected by changes in pH levels between 6 & 10 (Dychdala, 2001). Manufacturers claim that commercial products remain effective between pH 3-10. Chlorine dioxide is also reported to have greater antimicrobial activity than sodium hypochlorite, in particular against spores (Dychdala, 2001).

### *A 4.3.2 Peroxygen agents*

Peroxygens include hydrogen peroxide, peracetic acid and monosulphates of either sodium or potassium. Peroxygen disinfecting agents are very active, not affected by organic matter but some products may be corrosive to alloys, aluminium and plain steel.

Peracitic acid is an extremely effective biocide and has no toxic residuals (Block, 2001). Peracid disinfecting solutions are generally sold as a mixture with acetic acid and hydrogen peroxide because these two latter compounds have a synergistic effect with peracetic acid. They are active against all types of microorganisms, including spores, and retain activity in the presence of organic matter (Jeffrey, 1995). Although biocidal activity is effective over a wide pH range, peracids tend to be more effective as weak acid solutions.

Powdered forms of peroxygens occur as sodium or potassium monosulphates (eg. potassium peroxomonosulphate triple salt). Throughout this document they will be referred to as monosulphates to differentiate them from other peroxygen agents. Monosulphates produce chlorine from salt solutions and peroxide in acid conditions. They therefore have dual actions depending on water pH. One common example of this group has achieved wide acceptance as a general disinfectant in the veterinary industry and is commonly used during emergency livestock disease events.

### *A 4.3.3 Iodophors*

Iodine is a potent disinfecting agent that is effective against a wide range of bacteria, fungi and viruses. The older forms of iodine disinfectants, inorganic aqueous or alcohol solutions, are generally toxic and corrosive making them unsuitable for decontamination programs. These problems have largely been overcome in the group referred to as the iodophors, which provide an effective disinfecting solution that is widely used.

Iodophors are a complex of iodine and an organic carrier molecule, allowing a sustained release of iodine over time in aqueous solution and increasing solubility. Iodophors are generally non-staining, have lower toxicity or irritant effects and are less affected by organic matter (3x) than chlorine disinfection compounds (Gottardi, 2001).

Iodophors also have the unique characteristic of producing higher levels of free molecular iodine (the disinfecting agent) when diluted. The concentration of free molecular iodine rises tenfold with a 1:100 dilution of 10% povodine-iodine solution, thereafter the biocidal effect decreases with further dilution (Gottardi, 2001). Thus making the optimum working solution 0.1% povidone-iodine for maximum free molecular iodine.

As free iodine also gives iodophor solutions their brown colour and solutions lose colour as iodine is consumed, this characteristic may be used as an indicator of solution exhaustion.

A commonly available iodophor is povidone-iodine, which uses a particular type of carrier molecule and is commonly used as a general disinfectant in veterinary medicine. Povidone-iodine is particularly non-toxic and non-corrosive and suitable as a disinfectant for skin or delicate equipment. Povidone-iodine gained wide acceptance in aquaculture through its use in the disinfection of fish eggs and the control of viruses such as infectious pancreatic necrosis virus.

Other iodophor solutions commonly used for disinfection on farms are acidified solutions, as this enhances their biocidal activity and penetrating ability. These solutions are commonly used in dairies for the disinfection of milking equipment and removal of milk deposits. Such preparations would also have applications in the cleaning and disinfection of aquaculture recirculation systems. Due to their low pH, acidified iodophor solutions may be corrosive to some materials.

## A 4.4 pH modifiers

### *A 4.4.1 Alkalis*

Alkalis are effective against a wide range of pathogens and act by raising the ambient pH to very high levels. Although compounds such as sodium hydroxide and sodium carbonate are commonly included in the formulation of cleaning compounds, when used at high concentrations they also have significant antimicrobial properties. Strong alkalis have been shown to have excellent activity against all categories of viruses at pH 12 or more.

Alkalis retain their effectiveness in the presence of heavy burdens of organic matter and assist the penetration of soiling through their saponifying action on fats as well as being effective in loosening organic matter. They are particularly useful for the decontamination of ponds, drains, effluent waste pits and carcase disposal pits. Their alkaline nature also means that they may be used on concrete surfaces.

Alkalis are corrosive to some metal alloys as well as irritant to skin and mucus membranes. Care should be taken when treating metal or painted surfaces. Staff must be supplied with appropriate safety equipment.

### *A 4.4.2 Acids*

The antimicrobial activity of acids is highly pH dependent and the biocidal mechanisms involved are uncertain (Quinn & Markey, 2001). Acids act slowly and although they have specific benefits as disinfectants, on their own their use is limited. They are more likely to be used as adjuncts to other compatible disinfecting agents, such as iodophors, where they produce optimal pH and enhance penetration or rinsing qualities.

**Table A10: Summary of corrosive qualities of some commonly used chemical disinfectants**

| *Corrosive nature* | *Common examples* | *Corrosive against* | *Relative corrosive strength* | *Comments* |
|---|---|---|---|---|
| Oxidising agents | Chlorine | Metal alloys<br>Rubber compounds | Moderate/High | |
| | Chlorine dioxide | Metal alloys | Moderate/High | |
| | Iodophors | Metal alloys | Low/Moderate | 1, 3 |
| Strong alkalines | Sodium hydroxide | Metal alloys<br>Aluminium | High | 2, |
| | Calcium hydroxide | Metal alloys<br>Aluminium | High | |
| Acids | Acidified iodophors | Concrete<br>Metal alloys | Moderate | |
| | Peracids | Concrete<br>Rubber<br>Metal alloys | Low | 4 |
| | Organic acids | Concrete | Low | |

Compiled from Bruins *et al.* (1995); Ritcher and Cords(2001); and Quinn *et al.* (2001).

1: Corrosive only at higher temperatures (>40$^{o}$C)
2: Highly corrosive to aluminium
3: Dependant on pH of specific formulations
4: Corrosive to steel & copper

## A 4.5 Aldehydes

Two aldehyde compounds that may be used during decontamination of aquaculture facilities are formaldehyde and glutaraldehyde. They act by denaturing protein, are highly effective against a wide range of organisms but relatively slow in action. Aldehydes maintain their activity in the presence of organic matter and are only mildly corrosive. Their main disadvantages are the irritating fumes that they produce, their expense and that they have been identified as carcinogens.

Formalin is a 40% aqueous solution of formaldehyde gas. Formalin diluted to 8% (12x dilution factor) is considered effective against most viral groups (AUSVETPLAN Decontamination Manual[1]). Gluataraldehyde is approximately three times more active than formalin and is commonly used at 1-2% concentrations. It is more active as neutral or alkaline preparations.

Formaldehyde gas is sometimes used to fumigate equipment and premises. For gaseous formaldehyde to be effective, the conditions must be carefully controlled in terms of gas concentration, gas distributions, temperature, humidity and contact time. It requires a relative humidity of greater than 70%, an air temperature of more than 13°C and a contact time of at least 12 hours. Given that buildings would constitute a relatively low risk during an aquatic disease event and that formaldehyde gas is extremely toxic, this method of disinfection would not routinely be recommended as it is unlikely that all parameters can be controlled adequately. Its use may be justifiable for sealed spaces that are otherwise difficult to disinfect such as cool rooms, boat holds and complex pipe-work. Refer to section B 2.5 for further details.

## A 4.6 Biguanides

Of the many biguanides available, chlorhexidine is probably one of the most commonly used. Chlorhexidine preparations do not irritate tissues and are commonly used as skin disinfectants, however they are not effective in hard or alkaline water and are less active against most types of pathogens than many other disinfectants. Chlorhexidine is sometimes used in combination with other disinfectants such as quaternary ammonium compounds in commercial preparations.

The use of chlorhexidine during emergency disease events would generally be restricted to use as a skin cleansing agent or disinfectant for delicate materials.

## A 4.7 Quaternary ammonium compounds (QAC's)

The biocidal efficacy of QAC's is variable and selective. They are effective against some vegetative bacteria and some fungi, but not all viruses (Treeves-Brown, 2000; Ritcher & Cords, 2001). QAC's are most active against Gram-positive bacteria, but action against Gram-negative bacteria is slow with some strains showing resistance. These compounds are not effective against spores.

The advantages of QAC's are that they are odourless, non-corrosive, non-irritant, have wetting properties and have low toxicity to mammals. They also retain activity over a wide pH range (pH 3 to 10.5), are stable at higher temperatures, are not generally not affected by organic matter and

1:www.animalhealthaustralia.com.au

maintain a residual effect on treated surfaces. Hard water and anionic detergents inhibit QAC's, limiting their use to freshwater situations.

As with the chlorhexidines, QAC's are more commonly used for sanitation rather than disinfection. Being a cleansing agent, they may be used to combine the cleaning and disinfection stages where appropriate.

### A 4.8 Ultraviolet radiation

Ultraviolet irradiation (UV) is a viable option for the treatment of water entering and/or leaving aquaculture facilities where there is some control over water flows (eg. semi-closed systems such as hatcheries or shore-based abalone farms) and where other chemical or heat treatments are not viable options.

UV disinfection systems use low-pressure mercury lamps enclosed in quartz tubes. The tubes are immersed in flowing water channels and allow passage of UV radiation at a wavelength of approximately 260nm (Bitton, 1994).

Some units also use a titanium dioxide catalyst which, when irradiated with UV light, produce super oxide ions and hydroxy radicals that increase the disinfection capability. These systems are lightweight and function over a range if temperatures, pressures and pH (McDonnell and Pretzer, 2001). Similar units have recently been used to control fungal infections in finfish hatcheries.

In general, resistance to UV follows the same pattern as described in Figure A2 (Bitton, 1994). The efficacy of UV disinfection depends on the type of microorganism, the clarity of the water, the intensity of light and exposure time. Many variables such as suspended solids, chemical oxygen demand or water colour affect the transmission of UV radiation and as a result, the practical disinfecting capability. Vegetative bacteria and enveloped viruses may only require $10mJ/cm^2$ but non-enveloped viruses may need as much as $200mJ/cm^2$ (Bitton, 1994).

For UV to be most effective, water **must** be pretreated to remove contaminants that could inhibit light penetration. Flocculation and filtration of wastewater prior to irradiation significantly improves the disinfecting effect and reliability of UV radiation units. Meters capable of measuring the direct UV dose during exposure are available.

Although it is unlikely that UV radiation would be used during initial stages of an emergency response, add-on units are now readily available within aquaculture. These should be considered if environmental contamination by chemicals is a significant concern, or it is anticipated that a disinfection process for water out of infected premises will be required for some time. They may also be use to safeguard facilities from re-infection when used to treat inlet water.

## A 4.9 Heat

Under most conditions the use of moist heat is considered more effective than dry heat. The use of steam or hot water pressure cleaners to apply wet heat to surfaces is likely to be the most common form of heat process during an emergency disease response. These types of steam/heat pressure cleaners are readily available and although their primary purpose is to use heat to loosen oily build-ups, the heat applied can also have significant disinfecting characteristics.

The effect of heat is completely time and temperature dependent but unless applied under controlled conditions, such as autoclaves, it is difficult to measure for practical disinfection purposes. However if combined with complete drying or chemical disinfection, wet heat processes are considered excellent supplementary methods for decontaminating equipment such as transport bins, tanks or machinery. Caution should be taken to ensure that temperature and water pressure applied during such processes does not damage equipment.

Heat is also an important tool in the disinfection of small volumes of contaminated water and is a process used within some laboratories where aquarium wastewater is temporarily heated for prescribed periods prior to its release.

Dry heat may also be used to thoroughly dry equipment following cleaning. For many pathogens the process of desiccation is an effective disinfecting process and should not be under-estimated as a final stage to the decontamination process. Practical applications for dry heat include the use of heat rooms for diving equipment to ensure that suits and other delicate equipment are thoroughly dried at the end of each day. Within Australia, the hot dry climate is an important disinfecting tool that is often overlooked but one that is an extremely effective adjunct to other disinfection procedures if equipment is left to dry in areas exposed to sunlight.

The use of ‘flame-guns’ has been promoted in some literature as an effective method of applying dry heat to large areas such as buildings, concrete tanks or other non-flammable structures. In reality, flame-guns are difficult to source and have major workplace safety risks associated with their use. Although they would be suitable for treating large concrete ponds in practice their use is unlikely and not recommended.

**Table A11: Relative susceptibility of viruses, fungi & protozoa to disinfecting agents**

| | *Virus Category A* | *Virus category B* | *Virus category C* | *Fungi* | *Spore-forming protozoa* |
|---|---|---|---|---|---|
| *Strong Alkalis* | ++ | + | ++ | ++ | + |
| *Aldehydes* | ++ | + | ++ | ++ | + |
| *Peracetic acids* | ++ | ++ | ++ | ++ | + |
| *Chlorine* | ++ | + | ++ | ++ | +/-[1] |
| *Chlorine dioxide* | ++ | ++ | ++ | ++ | + |
| *Iodophors* | ++ | +/- | ++ | ++ | +/-[1] |
| *Ozone* | ++ | + | ++ | + | +/- |
| *Ultraviolet* | + | +/- | + | + | ? |
| *QACs* | +/- | - | - | + | - |
| *Acids* | + | - | +/- | - | - |
| *Biguanides* | + | - | - | - | - |

**Table A12: Relative susceptibility of bacteria to disinfecting agents**

| | *Gram negative* | *Gram positive* | *Mycobacteria* | *Rickettsia-like* | *Bacterial spores* |
|---|---|---|---|---|---|
| *Strong alkalis*[1] | ++ | ++ | + | ++ | + |
| *Aldehydes* [2] | ++ | ++ | + | + | + |
| *Peracetic acids* | ++ | ++ | ++ | ++ | + |
| *Chlorine dioxide* | ++ | ++ | ++ | ++ | + |
| *Chlorine* | ++ | ++ | ++ | ++ | + |
| *Iodophors*[2] | ++ | ++ | ++ | ++ | + |
| *Ozone* | ++ | ++ | ++ | ++ | + |
| *Ultraviolet* | ++ | ++ | + | ++ | ? |
| *QACs* | +/- | + | - | + | - |
| *Acids*[2] | + | + | +/- | + | +/- |
| *Biguanides* | + | + | - | + | - |

| | |
|---|---|
| ++ | Highly effective |
| + | Effective |
| +/- | Limited activity |
| - | Not recommended |

1: high concentrations required to be effective
2: Prolonged contact times required in some circumstances, in particular spores.
3: limited data available

**Table A13: Summary of working characteristics for major chemical disinfectant groups**

| | *Comparative spectrum of activity score (0-10)* | *Effective pH working range* | *Relative chemical hazard to user (Concentrate)* | *Relative chemical hazard to user (Working sol.)* | *Relative chemical hazard to environment* | *Comparative corrosion characteristics* | *Stability of working solutions* |
|---|---|---|---|---|---|---|---|
| ***Alkaline compounds*** | 5-8 | Alkaline Conditions | 10 | 7 | 8 | 10 | >7 days |
| ***Acid ionic surfactants*** | 5-7 | Narrow pH 2 – 3 | 3 | 1 | 4 | 4 | > 7 days |
| ***Acids*** | 5-7 | Narrow pH 2 - 3 | 8 | 5 | 2 | 3 | > 7days |
| ***Chlorine compounds*** | 7-9 | Moderate pH 6 - 10 | 8 | 4 | 3 | 8 | 1 day |
| ***Iodine (iodophors)*** | 7-9 | Moderate pH 2 -6 | 6 | 2.5 | 6 | 6 | 5 days |
| ***Peracids*** | 8-10 | Wide | 7 | 0.5 | 0.5 | 4 | 1 day |
| ***Chlorine dioxide solutions*** | 9-10 | Wide | 8 | 7 | 1 | 8 | <1 day |
| ***QA compounds*** | 5-6 | Wide pH 3 –10.5 | 1 | 0.5 | 4 | 0.5 | >7days |

Table adapted from summary information provided in Ritcher & Cords, 2001 and Bruins & Dyer, 1995.

**Poor working characteristics**
**Acceptable working characteristics**
**Good working characteristics**

**Table A14: Summary of major advantages and disadvantages of major chemical disinfectant groups**

| | *Inactivation by organic matter* | *Wetting ability* | *Temperature tolerance* | *Effect of hard water* | *Effectiveness against mineral deposits* | *Residual activity* | *Foaming character* | *Inhibited by* |
|---|---|---|---|---|---|---|---|---|
| ***Acids*** | Stable | Good | Wide, some loss at v. low temps | Low | Effective | Slight residual bacteriostatic activity | Low | Cationic surfactants<br>Very low temps. |
| ***Chlorine compounds*** | Loses activity rapidly | None | Wide | None unless alkaline | None | Limited | Nil | Organic matter, High pH |
| ***Iodophores*** | Moderate to high loss of activity | Moderate to good, dependant on formulation | 5-40°C Loss activity below 50 and off gassing above 120. | Moderate | Limited dependent on pH of formulation. | Some | Moderate, dependant on formulation. | Hard water<br>Organic matter<br>Temperature extremes<br>High pH |
| ***Peracetic acids*** | Moderate to low loss of activity | Dependent on product formulation | Wide | None | Limited effect due to acid nature | Some | Low, unless combined with a surfactant | Copper, iron manganese and chloride ions |
| ***Chlorine dioxide*** | Low to moderate | None | Wide | None | None | Some | Nil | |
| ***Quaternary ammonium compounds*** | Moderate to Stable | Good | Stable | Inactivated by hard water | None | Some | High | Very low temps.<br>Anionic detergents or wetting agents |

**Poor working characteristics** (dark grey)
**Acceptable working characteristics** (light grey)
**Good working characteristics** (white)

# Part B: Procedures and recommendations

## B 1. Recommendations for enterprise types

Aquatic animal industries are highly variable, as are the range of disease agents and hosts that may be involved in the emergency disease situation. In many cases limited information may be available and a control strategy may need to be quickly developed using first principles. Decontamination procedures must be appropriate for the different management systems that exist for intensive and extensive aquaculture systems.

For the purposes of AQUAVETPLAN[1], aquaculture systems have been categorised into four basic types; open, semi-open, semi-closed and closed systems. A single industry might use more than one system in different phases of production. For example, salmon production within Tasmania often uses closed systems during egg incubation and larvae growth, semi-closed systems for the production of smolt and semi-open systems for final grow-out.

The structure and operation enterprise types is explained in detail within the AQUAVETPLAN Enterprise Manual[1], and should be consulted if further information is required.

### B 1.1 Open systems

***General characteristics***

- Usually large infected area
- Limited or no control over water movements
- Limited or no control over stock movements
- Limited or no control over non-target fish movements
- Limited or no ability to decontaminate the system
- Decontamination restricted to movement in and out of the infected area
- Very wide group of stakeholders.

***Common examples***

- Native fish stocks within natural waterways, dams or bays
- Recreation fishing stocks within dams, lakes or rivers.
- Stock used in reseeding or restocking programs.

1: www.daff.gov.au/aquaticanimalhealth

Open systems are waterways where there is no control of either aquatic animal stock movement or water flow (eg wild-caught fisheries, sea ranching). Aquatic animal disease emergencies occurring in open waterways will invariably be difficult to manage due to problems associated with controlling animal and water movements as well as the very large areas involved. There may also be significant impact on the environment by decontamination procedures and involve a wide group of stakeholders affected by control measures.

Eradication and control programs in open systems require significant long term planning to determine how programs will be undertaken but will generally involve the control of susceptible species and measures to limit spread of the pathogen. In such circumstances, decontamination programs will tend to be limited to decontamination of personnel, vehicles and equipment moving out of the infected area.

As the infected area will usually be associated with a particular water catchment or large water body, there are likely to be multiple access points that are difficult to control. Control measures will rely on simple measures undertaken by multiple users.

The potential for litigation resulting from recommendations made to the general public, or action taken by authorities is extremely high. Under such circumstances, decontamination procedures must be simple, safe and non-corrosive. Unless undertaken by trained officers, decontamination procedures recommended to the general public should rely primarily on good cleaning procedures using products that would normally be available for such purposes. The use of more corrosive or irritant chemicals, such as sodium hydroxide or formalin, should be avoided.

Decontamination control measures that may be applied include:

- the installation of wheel baths at strategic points around the control area;
- production of technical literature explaining how the general public may undertake simple cleaning or disinfection procedures
- establishment of signage and wash-down bays at boat ramps
- the establishment of logbook systems for commercial operators working within the infected area that document when decontamination procedures are undertaken, and
- training workshops for those frequently entering or leaving infected areas.

## B 1.2 Semi-open systems

### *General characteristics*

- Limited or no control over water movement
- Control over stock movements
- Limited or no control over non-target fish species
- Limited or no ability to decontaminate the environment

- Decontamination tends to be restricted to personnel or equipment moving out of infected areas and the safe disposal of infected material.

*Common examples*

- Finfish marine farms (salmon, ocean trout, tuna, yellowtail kingfish)
- Oyster or mussel leases
- Open water abalone farms
- Finfish cages within freshwater systems

In semi-open systems there is control of aquatic animal stock movement but no control of water flow. Infected areas for semi-open systems are likely to involve whole water bodies such as estuaries, lakes or bays. Under such circumstances the disinfection of water and animal wastes may not be practical. Decontamination operations in semi-open systems should concentrate on controlling spread of disease through decontamination of personnel, equipment, machinery and vessels leaving the infected area.

Although wild fish stocks or water currents may carry pathogens out of the area, this is generally associated with a significant dilution factor. Any equipment used to contain fish stocks or waste material has a significantly higher risk of transferring disease if allowed to leave the area without appropriate disinfection. Similarly, personnel and equipment that come into contact with infected material should also be thoroughly cleaned and disinfected. Equipment nets and cages left on site should also be decontaminated as these may act as reservoirs of infection and thus compromise ongoing decontamination operations or allow reinfection once stock are re-introduced to the site.

Semi-open systems are often some distance from shore and will have specific problems associated with the availability of suitable water supplies for cleaning and disinfection operations. Wastewater resulting from decontamination operations will present problems for disposal and may rely primarily on adequate dilution before release into the aquatic environment. Chemical agents that have low environmental impact should be chosen and appropriate authorisation obtained from relevant State or Territory authorities.

The use of plastic liners within polar circles is a common method of transporting freshwater for the treatment of parasitic disease within the Tasmanian salmonid industry. Such liners are also useful for holding large quantities of water for cleaning and disinfection operations. Liners may also be used to store wastewater containing disinfecting agents prior to transport to an appropriate disposal site, or in the case of chlorine based disinfectants, holding until chemicals have decomposed to levels considered safe for discharge into natural waterways.

If required, various stages of cleaning and disinfection may be undertaken at separate locations with initial cleaning of equipment, personnel and vessels undertaken at the farm site prior to movement to a shore-based location for final disinfection. This separation of operations allows the removal of gross fouling at the farm, retaining the majority of infected material at the site and thus reducing the amount of waste material that must be disposed of onshore. This type of approach may require the need for additional work teams, but has the advantage of breaking the decontamination program down into manageable sections, especially where water based facilities are restrictive.

### B 1.3 Semi-closed systems

***General characteristics***

- Some ability to control water movements
- Ability to control stock movements
- Ability to exclude non-target fish species
- Ability to decontaminate the infected premises
- Disinfection of large volumes of water may be required

***Common examples***

- Finfish hatcheries using river water
- Prawn farms
- Land based abalone grow-out sites (non-recirculation)
- Land based mollusc hatcheries (non-recirculation)
- Laboratories using flow-though systems
- Marron or yabby farms based on river systems

Semi-closed systems are systems where there is control of aquatic animal movement and some control of water flow (eg pond culture, raceway culture). In these systems species of fin-fish, crustaceans or molluscs are contained so that the animals, water and other associated materials are not in direct contact with natural waterways. Water is usually taken from an adjacent natural source and discharged from the enterprise further downstream. Release of this water may be a continuous or intermittent flow.

Under such circumstances it is possible that an infected area may be restricted to one or more premises rather than a complete water catchment and therefore decontamination of individual premises is a viable option. In addition to decontamination of personnel, equipment and vehicles leaving the infected premise, decontamination in semi-closed systems is also likely to include tanks, pond systems, large machinery, buildings, pipe-work and large volumes of water.

Prior to decontamination, inlet water into the facility will need to be diverted and the discharge of infected material or chemical wastes strictly controlled. Apart from water drained from tanks and ponds, there should be no need to repeatedly disinfect large volumes of water while inlet water is diverted.

Water within tanks, ponds, pipelines and biofilters may be treated with chemical disinfectants prior to release or disposal. Due to the large volumes involved and the relatively low organic loading, chlorine-based disinfectants (in particular hypochlorites or chlorine dioxide), will most likely be used. If a high level of organic matter is present, chlorine-dioxide solutions, alkaline compounds or peracids may be considered as alternatives to hypochlorite. The use of flocculating agents as a pretreatment, other oxidising disinfectants and UV irradiation are also possible alternatives that could also be considered.

Decontamination of water entering and/or exiting semi-closed systems will be a major challenge. Attempts to disinfect large volumes of water will depend on whether infection is localised to the specific enterprise, or whether the waterway from which it feeds is also infected.

If infection is localised to a specific site, discharge of infected wastes downstream should be strictly controlled. However, there is little point in disinfecting water exiting a facility into a known infected open system. Under such circumstances, disinfection of water entering the enterprise after decontamination of the site becomes more important.

Water disinfected with oxidising agents such as hypochlorite or iodophores may be inactivated with thiosulfate prior to release into waterways. Alternatively, chlorine based disinfectants may be held until chlorine levels dissipate to acceptable levels, or discharged at controlled rates to achieve adequate dilution factors. Discharge onto waste ground or irrigation over pastures are also potential options in some circumstances. The latter strategy has the benefit of achieving additional pathogen reduction through the actions of sunlight and desiccation.

Following decontamination of the facility, there may be a need to decontaminate discharge water during a monitoring period and/or have ongoing disinfection of inlet water. Under such circumstances, the use of filtration and UV radiation or ozonation may be appropriate.

Advice from State or Territory environmental management authorities should be sought regarding appropriate maximum discharge levels. Where there is any doubt about the levels of chemical remaining in the discharge water, levels should be tested prior to release.

## B 1.4 Closed systems

### *General characteristics*

- Good control of water movements
- Good control over stock movements
- Able to restrict non-target fish species
- Able to disinfect infected premises
- Disinfection of large volumes of water may be required
- Generally associated with water recirculation facilities.

### *Common examples*

- Closed aquarium facilities
- Pet stores
- Laboratories using water recirculation
- Finfish, crustaceans or molluscs held in recirculation facilities.

Within a closed water system, both the stock and the water are closely controlled, usually in tanks with attached filtration systems (eg aquaria). Decontamination programs within closed systems have the greatest chance of being successful in the long term since infection tends to be confined to the facility. Following disinfection, external water supplies can be treated before entering the facility.

Decontamination within closed systems will almost certainly require the decontamination of biofiltration systems and complex pipe-work. If the facility is small and uses multiple biofilters, it is safer and often more cost effective to dispose of gravels, plastic tubing, biofilter substrates and filter components rather than attempting to disinfect. Such porous material will be difficult to clean and disinfect and, as a result, may provide a nidus of future infection.

Larger closed systems will have complex systems of pipe-work and large biofilter towers. The complex nature and limited access to these structures makes them difficult to disinfect without complete or partial dismantling. As with smaller closed systems, attempts to salvage porous material may represent false economy.

Biotowers should have substrates removed for disinfection or replacement. All filter canisters or sand (in the case of sand filters) should be replaced. Pipe-work should be cleaned via a pigging system (refer to section A 3.5.6 and B 3.4 for further information on pigging systems) or completely dismantled. Following cleaning and disinfection, the whole system should be allowed to dry completely for a significant period of time.

Closed systems lend themselves to the use of heat, ozone, UV or chemical treatment of both intake and discharge water as these can be held in batches and treated before entry into the system or release into the environment.

# B 2. Recommendations for specific chemical agents

## B 2.1 Hypochlorite solutions

Hypochlorites are amongst the most commonly used disinfectant solutions. They are fast acting with a wide spectrum of activity, inexpensive and readily available. Their major disadvantages are that organic matter readily inactivates them and working solutions tend to decompose quickly (the latter also being an advantage when wishing to dispose of disinfection solutions).

The concentrate liquid solutions of sodium hypochlorite and potassium hypochlorite also degrade over time with open containers losing up to 50% of their original concentration within one-month (Quinn and Markey, 2001). Similarly powder formulations, although significantly more stable, can react with moisture if open to the air.

As outlined in Table A9 (page 29), the available chlorine levels produced by various chlorine disinfectants varies significantly. Sodium hypochlorite is commonly supplied in a solution containing 14% wt/vol (but may vary from 1-15%), whilst calcium hypochlorite is generally 65% active chlorine. Using these products, either 1 litre of sodium hypochlorite (at 14% available chlorine) or 216 grams of calcium hypochlorite mixed with 140 litre of fresh water produces a solution containing 1000mg/L available chlorine.

Chlorine test kits are readily available from pool supply or aquarium stores and it is important to confirm the concentration of both the initial dose and residual levels of chlorine in any working solutions used. Refer to section B 2.8 for further explanation of initial dose and residual levels.

Refer to section A 4.3.1 and Tables A11 to A14 (pages 36-38) for further details on hypochlorite disinfectants.

### *Advantages*

- Wide spectrum of activity effective against bacteria, fungi, viruses, protozoa and spores
- Rapid disinfecting action
- Non-foaming action and is easily rinsed from surfaces
- Not affected by cold temperatures
- Not affected by hard water unless pH is high
- Inexpensive and readily available
- Low toxicity at dilute concentrations
- Ease of use
- Relatively low cost.

### *Disadvantages*

- Working solutions degrade rapidly
- Readily inactivated by organic matter
- Disinfecting ability significantly affected by pH with loss of activity above pH 8.5
- No wetting capability
- Concentrate solutions tend to degrade over time.

### *Availability*

Hypochlorite disinfectants are readily available from commercial cleaning supply wholesalers, swimming pool supply stores and chemical wholesalers in a range of concentrations.

### *Environmental / workplace safety considerations*

- Recommendations and safety advice from the manufacturer and outlined within the appropriate material safety data sheet should be adhered to
- Toxic to fish, but the effect of hypochlorites tends to be rapidly neutralised by organic matter and therefore any effects are short-lived
- Inactivated by thiosulphate
- Hypochlorites are powerful oxidising agents and some compounds may cause fire, explosion or produce severe burns. Concentrate preparations should not to come into contact with other chemicals (especially acids) or with combustible material such as paper, fabric, sawdust or kerosene
- Concentrate preparations should be stored in dry, well-ventilated areas away from sunlight.
- Do not mix with other chemicals or with different types of chlorinating chemicals
- Concentrate preparations can irritate eyes, nose, throat and skin. Avoid contact with skin, eyes, and clothing. Avoid breathing dust or vapour
- Liberates chlorine gas at low pH and therefore should not be mixed with acids.

### *Applications*

- Use as a basic disinfecting agent for most applications, taking into account the points listed above
- Use over clean surfaces
- Disinfection of water
- Disinfection of previously cleaned buildings, equipment, vehicles tanks and pipework

- Not recommended for disinfection of slurries, manures, carcases, uncleaned surfaces or other circumstances where high levels of organic matter may be present.

## B 2.2 Chloramine-T

Chloramine-T is considered to have a slower disinfecting action than the hypochlorites and is most suited to those applications where greater contact times are possible and a more stable or less corrosive solution is required.

As with hypochlorites, disinfecting capability is affected by water pH with biocidal activity of chloramine-T being greatest under acidic conditions but reduced by high pH levels, high organic loading and excessive water hardness.

Chloramine-T (sodium p-tolulene) is a white crystalline powder which, like all chlorine compounds, is an oxidising agent and may cause respiratory irritation. Preparations generally supply 25% available chlorine, requiring 4 grams dissolved into 1litre to produce 1000mg available chlorine. Experience has shown that the coarser crystalline formulations are significantly less irritant to eyes and respiratory membranes than the fine powder preparations.

Refer to section A 4.3.1 and Table A11 to A14 (pages 36-38) for further details on organic chlorine solutions.

***Advantages***

- Less affected by organic matter than hypochlorite solutions
- Less corrosive and irritant that hypochlorite solutions
- Effective against a wide range of organisms, although data on specific fish pathogens is limited
- Concentrate powder is very stable
- Comparatively more stable in solution than other chlorine liberating agents
- Effective against biofilms

***Precautions / Disadvantages***

- More expensive than hypochlorite but comparable in price to iodophors
- Slower disinfecting activity than hypochlorites, therefore requires longer contact times
- Limited specific data on fish pathogens
- Some preparations are fine powders that are highly irritant to respiratory tracts
- Activity reduced by high pH

- Activity reduced by hard water.

*Environmental / workplace safety considerations*

- Recommendations and safety advice from the manufacturer and outlined within the appropriate material safety data sheet should be adhered to
- Reported to have lowest acute oral toxicity of twelve chlorine liberating compounds tested, including hypochlorites and chlorine dioxide (Dychdala, 2001)
- Concentrate powder is a strong oxidising agent, may be irritant to skin eyes, respiratory tract and mucous membranes. However solutions are considered relatively safe
- Inactivated by thiosulphate
- Unlike hypochlorites, do not form carcinogenic trichloro-methanes
- Oxidising agent that may cause may cause fire, explosion or produce severe burns. Powder preparations should not to come into contact with other chemicals (especially acids) or with combustible material such as paper, fabric, sawdust or kerosene
- Liberates chlorine at low pH and therefore should not be mixed with acids.

*Availability*

- Availably through veterinary wholesalers or distributors as registered veterinary products
- Generic compounds available through chemical wholesalers.

*Applications*

- Useful where chlorine disinfection is required and long contact time is possible, but the presence of organic matter, possible corrosion and the need for a relatively stable working solution preclude the use of hypochlorites
- Use as a general disinfectant where longer contact times are possible or the solution is left to dry on treated surfaces
- Disinfection of water, dive equipment, pipe-work, nets, ropes and instruments
- Use in footbaths.

## B 2.3 Stabilised chlorine-dioxide solutions

These products commonly use sodium chlorite (also referred to as ‘stabilised chlorine-dioxide’) solutions that are treated with an acid ‘activator solution’ to generate chlorine-dioxide in solution.

Chlorine-dioxide has a number of significant advantages over other chlorine-based solutions as it is less affected by the presence of organic matter and tolerant of changes in pH levels. Chlorine dioxide is also reported to have significantly greater antimicrobial activity than sodium hypochlorite, in particular against spores (Dychdala, 2001).

The most significant problem associate with chlorine-dioxide is its tendency to gives off fumes when first activated and the short working life of activated solutions.

When making up disinfection solutions, the stabilised chlorine-dioxide solution is first diluted with water and then an activator acid solution added (or as per manufacturer instructions). At this point care must be taken to avoid any fumes given off during the reaction and the activated stock solution is generally left to stand for 20 minutes. Following this the activated solution is then diluted to appropriate working concentrations of the final disinfecting solution.

Activated solutions are unstable if exposed to sunlight or temperature and manufacturers recommend making up solutions immediately before use. Stability of activated solutions is enhanced if stored in sealed, dark containers at cooler temperatures. Advice on the working life of solutions should always be sought from the manufacturer, alternatively chlorine-dioxide test kits are available and should be used to measure the residual concentration of working solutions.

Some manufacturers also recommend the application of un-activated stabilised chlorine dioxide solution to liquids. Under such situations the solution is reported to degrade slowly and produce low levels of chlorine dioxide for prolonged periods, usually 2-3 days.

There is little documented information within the literature on the effectiveness of chlorine dioxide against pathogens of aquatic species. Given that the disinfecting activity is considered to be greater than hypochlorite solutions, it is reasonable to use recommendations for hypochlorite as a conservative guide. However the advice of the manufacturer should always be sought before use.

Refer to section A 4.3.1 and table A11 and A14 (pages36-38) for further detail on chlorine dioxide solutions.

***Advantages***

- Not affected by high levels of organic matter to the same extent as other chlorine liberating compounds
- Does not form toxic compounds when reacting with organic matter. Chlorine dioxide does not react with ammonia to form inorganic chloramines or toxic trihalomethanes (Bitton, 2005)
- Works affectively over a wide pH range, up to pH 10

- Reported to be effective against biofilms
- Highly effective disinfectant with activity greater than hypochlorite solutions
- Unactivated solutions relatively stable.

### *Disadvantages*

- Gives off toxic fumes when first activated
- Strong oxidising potential means that chlorine dioxide has similar corrosive characteristics to hypochlorite solutions
- Working solutions unstable, especially in the presence of sunlight and elevated temperature.

### *Environmental / workplace safety considerations*

- Recommendations and safety advice from the manufacturer and outlined within the appropriate material safety data sheet should be adhered to
- Considered to have comparatively low environmental impact
- Manufacturers recommend that solutions should have residual levels of less than 10ppm chlorine dioxide before release into the environment
- Stock solution is highly alkaline and harmful if ingested, corrosive to eyes and causes burns to skin.

Caution note:

B1: Stabilised chlorine dioxide produces irritant vapours when first activated. The solution must be allowed to stand in a well-ventilated area for a period before use. Inhalation of vapours, mists or aerosols may result in respiratory irritation.

### *Availability*

Stabilised chlorine dioxide solutions are available through cleaning and disinfection manufacturers or wholesalers as range of brands.

### *Applications*

- A useful disinfectant on hard surfaces where fast action is required
- Disinfection of pipe-work and boat holds
- Treatment of water containing higher levels of organic matter
- Treatment of containers or facilities used to contain or manufacture food for human consumption

## B 2.4 Iodophors

### *General characteristics*

Iodophors generally have low toxicity and low irritant characteristics when compared to other disinfecting compounds. Gottadi (2001) reports iodine reacts with proteins at least three times slower than chlorine, thus making iodophors comparatively more stable than hypochlorites in the presence of organic loading. However, iodophors are more adversely affected by water hardness and alkaline conditions.

With the exception of povidone-iodine, which tends to be neutral, iodophors form mild acid solutions and are most active at low pH. As a result they still retain some corrosive characteristics to metal and fabrics. Iodophors have optimum biocidal activity between pH 2 and pH 5, but retain effectiveness up to pH 7. Some iodophor solutions are formulated with phosphoric acid to provide optimal pH conditions (pH3) for enhanced biocidal activity.

Available free iodine is the active component of iodophors and can be measured to assess the viability of working solutions, but it is more common to use colour as an indication of solution exhaustion. Once solutions have lost their brown colour to become colourless they are no longer active.

Iodophors must be properly diluted to achieve full anti-microbial activity. Dilution causes more iodine to be available in solution and thus enhances anti-microbial activity. In the case of povodine-iodine, the optimum working solution is 0.1% for maximum free molecular iodine (Gottardi, 2001).

Refer to section A 4.3.3 and Tables A11 to A14 (refer to pages 36-38) for further details.

Caution note:

B2: The bactericidal agent in iodophor solutions is free molecular iodine rather than total iodine or iodophor concentration. There is considerable variation in how the iodine content is reported between different brands of iodophors. Manufacturers should be consulted for recommended dilution rates if there is any doubt.

### *Availability*

- Povidone-iodine solutions are readily available in a range of brands with most products being sold as 10% W/V povidone-iodine solution, providing 1% available iodine. The products are commonly available through veterinary or medical wholesalers
- Acidified iodophors are commonly utilised by the dairy industry for cleaning and disinfection purposes. These products are generally available through agricultural supply companies.

*Advantages*

- Excellent broad-spectrum anti-microbial activity, having good activity against bacteria, fungi, viruses and protozoa, as well as bacterial and fungal spores. Treatment of spores and non-envelope viruses will require longer contact times
- Less affected by organic material than chlorine compounds. Remains active in the presence of organic matter, provided pH does not rise above pH 4
- More stable than chlorine solutions
- Lower corrosive qualities and less irritant than chlorine, alkaline or peroxygen compounds. Acidified iodophors still retain some corrosive qualities
- Working solutions easy to monitor, as brown colour disappears when inactivated
- Mild acidic nature prevents film formation and makes it easy to rinse off
- Works equally well at both low and high temperatures, 10-40$^{o}$C.

*Precautions / disadvantages*

- Recommendations and safety advice from the manufacturer and outlined within the appropriate material safety data sheet should be adhered to
- Acidic solutions may be corrosive and are not recommended for concrete surfaces
- Biocidal activity is reduced when diluted with highly alkaline water
- Can cause staining under some circumstances
- Can produce iodine gas if used at temperatures above 50$^{0}$C (Ritcher and Cords, 2001)
- Hard water and very high levels of organic matter reduces the activity of iodophors, particularly under alkaline conditions
- Comparatively expensive
- Inactivated by thiosulphate.

*Environmental/ workplace safety considerations*

- Highly toxic to aquatic life. Toxic to fish at concentrations as low as 50ppm (ref)
- Waste solutions may be discharged into sewers, where they will gradually be inactivated by proteins (subject to approval by the appropriate authority)
- May be neutralised by sodium thiosulfate.

*Applications*

- Footbaths
- Disinfection of hands

- Disinfection of smooth surfaces, including fibreglass or plastic tanks
- Disinfection of diving equipment with povodine-iodine
- Disinfection of personnel (povidone-iodine)
- Water treatment.

## B 2.5 Alkaline compounds

### *General characteristics*

These compounds are effective against a wide range of pathogens and act by raising the ambient pH. Strong alkalis have been shown to have excellent activity against all categories of viruses at pH 12 or more.

Alkalis retain their effectiveness in the presence of heavy burdens of organic matter and assist the penetration of soiling. They are particularly useful for the decontamination of ponds, drains, effluent waste pits and carcase disposal pits. Their alkaline nature also means that they may be used on concrete surfaces.

Alkalis are corrosive to some metal alloys and irritant to skin and mucus membranes. Care should be taken when treating metal or painted surfaces. Staff must be supplied with appropriate safety equipment.

The activity of alkalis is relatively slow when compared to other disinfectants such as hypochlorites, peracids or chlorine dioxide. Raising water temperatures and increasing concentration can enhance the effect of most alkali compounds, but this should be undertaken with extreme caution due to increased workplace safety issues and corrosion risks.

Alkalis can form complexes with ions from hard water when used at high temperatures and these precipitates can be difficult to rinse off equipment. An acid rinse to remove residues may be required.

Refer to section A 4.4.1 and Tables A11 to A14 (pages 36-38) for further details on alkali disinfectants.

### *Availability*

- *sodium hydroxide* (caustic soda)
- *calcium hydroxide* (slaked lime)
- *calcium oxide* (quicklime or burnt lime)
- *Sodium carbonate,* anhydrous or hydrated forms (soda ash or washing soda)

**Table B1: Comparison of the relative activity of alkali compounds**

| Chemical | Disinfection activity | Comments |
|---|---|---|
| CaO (quicklime) | High | Produces heat in contact with water, often used to disinfect carcases |
| $Ca(OH)_2$ (slaked lime) | Very high | Stains surfaces |
| NaOH (caustic soda) | High | Produces heat when reacting with water |
| $Na_2CO_3$ (washing soda or soda ash) | Moderate | The anhydrous form is more active |
| $CaCO_3$ (limestone) | Poor | Particles need to be small (<0.24mm) |

### *Advantages*

- Not affected by the presence of organic matter, therefore useful in the disinfection of pond bases
- Useful for the decontamination of carcases and organic matter in burial pits
- Relatively cheap and available in bulk form
- Effective against a wide range of pathogens, especially viruses.

### *Precautions / disadvantages*

- Corrosive on metallic structures, especially aluminium and soft metal alloys
- Irritant to skin and mucus membranes. Sodium hydroxide and calcium oxide are highly corrosive and irritant
- Use requires experience and appropriate personal protective equipment
- Run-off into waterways should be avoided
- May be corrosive to painted surfaces.

Caution notes.

B3. Sodium hydroxide is highly irritant and should be used with care. Appropriate safety equipment, including waterproof clothing, hats, boots and eye protection should be worn.

B4. Sodium hydroxide is corrosive and is therefore suitable for use only in footbaths and on paths where rubber boots are worn.

B5. Under some circumstances sodium hydroxide may make surfaces slippery. Care should be taken to ensure its use does not result in a slipping hazard.

### *Environmental / workplace safety considerations*

- Recommendations and safety advice from the manufacturer and outlined within the appropriate material safety data sheet should be adhered to

- May affect the pH of surface waters, especially freshwater where large amounts of run-off occur and as a result affect aquatic life in localised regions.

***Applications: sodium hydroxide***

- High concentrations produce pH 12 or higher and are effective against a wide range of bacteria and viruses, including spores and mycobacteria
- Disinfecting earthen ponds when mixed in a solution with a wetting agent ('Teepol') and lime.
- Disinfecting concrete structures and plastic structures (including tanks)
- Disinfecting footpaths
- Use in footbaths.

***Applications: Calcium oxide***

- Disinfecting earthen ponds, in particular cases of Whirling disease (infection with *Myxobolus cerebralis*)
- Disinfecting carcases and organic material at the time of burial.

### B 2.6 Peroxygen compounds

***General characteristics***

Peroxygens include peracid (peracetic acid) solutions and monosulphate compounds. They are very active, not affected by organic matter and do not leave toxic residues, but may be corrosive to alloys, aluminium and plain steel under some circumstances.

Refer to section A 4.3.2 and Tables A11 to A12 (pages 36-38) for further details on peracids and monosulphates.

***Availability***

Peracid solutions disinfectants are available in solution from manufacturers or wholesalers of chemical disinfectants.

Monosulfates are available as powder concentrates from veterinary wholesalers or direct from the Australian distributors.

***Advantages***

- Wide spectrum of activity
- Remains effective at low temperatures
- Fast acting

- Effective sporicides
- Effective in the presence of organic matter
- Effective over a wide pH range, but most effective in weak acid solutions
- Relatively non-toxic.

***Precautions/disadvantages***

- Concentrate peracid solutions are considered relatively unstable with Block (2001) reporting a loss of 1-2% activity per month. Powdered preparations (monosulphates) are stable if kept dry
- Working solutions must be replaced every 2-3 days
- Corrosive to metals, including steel if left in contact for prolonged periods
- Relatively high cost.

***Environmental/ workplace safety considerations***

- Recommendations and safety advice from the manufacturer and outlined within the appropriate material safety data sheet should be adhered to.
- Concentrate peracid solutions tend to be corrosive and will cause chemical burns if ingested or spilt onto skin or mucus membranes
- Appropriate protective equipment should be worn when mixing
- Working solutions tend to be low irritant and low toxicity.

***Applications***

- Use as a general disinfectant for personnel and equipment
- Use as a fogging agent for decontamination of buildings
- Disinfection of pipe-work
- Disinfection of machinery
- Use in footbaths
- Some monosulphates have added detergents and may be used as a one stage cleaning and disinfection compound, when light soiling is present

## B 2.7 Aldehydes

### *General characteristics*

Although there are several aldehydes available, only formaldehyde and glutaraldehyde are routinely used as disinfectants. Both compounds have wide spectrum of activity and are considered highly effective disinfecting agents, but their toxicity, irritant qualities and potential as carcinogens limit their use to specific applications (Quninn & Markey, 2001). Both agents act slowly but their biocidal activity may be increased with temperature (as are the irritant vapours) and alkaline pH.

Glutaraldehyde is only minimally affected by organic matter and generally non-corrosive (Quinn & Markey, 2001). It is generally used at a 2% solution for disinfection purposes. Due to cost and difficulties of supply, use of glutaraldehyde in large-scale disinfection operations is unlikely. It is best retained for disinfection of smaller items requiring a highly effective but non-corrosive solution.

Formaldehyde may be used as a disinfecting solution and as a fumigant. Although still active in the presence of organic matter, it is more affected by very high levels of organic matter than glutaraldehyde. Formaldehyde produces highly irritant vapours and considerable care should be taken in its use.

**Table B2: Characteristics of common aldehydes**

| | *Presentation* | *Use concentrations* | *Comments* |
|---|---|---|---|
| ***Formalin*** | 40% formaldehyde in solution diluted to 8% for use | 8%(v/v) | Cheap but may not be suitable for small, non enveloped viruses<br>Toxic, flammable and explosive. |
| ***Formaldehyde gas*** | Special generation required | As per instructions given below<br>24 hours | Most effective at 70% humidity and 14°C |
| ***Glutaraldehyde*** | Concentrate solution | 2% (w/v) for 10-30 minutes | Expensive |

### *Use of gaseous formaldehyde*

Gaseous formaldehyde can be used to decontaminate the inside of sealed spaces and equipment that must be kept dry (for example areas containing electrical equipment). To be effective the conditions for formaldehyde gas must be carefully controlled, including gas concentration, gas distribution, ambient temperature, ambient humidity and contact time.

Spaces to be decontaminated must be completely sealed to prevent gas escape. Under emergency decontamination circumstances it is unlikely that suitable conditions will be available for the use of formaldehyde gas, but it may have applications for the disinfection of cool-rooms, fish holds aboard fishing vessels, within and around complex pipework in hatcheries and buildings containing electrical equipment.

Although an elevated relative humidity is necessary for optimal activity, water cannot be present in liquid form as it will dissolve the gas and reduce its effective concentration in the gaseous phase.

An evenly controlled temperature is also essential for effective decontamination. If the temperature of surfaces falls during decontamination, the formaldehyde will form a powdery residue of paraformaldehyde which reduces the effectiveness of the operation and creates problems of residual toxicity.

Torgersen & Hastein (1995) recommend the following method for generation of formaldehyde gas for fumigation purposes. A description of formaldehyde gas generation is also contained within the AUSVETPLAN Operational Procedures Manual: Decontamination[1]:

1. The area to be disinfected should be rigorously cleaned
2. All appropriate safety procedures and authorities should be arranged before commencing disinfection operations.
3. Staff should be adequately briefed and issued with appropriate safety equipment (including gloves, eye and face protection). Personnel trained and equipped with breathing apparatus should be available in case of emergency.
4. One litre of commercial grade formalin (30-40% formaldehyde) is to be mixed with 300grams of potassium permanganate ($KMnO_4$) for every 20 cubic meters of space to be disinfected.
5. Place 1-2 litres of formalin in buckets made of metal or heat stable plastic. Buckets should be at least 25-litre capacity.
6. Position the necessary number of buckets on the floor and beside each bucket place an appropriate amount of potassium permanganate.
7. Beginning as far away from the exit as possible, pour the potassium permanganate into the buckets, moving quickly from each. The formaldehyde gas develops in a few minutes.
8. The area should be completely sealed for 24 hours and warning signs erected.
9. Ventilate treated areas well before allowing personnel to re-enter.

***Availability***

Formalin is available as a 40% formaldehyde solution from chemical wholesalers and laboratory suppliers. Formalin is also registered as a treatment for footrot in sheep and some products may also be available through veterinary wholesalers and rural supply stores.

Glutaraldehyde is generally only available through chemical wholesalers or laboratory suppliers.

1: www.animalhealthaustralia.com.au

**Caution Notes**

B6. Formaldehyde gas is **highly irritant and potentially deadly**. Its use is not recommended during decontamination operations unless no viable alternative is available and disinfection of the affected space is essential.

B7. Formaldehyde gas fumigation should only be used in sealed spaces.

B8. Approval from an appropriate authority is required before releasing gas into the environment.

B9. Personnel **must** be equipped with appropriate safety equipment and all relevant safety procedures **must** be followed.

***Advantages***

- Wide spectrum of activity
- Generally non-corrosive
- Formalin is relatively cheap
- Generally not affected by organic matter

***Disadvantages/precautions***

- Significant workplace safety concerns depending on use and presentation. Produce vapours that irritant to skin, eyes, respiratory tracts and mucus membranes. Formaldehyde gas is highly irritant and potentially deadly.
- Glutaraldehyde is expensive

***Environmental/ workplace safety considerations***

- Identified as potential carcinogens
- All aldehydes are irritant to mucus membranes or skin. Avoid contact with skin and eyes. Avoid working with and breathing spray mist
- Formaldehyde gas is extremely toxic and must only be used under appropriate conditions. It also reacts with chlorines to produce carcinogenic compounds and may be explosive
- Advice from an appropriate authority should be sought before venting formaldehyde gas into the environment
- Those handling solutions should wear protective clothing made of resistant material, eye protection, boots and gloves
- Adequate ventilation should be available. Do not use formaldehyde in confined spaces (this recommendation does not relate to the use of formaldehyde gas)
- Wash exposed parts of body after use and before eating or smoking
- Toxic fumes may be emitted if aldehyde material is involved in a fire
- If poisoning occurs seek medical advice, remove affected person from the affected area, remove contaminated clothing and wash affected skin areas thoroughly

- If spills occur, increase ventilation, contain the liquid with soil and dilute with water not less than 4:1.

***Applications: Glutaraldehyde***

- Disinfection of smaller items subject to corrosion

***Applications: Formaldehyde solution***

- Footbaths (only in well ventilated outside areas)
- Disinfection of nets
- Disinfection of surfaces in well ventilated areas
- Disinfection of pipework
- Disinfection of water

***Applications: Formaldehyde gas***

- Disinfection of sealed spaces where no viable alternative is available.

**Table B3: Summary of disinfectant applications and recommended doses**

| *Disinfecting Agent* | *Application* | *Range of pathogens* | *Recommended dose* | *Comments on use* | *Reference Source* |
|---|---|---|---|---|---|
| Hypochlorite solutions (calcium hypochlorite or sodium hypochlorite) | Treatment of clean hard surfaces | All pathogens | Solution containing a minimum 30mg/litre available chlorine | Use as a general disinfecting solution | A, B |
| | Treatment of water (assuming low organic loading) | All pathogens | • Minimum 30mg/litre available chlorine<br>• Maintain a minimum of 5mg/litre of residual chlorine | • Hold for a minimum of 24 hours to inactivate.<br>• Test chlorine level prior to discharge or neutralise with thiosulfate.<br>• Less active in the presence of high levels of organic matter<br>• Re-dose if necessary | B |
| | Treatment of net pens | All pathogens | • Initial dose of 1000mg/L available chlorine<br>• Maintain a minimum of 5mg/litre of residual chlorine | • Ensure thorough mixing to ensure even distribution<br>• Immerse for minimum of 6 hours | K |
| | Dip treatment of absorbent material such as dip-nets, clothing, ropes or absorbent surfaces | All pathogens | Solution of >200mg/litre available chlorine | • Allow time to completely saturate plus additional minimum 2 minutes.<br>• Rinse items in fresh water or neutralise with thiosulfate | B, J |
| | Disinfection of tanks, floors and walls in culture facilities | All pathogens | Spray with a solution >1500mg/litre available chlorine | • Solution left for 2 hours then rinsed to free any remaining soils. Tanks filled freshwater chlorinated to 200mg available chlorine<br>• Left for 24 hours in the case of whirling disease | L |
| Chloramine-T | Treatment of water | Bacteria, viruses & fungi | 20g chloramine-T/ 1000 litres | • Hold for a minimum of 24 hours<br>• Test chlorine level prior to discharge or neutralise with thiosulfate. | D |
| | Disinfection of previously cleaned hard surfaces | Bacteria, viruses, fungi | 20g chloramine-T/litre | Leave to dry on suitable surfaces, or for a minimum of 30 minutes before rinsing | D |
| | Footbaths | Bacteria, viruses, fungi | 50g chloramine-T/litre | • Boots should be brushed clean prior to immersion.<br>• Leave to dry on boots | D |

**Table B3: Summary of disinfectant applications and recommended doses (continued, part 2)**

| *Disinfecting Agent* | *Application* | *Range of pathogens* | *Recommended dose* | *Comments on use* | *Reference Source* |
|---|---|---|---|---|---|
| Chloramine-T (cont) | Treatment of hard surfaces | All pathogens | 1% solution for >60 minutes, or as per manufacturers instructions | Concentrations and doses vary between products | F |
| Peracetic acid | Treatment of porous surfaces | All pathogens | 2.0% solution for >60 minutes, or as per manufacturers instructions | Concentrations and doses vary between products | F |
| | Treatment of waste slurries (high organic matter) | All pathogens | 40 litres concentrate solution / 1000litres | • Contact time > 1hour<br>• May cause excessive foaming and tanks overflow in presence of high levels of protein | M |
| Monosulphate compounds | Treatment of hard surfaces | All pathogens | As per manufacturers instructions (eg. 10g Virkon-S®/ litre) | • Application rate of 400ml/ m2 for >10 min | C, E |
| | Treatment of porous surfaces | All pathogens | As per manufacturers instructions (eg. 20g Virkon-S®/ litre) | • Application rate of 400ml/ m2 for >10 min | C, E |
| | Footbaths | All pathogens | As per manufacturers instructions (eg. 50 g Virkon-S®/ litre) | • Remove all organic matter on footwear prior to immersion<br>• Immersion time > 1 min<br>• Replace solution daily in areas of heavy use, every 4 days in areas of light use | C, E |
| Iodophors | Treatment of hard surfaces | Bacteria, fungi & viruses | >200mg/litre available iodine | • Applied to surface 1-2 minutes. | A, B, H |
| | Spray disinfection of equipment | Bacteria, fungi & viruses | 100 ppm available iodine | • Apply to previously cleaned & dried equipment | J |
| | Footbaths | Bacteria, fungi & viruses | >200mg/litre available iodine | • Clean boots prior to disinfection<br>• Replace daily in high use areas, or when solution has lost colur | |
| | Use as a hand or skin wash; angling or other delicate equipment | Bacteria, fungi & viruses | > 200mg/L available iodine | • Povidone-iodine solution only, do not use acidified iodine solutions | A |
| | Treatment of water | Bacteria, fungi & viruses | 30mg/L available iodine Left for 12 hours. | • Treat with thiosulfate prior to release | I |

**Table B3: Summary of disinfectant applications and recommended doses (continued, part 3)**

| *Disinfecting Agent* | *Application* | *Range of pathogens* | *Recommended dose* | *Comments on use* | *Reference Source* |
|---|---|---|---|---|---|
| Calcium oxide | Earthen based ponds | All pathogens | 0.5kg/m2 for one month | • Repeat dose on at least two occasions in wet areas or in event of flooding | A, |
| Sodium hydroxide | Disinfection of concrete or cracked surfaces of appropriate materials | All pathogens | Applied as a mixture with CaOH & teepol. | • NaOH generally sold as pellets<br>• Repeat dose on at least two occasions in wet areas or in event of flooding<br>• May also be used as a 0.2% solution as a cleaning agent for equipment<br>• Teepol (wetting agents) enhances penetration through soil and into concrete | A, C, J |
| | Disinfection of appropriate surfaces where high organic loading may be a problem | Viral pathogens on suitable surfaces | Applied as a solution 20g NaOH/L for >10 minutes | | |
| | Disinfection of wastewater | All pathogens | At a rate to achieve pH >12 for a period of 24 hours | | |
| | Treatment of waste slurries (high organic matter) | All pathogens | 50% solution at a rate of 30 litres/ 1000 litres of slurry | • Dose should achieve a pH of >12<br>• Treatment for >4 days | M |
| Calcium hydroxide | Treatment of waste slurries (high organic matter) | All pathogens | 40% solution at a rate of 60 litres/ 1000 litres of slurry | • Dose should achieve a pH of >12<br>• Treatment for > 4 days | M |
| Glutaraldehyde | Disinfection of small items or those subject to corrosion | All pathogens | 2% (w/v) for 30 min. | • Available as concentrate solution | C |
| Formalin solution | Disinfection of hard or porous surfaces. Foot baths | All pathogens | 8% (v/v) for 30 min. | • Available as 40% solution<br>• Dilute 1:12 for use<br>• Use only in well ventilated areas | C |
| | Treatment of waste slurries (high organic matter) | All pathogens | 40 litres formalin solution (40%) per 1000 litres | Must be distributed evenly | M |
| | Disinfection of pipelines or sewage channels (in-situ) | All pathogens | 300ml of commercial grade formaldehyde in for every 10 litres of water. | • Pipeline is completely filled with disinfecting solution left fir 24 hours | A |
| Quaternary ammonium compounds | Use on skin or delicate items | Some bacteria, some viruses | 1mg/litre for >1 min | Limited range of efficacy | A |
| | Use on hard surfaces | Some bacteria, some viruses | 2mg/litre for >15 min | Limited range of efficacy | A |

**Table B3: Summary of disinfectant applications and recommended doses (continued, part 4)**

| *Disinfecting Agent* | *Application* | *Range of pathogens* | *Recommended dose* | *Comments on use* | *Reference Source* |
|---|---|---|---|---|---|
| Heat | Disinfection of waste water | Most pathogens, Category A viruses and some bacteria may be resistant | 60ºC for 10 minutes<br>70º for 6 minutes<br>75º for 5 minutes<br>80º for 4 minutes | | A, B |
| | Disinfection of hard surfaces & equipment | Most pathogens, Category A viruses and some bacteria may be resistant | Steam cleaning at 115-130ºC for 5minutes | • Difficult to regulate, best utilised as a adjunct to other disinfection methods<br>• Especially suitable for treatment of transport tanks. | J. |
| Desiccation & light | Earthen tanks | Most pathogens | Dry for >3 months at an average temp. of >18ºC | • Drying period can be reduced if combined with an appropriate chemical disinfectant<br>• Use drying and sunlight as a general adjunct to all disinfection if possible. | J. |
| Ultra-violet light | Disinfection of waste water | Viruses, bacteria & fungi | >25mJ/.cm$^2$ | Requires pre-treatment with chemical precipitation or filtration. | A |
| | Disinfection of water | *Myxosporidean sp*. spores | >35mj/cm$^2$ | | A |
| Ozone | Water treatment | All pathogens | 1mg/litre for > 1 min | | A |

**References used in Table B3**


A: Torgersen and Hastein (1995)
B: OIE Aquatic Animal Health Code (2004)
C: AUSVETPLAN Decontamination Manual (1996)
D: Halamid® product recommendations for aquaculture disinfection
E: Virkon® product data, DuPont Animal Health Solutions
F: Hyperox® product data, DuPont Animal Health Solutions
G: Sanidex 80® fact sheet, Cleantec product information
H: Finlay, 1978
I: Hedge, Antony & Rao, (1996)
J: Hnath, (1983)
K: Fisheries Research Services (1999)
L: Bell & Lightner (1992)
M: Haas *et al.* (1995)


Levels recommended within this table come from a number of sources and have been provided here as a general guide. Since the disinfecting capability of disinfecting agents will vary depending upon the conditions involved, the concentrations and contact times quoted should be viewed as minimum acceptable levels for decontamination purposes.

## B 2.8 Calculation of concentration and quantities required

### *Dose calculation*

Contained within this document is a range of recommendations for chemical disinfectants and the levels required. Chemical disinfectants come in a range of concentrations and presentations therefore, wherever possible, the concentration of the active disinfecting agent is quoted. For example, chlorine based disinfectants can range from 1% to 70% available chlorine (refer to table A9). The available 'active' for each unit of concentrate should always be checked prior to mixing the working solution.

### *Initial dose versus residual level*

It is important to note that some disinfectants (for example hypochlorites, chlorine-dioxide or other oxidising agents) begin degrading as soon as they are mixed. In such cases, two recommended levels may be attributed to the disinfectant solution, a dosage level and a residual level.

Initial dose refers to the concentration of chemical disinfectant mixed into solution at the start of the disinfection process. In many cases the initial dose is calculated to achieve a minimum residual level taking into account consumption of the chemical agent over time.

Residual level refers to the level of active remaining in the solution during the prescribed contact period. This level is normally reported as a minimum level, ie. >5mg residual chlorine, and may necessitate re-dosing if working solutions fall below the required residual level. Residual levels are best monitored using commonly available chemical test kits.

### *Amount required*

The amount of chemical disinfecting solution required for specific tasks varies depending on the surface type and degree of soiling. For a hard non-porous surface the AUSVETPLAN Decontamination Manual[1] recommends 100ml of disinfecting solution per square meter where specific product recommendations are not available. For porous surfaces such as concrete or wood, the volume required is at least 3x that required for hard surfaces. Other authors recommend a minimum of 400ml disinfecting solution per square meter of surface.

### *Combination of chemicals*

It is unwise to mix different chemicals unless specific technical advice has been sought from the manufacturer. Most commercial products have been formulated to achieve maximal activity for a specific purpose and there is little to be gained from mixing such products with other chemicals.

1: www.animalhealthaustralia.com.au

## B 2.9 Use of thiosulphate to inactivate oxidising disinfectants

Chlorine and iodine based disinfecting agents are toxic to aquatic life and in some circumstances must be inactivated prior to release into the environment.

A 1% solution of thiosulphate may be use to inactivate both compounds when used at the following proportions.

*Chlorine*
28.5 x (litres of disinfecting solution x concentration in mg/litre)/100 = mls of 1% thiosulphate

*Iodine*
7.8 x (litres of disinfecting solution x concentration in mg/litre)/100 = mls of 1% thiosuphate

# B 3. Disinfection of site infrastructure

## B 3.1 Disinfection of earthen ponds

### *Applications*

Decontamination of earthen based facilities used to hold diseased stock, including ponds, channels, dams and settlement areas.

### *Procedures*

1. All ponds, including intake channels and settlement ponds, should have fish[1] stocks removed and disposed of in an appropriate manner. Refer to the AQUAVETPLAN Disposal Manual[2] for details on disposal.
2. All ponds and channels should be drained or pumped out. Consideration needs to be given to whether it is appropriate to discharge untreated water into natural waterways, treat water with disinfectants prior to discharge or dispose of water at a separate location.
3. As ponds empty, there is a greater chance that sediment and organic matter containing high pathogen loads close to the bottom will be discharged, therefore precautions should be taken to control sediment discharge into waterways. This is best undertaken though controls at the settlement pond if one is present.
4. Sediments, organic matter and the top 10-15 cm of silt should be removed using excavators and disposed of by burial or treatment with alkaline compounds. Excavation should begin at the uppermost section of the pond system, gradually working downstream.
5. Recommendations for the treatment of ponds in summarised in Table B3. Areas treated should be kept dry for at least two months. Where ponds have re-flooded after cleaning or it is impossible for them to be completely dried out, wet areas should be pumped out and retreated on at least two additional occasions. In hot dry conditions (> $10^{o}$ C minimum temperature) the dry out period may be reduced to one month.

   Where possible the chemicals should be incorporated into the top 5cm of the clean moist pond base.

   Following treatment all ponds should remain dry until the total clean-up has been completed for the entire farm facility.
6. Care should be taken when refilling treated pond systems. Torgersen and Hastein (1995) recommend that water should be less than pH 8.5 before discharge into natural waterways, however acceptable levels should be confirmed with appropriate State or Territory authorities.

1: Fish is defined here as any aquatic animal and may include finfish, molluscs or crustaceans

2: www.daff.gov.au/aquaticanimalhealth

**Table B4: Recommendations for disinfection of earthen pond bases**

| *Disinfection Agent* | *Application rate* | *Dry out period* | *Comments* |
|---|---|---|---|
| ***Calcium oxide*** | 0.5kg/m2 or 5 tonne/ha of dried ponds.<br>Re-treatment of wet areas at a rate of 1kg/m2 on two subsequent occasions | Min.1 month | Recommended for *Myxobolus cerebralis* |
| ***Calcium hydroxide and sodium hydroxide mix*** | 500gCaO2/100g NaOH/10g teepol/10 litres applied at a rate of 2 litres/m2 | Min. 14 days | |
| ***Calcium hydroxide*** | 1.5 tonne/ha applied evenly across the base of ponds. | Min. 1month or until deep cracking occurs | Procedure recommended for prawn ponds |

Torgersen and Hastein (1995); Le Breton (2001b); OIE Animal Health Code (2001); Bell And Lightner (1992).

## B 3.2 Decontamination of tanks (Fibreglass, concrete or plastic)

### *Applications*

Disinfection of tanks used for holding infected stock

### *Procedures*

1. All fish[1] stocks, carcasses, faecal matter and uneaten feed should be removed from tanks for disposal. Refer to the AQUAVETPLAN Operational Procedures Manual - Disposal[2] for further details
2. Tanks and associated pipework or channels should be drained taking into account the safe disposal of infected water.
3. Any ancillary equipment such as feeders, aerators or lights should be removed for separate cleaning and disinfection.
4. Tank surfaces should be washed using high-pressure water cleaners to remove gross fouling. Very high-pressure cleaners have the potential to erode the surface of concrete tanks if used incorrectly. This problem may be overcome by using wider spray nozzles or reducing water pressure.
5. Once gross fouling has been removed, alkaline or other powerful detergents should be sprayed onto surfaces using low pressure, then the area washed using pressure cleaners or mechanical scrubbing. If possible, heated water should be used to enhance the cleaning process. Refer to Table A3 (page 15) and caution notes A1-A5 (page 23).

   Where mineral deposits are present, acidic detergents may be use to assist removal. Acidic detergents should not be used on concrete surfaces. If waters are very hard (marine water, or freshwater with high calcium levels), nonionic or acidic detergents should be used
6. Each cleaning stage should always start from at the top and proceed downwards. Excess water should be allowed to drain away before application of disinfection solutions.

1: Fish is defined here as any aquatic animal and may include finfish, molluscs or crustaceans
2: www.daff.gov.au/aquaticanimalhealth

7. An appropriate disinfectant should be sprayed over the entire surface of the tank at a rate of >400ml/$m^2$ (Torgersen and Hastein, 1995; Quinn and Markey, 2001) and left for the recommended time period. The application of disinfectants should start from the base of the tank and proceed upwards.
8. Unpainted and cracked concrete surfaces are best disinfected using alkaline disinfectants (OIE Aquatic Animal Health Code 2001). Torgersen and Hastein (1995) recommend the use of a sodium hydroxide/calcium hydroxide/teepol mix sprayed onto concrete surfaces at a rate of 0.1L/m2 and left for 48hours.

   Plastic and fibreglass tanks can be disinfected with any chemical agent suitable for hard surfaces, for example hypochlorites, peracids, iodophors, chlorine dioxide or chloramine-T. Refer to table B3 (page 60) for further details.
9. When applying disinfectants to vertical surfaces, care must be taken to ensure that adequate contact time is maintained before the disinfectant drains away. Hypochlorites, chlorine dioxide solutions or peracids are recommended if short contact times are required on previously cleaned vertical surfaces.
10. Following disinfection, tanks should be rinsed and allowed to dry completely. This may require the removal of grids or dismantling of pipes to ensure all water is drained and does not lie in pools at the base of tanks or drains. All tanks should remain dry until the site has been cleared for restocking.

## B 3.3 Decontamination of cages & marine equipment

***Applications***

Disinfection of equipment and infrastructure used on marine farm sites including nets, polar circles, rigid farm systems and pontoons.

***Procedures: Nets***

1. All nets should be removed from floats and brought to shore for treatment.
2. Nets should be thoroughly cleaned using net-washers or laid out on a hard surface and cleaned with high-pressure water cleaners. Refer to section A 3.4 for further details.
3. Where possible, disinfecting agents that are not affected by organic matter, suitable for porous surfaces and unlikely to damage netting should be chosen. Possible options include chlorine-dioxide, formaldehyde solutions and iodophors (povidone iodine), however hypochlorite solutions may also be used if the nets are cleaned and rinsed thoroughly.

   Where disinfection solutions are used, these should be thoroughly mixed and the nets spread out as much as possible to ensure even exposure over all surfaces.

   Recommendations for the control of infectious salmon anaemia in Scotland include immersion of nets in freshwater dosed with sodium hypochlorite at a rate of 1000mg/litre for a minimum of 6 hours. Where nets cannot be adequately cleaned and are heavily fouled, a minimum residual chlorine level of 5mg/litre available chlorine should be maintained.

1: Fish is defined here as any aquatic animal and may include finfish, molluscs or crustaceans

Recommendations also included the immersion of nets in water at a temperature of 55-70°C for a minimum of 5 minutes (MLA, 2000).

4. It is preferential to place cleaned nets into disinfecting solutions while still wet since this assists penetration of nets fibres by the disinfection solution.

   McCarthy (1975) found that it was possible to disinfect both wet and dried nets contaminated with *Aeromonas salmonicida* using acriflavine (1:4000) and 0.1%teepol in 1% NaOH, but 1% hypochlorite alone disinfected only wet cage nets.

5. Following disinfection nets should be rinsed of residual chemicals and completely dried. Nets should not be rolled up for storage until they have been disinfected and dry.

6. Where appropriate treatment of nets cannot be achieved, nets should be destroyed by incineration or disposed of in approved landfill sites.

***Procedures: Marine infrastructure***

1. Where possible floating installations should be dismantled and brought on-shore for cleaning.

2. Water should be drained from all equipment by opening drains and inspection ports. Where there is suspicion of water in non-accessible areas, drainage holes may need to be installed, however it is important that these are placed in positions that are easily repaired following decontamination.

3. All surfaces should be thoroughly cleaned using high-pressure water cleaners, scrapers and mechanical brushing to remove fouling organisms and gross soiling. On suitable surfaces, these can be combined with a non-ionic or acidic detergents to removed soil build-up. If using freshwater, strong alkaline detergents may be used to remove heavy soiling, but their use should be avoided on soft metals or galvanised surfaces.

   The use of wet heat, in the form of steam cleaners, is also a viable option for cleaning and disinfection of marine infrastructure if adequate supplies of freshwater are available. This has the added advantage of not producing chemical wastes requiring containment and disposal.

4. Surfaces should be disinfected using chemical agents suitable for hard surfaces. Options include hypochlorite solutions, chlorine dioxide solutions, chloramine-T or iodophors.

   Drainage of chemicals into the surrounding environment should be taken into consideration when undertaking disinfection on floating facilities. Drainage of washwater containing detergents and disinfectants should be contained for later disposal.

5. In many cases it is difficult and time consuming to dismantle floating installations for cleaning and disinfection onshore. Where installations cannot be dismantled, the underwater section can be cleaned by divers using mechanical scrubbers routinely used for cleaning the hulls of commercial vessels.

6. Torgersen & Hastein (1995) report that marine facilities in Norway have been effectively disinfected by wrapping the underwater section in tarpaulins, pumping the internal section dry and refilling with freshwater containing an appropriate disinfectant. This may not be practical on larger facilities and makes safe disposal of the disinfectant solution difficult.

Sodium hypochlorite at a rate of 1000 mg/litre with the tarpaulin held in place for 24 hours has been used for this purpose. Chlorine-dioxide, peracid solutions or formaldehyde would also be suitable for this purpose and would have lower environmental impacts than chlorine.

7. Wherever possible, structures or equipment should always be removed from the water for cleaning and disinfection.

## B 3.4 Decontamination of pipework

Complex pipework systems in hatcheries, recirculation facilities or boats present significant challenges for disinfection due to limited access and the formation of biofilms.

### *Applications*

Decontamination of pipework, pumps and filters used to circulate water through fish holding facilities including recirculation facilities; bio-towers; seawater inlets or outlets; pipework on transport barges and fishing vessels

### *Procedures*

1. The pipework should be drained and any external fouling removed.
2. Any ancillary equipment should be removed and electrical equipment made safe by qualified technicians.

**If using foam projectile pipe cleaning systems1 (pigging systems)**

If pigging systems are available and the pipework design is suitable for their use, these may reduce the amount of dismantling required. Refer to section A 3.4 for further details.on pigging systems.

3. Pipework should be divided into sections where foam projectiles may be forced through easily.
4. Appropriate plates or valves should be removed from the end of each section to allow access.
5. Pipework should be first cleaned using an abrasive projectile to remove biofilms and internal build-ups. Multiple passes of the projectile may be required to remove as much internal fouling as possible.
3. If required, the system may be flushed with a strong alkaline detergent to loosen residual fouling or, if calcium deposits are a problem, flushing with an acidic detergent will be necessary.

   A drying projectile may be used to force out any remaining detergent solution. The pipework should then be flushed with fresh water and allowed to drain.
4. Pipework should be filled with an appropriate disinfection solution. Hypochlorite, chloramine-T, monosulphates, chlorine dioxide, formaldehyde or iodophor solutions are suitable for this purpose subject to potential corrosion effects.

If there is any doubt about the effectiveness of cleaning those disinfectants that retainactivity against biofilms should be used. (for example monosuphates, chlorine dioxide, formaldehyde or chloramine-T solutions). Where residual mineral deposits are an issue acidified iodophor solutions are most suitable.

When choosing appropriate chemical disinfectants, their corrosive nature against soft metal alloys or rubber seals present in the system should be considered. Thorough flushing after disinfection should alleviate most corrosion problems.

5. Following disinfection, clean fresh water should be flushed through the system and a second drying projectile forced though.
9. Pipework should be left to dry thoroughly with access plates removed to allow circulation of air. The system should remain dry until the whole facility is cleared of disease and ready for restocking.

**If not using pigging systems**

3. All access plates and valves should be removed. Any blind-end pipes, where water does circulate, should be either opened or removed.
4. Where possible, internal fouling should be removed using high-pressure water sprayers, scrapers or brushes. Reverse flushing with water may also assist in loosening deposits.
5. The all pipework should be filled with strong detergents and this thoroughly circulated through the system. If calcium deposits are a problem, flushing with an acidic detergent will be required. The system should then be flushed thoroughly with freshwater and allowed to drain.
6. Pipework should be refilled with an appropriate disinfectant and left the prescribed period of time. Hypochlorite, chloramine-T, monosuphates, chlorine dioxide iodophore or formaldehyde solutions are most suitable for this purpose.

   If there is any doubt about the effectiveness of cleaning those disinfectants that retain activity biofilms should be used (for example monosuphates, chlorine dioxide, formaldehyde or chloramine-T solutions). If there are residual mineral deposits, acidified iodophor solutions are most suitable.

   When choosing appropriate chemical disinfectants, their corrosive nature against any soft metals or rubber seals present in these systems should be considered. Thorough flushing after disinfection should alleviate most corrosion problems.
8. The pipework should be drained and again flushed with freshwater.
9. All pipework should be left to dry thoroughly with access plates removed to allow circulation of air. The system should remain dry until the whole facility is cleared of disease and ready for restocking.

## B 3.5 Decontamination of livestock transport vehicles

### *Applications*

Decontamination of transport containers used to carry live fish including tanker trucks, removable transport bins, containers used for air transport and fish transport trailers. Accompanying fixtures and equipment such as airlines, pumps, pipework, oxygen diffusers/air-stones.

### *Procedures*

1. All water should be drained from transport tanks and any fish, faecal matter or other soil cleaned from tanks by flushing with clean water. All pipes and associated pumps should also be inspected and flushed to ensure that carcases or organic material trapped within are removed.
2. Equipment such as air diffusers, electrical monitoring equipment and other delicate or porous items should be removed for individual cleaning, disinfection or replacement.
3. The complete exterior of the truck and/or transport containers should be thoroughly washed using high-pressure water cleaners beginning at the top and working down to the wheels. The underneath of the truck and under tanks should also be washed (refer to section B 3.7 for disinfection of vehicles).
5. The interior of transport containers should be washed using high-pressure water cleaners and mechanical scrubbing. Cleaning should start from the top of the internal surface and move downward.

   All surfaces should be thoroughly rinsed if detergents have been used and allowed to drain.
6. Internal surfaces of tanks should be disinfected using wet heat (on suitable surfaces) or chemical disinfectants. Suitable chemical disinfectants include hypochlorite solutions, chlorine dioxide solutions, chloramine-T or iodophors. Refer to Table B3 (page 60) for appropriate times and concentrations.

   Disinfection should start from the lowest level of the tanks and gradually work upwards.

**Caution notes:**

B 10. Many chemical disinfectants give off vapours when applied that may affect personnel when used in confined spaces such as transport tanks. Personnel undertaking disinfection of transport tanks should follow appropriate safety procedures and should be monitored at all times.

B 11. It should be noted that many chemical agents, in particular iodophors, are toxic to fish at low levels. If the tanks are to be used for the transport of live fish in the future, special care must be taken to completely rinse all traces of chemicals from tanks, hoses or pumps.

7. Following disinfection, the transport tanks should be drained, thoroughly rinsed with freshwater and allowed to dry in direct sunlight. All valves, inspection ports and pipes should be left open or disconnected to allow free circulation of air.

### *Alternative method*

For routine disinfection of transportation equipment Amend & Conte (1982) have recommended the use of calcium hypochlorite mixed into solution and circulated through the tanks. This procedure requires the complete filling of containers with disinfecting solutions and therefore can only be used where sufficient quantities of freshwater are readily available and facilities allow the dumping of used disinfection solutions. The procedure is recommended as an alternative where tanks cannot be entered to enable manual cleaning and disinfection.

### *Procedure*

1. Fill the tank or container with desired amount of water
2. If pH of water is below 6 add glacial acetic acid at a rate of 40ml per 500 litres of water before adding calcium hypochlorite and mix (refer to caution note B12)
3. Add calcium hypochlorite to buffered water at a rate of 16 grams per 100 litres and thoroughly mixed
4. Run pumps to circulate the disinfecting solution throughout the tanks and pipework for 30 minutes
5. Thoroughly flush tanks and pumps
6. Allow the vehicle and tanks to dry completely in direct sunlight. All valves, pipes and inspection ports should be left open to all free circulation of air.

**Caution note**

B12. DO NOT ADD acetic acid to dry calcium hypochlorite or lower the pH level below 5. The mixing of concentrate chlorine compounds and acids produces toxic chlorine gas.

## B 3.6 Decontamination of boats

### *Applications*

These procedures apply to any vessels that operate in marine farms and can be slipped locally,

Decontamination of vessels operating between non-suspect sites within surveillance zones must be decontaminated down to, and including the water line between sites.

Those vessels operating within confirmed infected sites must be slipped and decontaminated before entering areas of lower risk. The route to the slip must be chosen to minimise contact with any other fish farm.

## Procedures

### On the water

1. Remove all gross fouling and organic matter by scraping, brushing or using high-pressure water cleaners.
2. Apply a suitable detergent solution over all surfaces on the inside of the hull. Suitable detergents include non-ionic detergents for marine situations and acidic detergents where there is fat, protein or mineral build-ups.
3. Clean all deck, equipment and superstructure surfaces by scrubbing or using high-pressure sprayers, starting on the upper surfaces and working down to and including decks. If available, heated water or steam cleaners will assist this process but can only be used on suitable surfaces.
4. Rinse all pipework and pumps, particularly those used to transfer water for fish holding facilities, with disinfecting solutions.
5. Repeat the stages 2 and 3 for gunwales and top-sides (outside of the hull).
6. Rinse all external areas with fresh water.
7. Apply a suitable disinfecting solution to all areas. Foaming solutions may be required for vertical surfaces.
8. Clean and soak all equipment (ie. mooring lines, life jackets, wet weather clothing & fenders) in disinfectant.
9. Leave the wastewater in the craft until ashore or, if approved, release it out in the main channel well away from the lease. Containment of disinfecting solutions may require temporary blocking of scuppers or drainage into the bilge. For safety reasons, scuppers should be re-opened immediately following rinsing and bilges emptied as soon as possible. Bilges may require additional dosing with disinfecting solution to achieve acceptable residual levels.

6. Thoroughly clean and all internal cabin areas. Wipe all surfaces, including floors, benchtops and seats, with a disinfecting solution
7. Rubbish, clothing and equipment should be bagged in heavy-duty plastic bags prior to their transport to shore. All plastic bags and containers should then be sprayed externally with disinfectant.
8. If not undertaken already, pump bilges and ventilate the whole vessel thoroughly.

***Onshore (trailable boats):***

1. Choose a site where contamination will not enter waterways and drain all bilges and decks.
2. Place all rubbish or contaminated items in plastic bags for later disposal or decontamination. The outside of bags should be sprayed with a disinfecting solution prior to their removal from the vessel.

3. Clean all external surfaces with a high-pressure water cleaning unit. In the absence of a high pressure cleaning unit, surfaces must be scrubbed with a detergent.
4. Apply a disinfectant and allow contact for the prescribed time.
5. Clean and soak all equipment (ie. mooring lines, life jackets, wet weather clothing & fenders) in disinfectant.
6. Rinse all surfaces, including bilges with fresh water. Allow the vessel to dry in direct sunlight with bilges, hatches and windows open.

***Non trailable vessels***

Procedures 1 though 8 (O*n the water*) should be followed.

9. Upon returning to shore, bilges should be drained. The vessel should be slipped, the hull cleaned and fresh antifoul paint applied.
10. For those vessels that cannot be slipped the hull should be tarped and the hull soaked with a disinfection solution as outlined in section B 3.3 under P*rocedures for marine infrastructure*.

## B 3.7 Divers and dive equipment

***Applications***

Decontamination of equipment used for commercial diving activities on fish farms including dive suits, regulators, hoses and control panels.

***Points to consider***

- Although an appropriate standard of cleaning and disinfection should always be undertaken, certain high risk tasks, such as mortality removal, ensure that divers are exposed to very high levels of infected material. Under such conditions frequent rinsing of dive suits and equipment throughout the day will assist in reducing build-up of organic matter and make the final decontamination procedures easier and more efficient.
- Where possible, equipment should be chosen which is non-absorbent and easy to clean. In the case of diving suits, membrane dry suits should be used in preference to neoprene wet suits.
- Many disinfectant chemicals are corrosive but adverse effects can be minimised by cleaning diving equipment well before the disinfection stage, not leaving equipment soaking in disinfection solutions longer than is necessary and rinsing well in freshwater.
- Equipment should be examined to ensure the whole surface is exposed to the chemical agent (ie. wetsuits) while ensuring that it does not enter delicate internal workings (regulators or electrical equipment).

- Dive equipment must be allowed to dry thoroughly by storing it in a well ventilated area. As well as reducing any corrosive effects of chemicals, the drying process significantly aids in the disinfection of equipment and ensures that moist microenvironments that may harbour pathogens are avoided. This is particularly important when dealing with wet suits, ropes and mort bags.

***Procedures***

1. Remove gross contamination of organic material by rinsing divers, equipment and decks throughout diving operations. Deck hoses and pressure sprayers may be used for this purpose, but divers eyes must be protected.
2. At the end of diving rinse all equipment in freshwater to remove salt water.
3. Wash all equipment in a cleaning solution to remove all traces of organic matter. If on-site showers are available, thoroughly rinsing wetsuits whilst showering is acceptable practice and has the advantage of using warm water to clean the suit. Diver must ensure that all areas of the suit are cleaned including the internal surface. Other equipment is best washed in large plastic bins. At this stage any detergent is satisfactory, subject to it being safe for staff and equipment and up to the cleaning task but alkaline detergents should be avoided.
4. Thoroughly rinse in freshwater.
5. Dip all equipment in a bath of disinfectant solution for the prescribed time. Suggested disinfectants include
    - Povodine-iodine solutions at 100mg/L available iodine for 10 minutes. Acidified iodophors should be avoided.
    - Chloramine-T solution at 2% by weight for 10 minutes.
    - Monosulphate solutions (Virkon-S®) at 0.5% by weight for 10 minutes).
    - Alternatively gear may be heat treated using hot water maintained at greater than 55$^{o}$C for at least five minutes.
6. Rinse in fresh water and dry in a well-ventilated area.

## B3.8 Decontamination of vehicles

(Adapted from AUSVETPLAN Decontamination Manual)

Most vehicles should remain off infected premises or dangerous contact premises. If the number of vehicles warrant it, a local area with a hard standing, drainage and a good water supply should be designated as a local vehicle disinfection station.

A carwash facility is ideal for decontamination of surveillance vehicles if one is conveniently located.

### *Applications*

Vehicles can be divided into four broad categories according to contact history with diseased stock or infected premises:

- those that do not need cleaning and disinfection
- those that need the wheels cleaned and disinfected only
- those that need the outside cleaned and disinfected only, and
- those that need both outside and inside cleaned and disinfected.

### *Procedures*

#### *Cars*

1. The wheels, wheel arches and undercarriage of the car should be sprayed with a non-corrosive detergent and dirt thoroughly rinsed away. Areas of bodywork covered with dirt or mud should also be cleaned with non-corrosive disinfectants. It is acceptable to use high-pressure water cleaners for wheels, wheel arches and undercarriage, but care should be taken not to damage paintwork.
2. Once cleaned these areas should be thoroughly rinsed, the wheels and wheel arches sprayed with a disinfecting solution.
3. Any rubber floor mats should be removed for scrubbing with disinfectant. The dash board, steering wheel, handbrake, gearstick and driver's seat should be wiped liberally with appropriate disinfectant.
4. If the rear compartment is considered contaminated, the contents must be removed and the interior of the boot wiped with disinfectant. The contents of the rear compartment should be treated similarly before being replaced.
5. Cleaning heavily contaminated vehicles should only be done on the infected premises as most cleaning processes, including high-pressure water cleaners, have the potential to spread infectious agents through the production of aerosols and water run-off. In such cases, brushing with disinfectant/soap and water to dislodge encrusted dirt and organic matter is preferable to washing with strong water streams.
6. Where possible cars should be parked in direct sunlight to dry.

#### *Transport trucks*

1. All solid debris should be removed from trailers and transport tanks/harvest bins. Any residual fish mucous, blood and faecal matter must also be removed.
2. Where the outside of the vehicle has been decontaminated, the tanks and bins should be lifted free from the trailer. The undersides of the tanks/bins and where the tanks/bins were sited on the trailer can then be decontaminated.
7. All fixtures and fittings must be dismantled to ensure that infected material is removed. Some trailers may carry extra equipment under the body – this must be treated. It is common

practice for specialised live transport vehicles to be self-contained with water and oxygen supplies for fish. All water, aeration equipment, pipe-work and pumps within live transport tanks must be disinfected (refer to section B 3.5 for further details).

3. Any wood surfaces must be cleaned and disinfected, or where appropriate or valued before removal for destruction.
4. The outside dual wheels and spare wheels must be removed to ensure:
   - adequate decontamination of wheel hubs, and
   - to inspect the spare wheel hangers which can be of hollow construction and therefore could hold contaminated material.
5. The wheels, wheel arches, bodywork and undercarriage must be cleaned and disinfected.
6. The external surface of the vehicle is then soaked in a detergent and scrubbed down thoroughly.
7. The vehicle is thoroughly rinsed and a disinfecting solution applied.
8. The driver's cabin and, where fitted, the sleeping compartment must be thoroughly cleaned. All water, foodstuff and litter carried in vehicles must be burnt or buried.
9. Enquires should be made of the driver as to what clothing and boots he/she was wearing when in contact with suspect fish stock. These articles must be identified, decontaminated and arrangements made for dry cleaning where applicable.
10. If the vehicle is known to have carried diseased or suspect stock, then every effort should be made to identify the area of disposal of these animals if they have been removed before departmental officers have identified the vehicle as being contaminated. Once identified, these materials must be disinfected and disposed of by burial or burning.
11. Where possible the truck should be parked in direct sunlight to dry.

## B 3.8 Footbaths

### *Applications*

Footbaths are a valuable tool to restrict the transport of pathogens on footwear between areas. Footbaths also serve the secondary purpose of continually emphasising the need for biosecurity procedures to personnel.

In order to be effective footbaths must:

- be of sufficient size
- utilise appropriate contact times
- use a disinfectant solution that is resistant to organic matter
- incorporate a cleaning procedure to remove accumulations of mud or soil, and

- be regularly emptied and refreshed.

Footbaths should be placed at points of entry and exit of all areas of differing levels of contamination.

### *Additional precautions*

Wherever possible, additional procedures should be used to facilitate the effect of footbaths by reducing contamination of the disinfecting solution and reducing potential for carriage of soil.

Such procedures include:

- a complete change of footwear at the point of entry
- all personnel being supplied with waterproof footwear, and
- complete scrubbing of footwear to thoroughly remove all remnants of soil.

### *Procedures*

1. Identify appropriate locations at the boundary of and within the infected site (for example at the entry of buildings) where footbaths are to be located.
2. Ensure that footbaths are protected from rain or flooding, are in a well ventilated area and, where possible, out of direct sunlight.
3. Footbaths should be placed on hard well-drained surfaces, or alternatively on small tarps (2m x 2m) to avoid the area becoming waterlogged and muddy.
4. Footbath stations should incorporate a method of cleaning footwear prior to immersion in the disinfecting solution. This may include a separate bath of detergent along side, stiff brushes to remove mud, or specially designed boot-scrubbers.
5. Footbaths should be large enough to allow the person to stand with both feet in the solution and deep enough to cover the tops of the feet. Recommended dimensions for footbaths are a minimum of 50cm by 50cm in area and 25cm in height. Disinfectant solutions should be at least 15cm deep.
6. Disinfectant in footbaths should be drained and refreshed daily. A log should be kept of disinfection solution changes.
7. Disinfectant solutions that may be suitable for use in footbaths include, monosulphate compounds (recommended), iodophors and chloramine-T. Formalin may also be used in well-ventilated areas.
8. Concise instructions, including boot cleaning procedures and contact times, should be posted at each station.

## B 3.9 Treatment of slurries

### *Applications*

The treatment of any material containing high levels of organic matter in a liquid slurry. Examples of such materials include solids (residual feed, faeces or carcase materials) drained from tanks and ponds; benthic material removed from ponds and channels; materials within settlement ponds/tanks; and washings from cleaning processes.

### *Procedures*

**Chemical treatment**

- Chemical agents of most practical importance in the treatment of slurries are those compounds that modify pH and formaldehyde.
- To be effective chemical disinfecting agents must be thoroughly dissolved and evenly distributed throughout the slurry. General recommendations for the chemical treatment of slurries (as outlined in Haas *et al*., 1995) suggest that slurries must be continuously agitated prior to, during the addition of chemical disinfectants and for a minimum of 6 hours afterward.

  This requirement causes significant practical difficulties, since most pumps are not suitable for pumping thick slurries and suitable mechanical mixers are not readily available. In addition, some of the chemicals used (eg. sodium hydroxide) will be corrosive to pumps and mixing equipment.

  The use of centrifugal impeller pumps to recirculate the slurry material is possible where the slurry is a liquid. Where slurries are thicker, diaphragm pumps will be required. Vigorous aeration of the slurry using compressed air may also aid the mixing effect.
- Alkalis are an economical and effective treatment of slurries, with sodium hydroxide and calcium hydroxide most commonly used (Haas *et al.* 1995). Treatments should aim to raise the slurry pH above 12.

  Recommendations include the use of:

  - $Ca(OH)_2$ in a 40% solution at a rate of 60 litres per cubic meter for a period of 4 days or more
  - NaOH in a 50% solution at a rate of 30 litres per cubic meter for a period of 4 days or more
  - formalin (40% solution) at a rate of 40 litres per cubic meter for a period greater than 4 days. Formalin has reduced effect below $20^{o}C$ and should not be used below $10^{o}$ C
  - peracetic acid at a rate of 40 litres per cubic meter for a period greater than 1 hour. The use of acids may cause excessive formation of foams that may spill out of holding containers.

**Spread over pastures**

In cases where the pathogen is readily inactivated by sunlight and desiccation, or where previous chemical treatment has been undertaken, distribution over suitable pastures is a practical means of disposal and further disinfection.

- This process requires the use of sewage transport trucks to pump out temporary storage facilities on the infected property and a practical means of spreading the slurry over a wide area (for example the use of liquid manure spreaders). All vehicles and operators should be dedicated to the decontamination procedure and not permitted to resume normal duties until thoroughly disinfected.
- Areas chosen for disposal of slurries should be away from waterways and there should be a low risk of heavy rainfall and flooding soon after application. This process is best suited to hot dry environments where adequate dry periods can be guaranteed.
- Wherever possible, the slurry should be incorporated into the soil for tillage crops following a period of desiccation and exposure to sunlight.

**Composting**

Where commercial composting operations are available, infected slurries may be injected into compost windrows. The aerobic composting process ensures that windrow temperatures will remain above 55$^{o}$ Celsius for a number of weeks (generally 12 weeks). This long term elevation of temperature will inactivate most pathogens, with the possible exception of some category B viruses.

- The final use of compost materials should be controlled to ensure that they not used in high-risk locations.
- This process requires the use of sewage transport vehicles dedicated to the transport of slurry
- Checks should made to ensure that any pre-treatment with chemical disinfectants does not adversely affect beneficial saprophytic organisms required within the composting windrows.
- This process is most suitable where large volumes of infected slurries require disposal and commercial composting operations are within reasonable distances.

**Heat treatment (Pasteurisation)**

Heat treatment of slurries to between 70$^{o}$ C and 100$^{o}$ for a minimum of 30 minutes is recommended for small amounts of material (Haas *et al*. 1995; Ekesbo, 1985).

Pasteurisation may not be completely effective against highly resistant organisms such as category B viruses (refer to section A 4.1) and some bacteria. Humphry *et al.* (1991) found that the infectious pancreas necrosis virus and *Renibacterium salmoninarium* could survive 70$^{o}$ C for periods in excess of 30 minutes. These findings were also supported by work undertaken by Whipple and Rohovec (1994).

# B 4. Procedures for personnel

## B 4.1 Personnel decontamination site

- A site designated for decontamination of personnel should be arranged near the exit point from any infected premises should allow staff to leave the infected premises without becoming re-contaminated.
- The personnel decontamination site should be placed at the limit of the contaminated area, or in an area that is easily and safely decontaminated. Where infected areas require the use of boats to transfer personnel from marine farms to shore, a personnel disinfection site is best located at the site where the boat docks or at the entrance to shore facilities. Alternatively a boat or barge may be designated as the personnel decontamination site, subject to it being easily disinfected and having adequate facilities on board to cater for disinfection procedures.
- Ideally the personnel decontamination site should be a building with power, water and drainage. If there is no suitable site then caravans, transportable toilet blocks, temporary barriers and plastic ground covers can be used. Wherever possible, the personnel decontamination site should include showers (even if they are cold) and changing rooms. Once determined the personnel decontamination site should be cleaned and sprayed with an appropriate disinfectant.
- Each person should have a clean change of clothes kept in plastic containers at the outermost point of the personnel decontamination site. Spare overalls and boots should also be kept in case of mishaps.
- Run off water from the personnel decontamination site must be controlled and not be allowed to flow into clean areas. If adequate drainage is not available, channels should be dug to contain washwater and divert it into pits or tanks within the infected area for later treatment and disposal.

## B 4.2 Personal decontamination procedures from infected premises

(Adapted from AUSVETPLAN Decontamination Manual)

The aim of personal decontamination is to safely remove any contamination from the body or clothing. The process minimises the risk of cross-contamination so that people can confidently move from a contaminated environment with minimal risk of transferring disease.

Heaviest contamination of personnel will occur:

- when infected animals are inspected and diagnostic samples collected
- at the sites of carcase slaughter, removal or disposal, and
- when removing faecal or organic matter and residues from ponds, tanks or pens during the clean-up phase.

***Procedures***

1. It is important that appropriate clothing is chosen prior to undertaking work activities since this will significantly reduce the amount of contamination. Wherever possible, water proof protective clothing and disposable clothing items (for example disposable overalls) should be worn.
2. Protective clothing is first cleaned using a sponge or low pressure pump whilst it is still worn. Wash the protective clothing from top to toe to remove gross material, paying particular attention to the back, under the collar, zip and fastenings and the inside of pockets. Rinse with water prior to removing and placing the items in disinfectant solution to soak for the required period.
3. Overalls are treated similarly, paying attention to the crutch, pockets and the inside of the bottom of trouser legs.
4. Disinfected items are then hung to dry (if they remain on site) or placed in a plastic bag for removal.
5. Rubber boots should be thoroughly scrubbed down, paying particular attention to the soles, then soaked completely in disinfection solution. These should be hung upside down to drain or bagged ready for removal. Industrial hard hats, or other protective clothing used on site, must also be scrubbed and bagged.
6. Equipment used on a daily basis should be left on site rather than disinfected and taken out of the infected area. Where possible, difficult to disinfect and disposable items should also be left on-site for appropriate disposal.
7. Any items that require specialised techniques for disinfection (for example irradiation or gas fumigation) should be cleaned as thoroughly as possible and placed in sealed plastic bags prior to their removal off-site.
8. All items removed from the infected site should always be double bagged, sprayed with disinfecting solutions and carried in solid containers in case of puncture.
9. The person then walks across the area, washes feet in a footbath, changes into clean overalls and street shoes and leaves directly without re-exposure to contaminated areas.
10. Wherever possible staff leaving infected premises should shower out through the personal decontamination site. Showering with soap, shampoo and hot water is considered the most effective, safe and practical method for decontamination of staff. Where shower facilities are not available, warm soapy water should be used for washing face, hair and exposed areas of skin. Chemical disinfectants approved for use on human skin as well as being effective against a wide range of pathogens are extremely limited. Most disinfecting hand washes use either quaternary ammonium compounds, chlorhexidine or povidone iodine as the disinfecting agent and are mixed with suitable non-irritant detergents. Of these povidone-iodine has the widest range of biocidal activity.
11. Wear minimum underclothing and always carry clean spares. If it is cold, wear two sets of overalls.

12. Plastic bags containing used overalls and other articles are sealed and given a second wash down in disinfectant and then placed at the outer limit of the area for collection by courier. These are then taken for cleaning. These garments should be autoclaved or treated as contaminated clothing in a hospital laundry. A sufficient daily supply of clean overalls should be supplied to each work site.
13. On returning to home or lodgings, the person should have a long bath or shower. If people are leaving an infected premises for other duties they must avoid susceptible stock for a period of time as directed. This period will be dependent on the pathogen involved and its ability to survive outside of the host.

## B 4.3 Decontamination procedures for diagnostic team personnel

The personal decontamination procedures outlined in section B 4.2 relate to all personnel, however since resources available during the initial stages of the event with vary significantly some personnel (for example diagnostic or surveillance teams) must ensure that they carry sufficient resources to enable decontamination.

***Equipment and resources for personal decontamination:***

- PVC protective clothing
- Rubber boots
- Disposable overalls
- Spare overalls
- Disposable PM/rubber gloves
- Disposable latex/nitrile gloves
- Disposable face masks
- Alcohol wipes
- Safety glasses
- Personal soap and towels
- Nail brushes
- Long sleeved heavy duty gloves
- Suitable quantities of disinfectant solutions.
  Due to storage and handling characteristics powdered formulations are preferential to liquids. More than one disinfecting type may also be required. Suggested agents include monosuphates, chloramine-T and povodine-iodine.
- Low pressure sprayer for applying disinfectant solution
- General purpose detergent
- Sufficient quantities of fresh water
- Plastic sheets (2@ 3m x 3m)
- 10 L Buckets
- large (approximately 50 litres) plastic bins with lids
- Long handle Scrubbing brushes
- Large heavy duty plastic garbage bags

- Quantity of ‘zip-loc’ plastic bags of varying sizes
- Biohazard waste bags
- Pen, pencils and paper (preferably waterproof)
- Facial tissues

Full-length overalls, eye protection and gloves should be worn when making up cleaning and disinfecting solutions.

*Procedures*

**On entering the site**

1. Arrange with the site manager to meet the diagnostic team where there is minimal chance of contamination occurring to their vehicle. Leave vehicle outside the premises if possible.
2. Take off all jewellery including watches.
3. Make sure your mobile phone has the correct time displayed and the battery is fully charged. Place the phone inside a sealed plastic bag of suitable size.
4. Spread the ground sheets between the vehicle boot and the farm entrance/’threshold’ so that the line demarcating the ‘clean’ area from the ‘dirty’ area runs down the middle of the sheets.
5. Ensure that the 10-litre sprayer is filled with disinfectant solution and placed on the ground sheet.
6. Put on two pairs of disposable overalls and rubber boots. The hood of one pair of the overalls must be drawn up over your head and the legs of the outside pair of overalls worn outside of boots. If the work situation is likely to damage the disposable overalls or weather conditions dictate, substitute the outer disposable overalls for plastic waterproofs. Street shoes are placed within easy reach in the vehicle boot.
7. Take the minimum of equipment required.
8. Prepare two buckets, one with wash solution and one with disinfecting solution suitable for personal disinfection (for example povodine iodine). Also prepare two plastic bins for decontaminating equipment, again one with detergent solution and one with disinfectant.

**On leaving the site**

9. Remove as much dirt and organic material as possible preferably via sponging and vigorous hosing.
10. Used needles and scalpel blades are placed in a sharps container. The sharps container, disposable syringes and their packaging are placed directly into the biohazard waste bag.
11. All paperwork, unexposed equipment, mobile phone, car keys etc and samples (in their respective plastic bags or waterproof containers) are cleaned and rinsed in the disinfecting solution and passed over to the ‘clean’ area.

12. Remove any visible dirt from your waterproofs (if wearing them), gum boots and other equipment, paying particular attention to the boot soles, inside the trouser cuffs and equipment that came in direct contact with susceptible animals.
13. While standing on the ‘dirty side’ remove waterproofs and boots and soaks in the disinfecting solution. Place in a garbage bag (double bag) for later disinfection on return to base.
14. Place disposable overalls and any other disposable items in biohazard waste bags. Spray the biohazard waste and garbage bags (double bag) in disinfecting solution and pass them over to the ‘clean’ side.
15. Using a paper towel and the disinfecting solution from the garden sprayer, wipe around the external surfaces of the car boot, door handles, wing mirror and steering wheel. Place paper towel in the biohazard waste bag.
16. Use the sprayer to spray wheels, wheel arches, buckets, plastic bins and cover sheet. The cover sheet is then bagged and placed in the empty plastic bin.
17. Thoroughly wash all exposed skin with soap and water; scrub finger nails; blow nose, clean ears. Dry with paper towel and any remaining waste items are placed in the biohazard waste bag and sealed. These may be left on the site for burning, but if there is any doubt that the bag will be disposed of properly, disinfect it again and bring it back to base for incineration.

**On returning to base**

18. Remove all equipment from vehicle for disposal or disinfection.
19. Wash the vehicle by taking it through a car wash
20. Shower (long and hot) and wash hair.
21. Change clothes again and wash clothes on a hot cycle.

## B 4.4 General safety warnings

- Ensure all personnel have been adequately briefed on duties and are aware of potential health risks.
- Ensure that appropriate risk assessments have been undertaken and documented for each procedure.
- Ensure that all personnel are issued with appropriate safety equipment, are competent in its use and adhere to safety procedures.
- Ensure all personnel are familiar with safety precautions when handling chemicals and equipment. The use of chemicals or equipment should conform to the manufacturers instructions and safety standards.
- Ensure all personnel operating machinery are appropriately qualified. For example, operation of boats, fork-lifts, front-end loaders, excavators, hoists or diving equipment.
- Ensure that only appropriately qualified personnel undertake duties requiring a licensed operator or technician. For example, connection and disconnection of electricity or repair of equipment.
- Suitable first aid kits must be available on every work site. These kits should be equipped to treat injuries caused by irritant chemicals.
- Allocate a safety officer for each work-site.
- All accidents, however small, should be logged, any treatment documented and reported back to the site supervisor and the local disease control centre.
- The use of electrical equipment is to be strictly controlled and steps taken to ensure that leads are protected from moisture and cannot fall into water.

## B 4.5 Safety instructions for handling chemicals

- Read all instructions, product information and safety advice on the label of chemicals used. Material safety data sheets should be available at all sites for all chemicals used.
- All personnel engaging in mixing disinfectants should wear boots, overalls, goggles or face shields and head covering for protection.
- When diluting concentrate chemicals, the concentrate should ALWAYS be added to water, NEVER water to concentrate (or powder).
- Do not mix acid and alkaline disinfectants.
- Chlorine compounds should not be combined with other chemical compounds, including other forms of chlorine. Chlorine compounds must never be mixed with acids.
- Strong oxidising agents such as chlorine liberating compounds should not come into contact with acids or combustible materials such as paper, sawdust or kerosene.

- Contact with acid or alkaline concentrates can cause chemical burns. If chemical burns occur, douse the affected area well with fresh water and seek medical advice. Refer to hospital if necessary.
- If chemical contact with eyes occur, the eye should immediately be irrigated thoroughly with eye wash solutions and the person referred to hospital.
- Store concentrate containers in a secure area under cover, away from sunlight in a well ventilated area and away from the main work area.
- Check containers each day for rupture or spillage.
- If spills occur, the affected area should be doused liberally with water.

**Table B6: Safety considerations for specific chemical disinfectants**

| *Chemical agents* | *Health aspects* | *Contradictions* |
|---|---|---|
| ***Hypochlorites*** | Irritant to eyes and skin | Strong oxidising agent |
| ***Peracids*** | Reasonable care necessary | |
| ***Sodium hydroxide*** | Highly irritant to eyes and skin | |
| ***Sodium carbonate*** | Irritant to eyes and skin | Avoid contact with strong acids |
| ***Acids*** | Irritant to eyes, skin and respiratory tract | Avoid contact with strong alkalis |
| ***Glutaraldehyde*** | Avoid eye and skin contact | |
| ***Formalin solution*** | Avoid eye and skin contact.<br>Releases toxic gas, irritant to respiratory tract and mucous membranes | May emit toxic fumes if involved in fires. |
| ***Formaldehyde gas*** | Very toxic to mucous membranes at concentrations down to 2ppm | Cannot be used in the presence of water or chlorine. Cannot be released into atmosphere |
| ***Chlorine dioxide*** | Concentrate extremely alkaline. Gives off toxic fumes when first activated | Strong oxidising agent |
| ***Chloramine-T*** | Concentrate can be irritant to eyes, mucus membranes and respiratory tract | Strong oxidising agent |

**Adapted from AUSVETPLAN Decontamination Manual**

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