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Safe Piped Water

*Managing Microbial Water Quality in
Piped Distribution Systems*

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Richard Ainsworth



World Health Organization



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Foreword

Pressurized pipe networks provide a means for supplying drinking-water to individual dwellings, buildings and communal taps. Their widespread adoption has contributed significantly to both the reduction and control of water-related diseases. They also reduce the burden of water collection, which is borne especially by women and children, and is itself associated with much disease and injury. Further development of piped water distribution will be critical to improving health and progressing development in countries worldwide. It is no coincidence that most of our villages and towns were originally concentrated near readily available sources of fresh water such as springs, rivers and lakes.

The microbial quality of water normally changes in a piped network. Although the changes often do not have health implications, there are many documented examples of serious contamination with pathogens occurring within the piped network. When contamination occurs, it may be difficult to trace and remedy because the pipework is normally below ground and difficult to inspect.

This review looks at the factors affecting the presence and growth of microorganisms in piped networks, and the practices of water supply organizations that can directly or indirectly influence their presence and growth. The information provided is based on experience with conventional

underground systems. The special requirements for systems in conveyances (ships, aircraft and trains) or within buildings are not discussed, although many of the general considerations presented here will be relevant.

The information and conclusions presented here are intended for policy-makers and those responsible for formulating water safety plans for the supply of drinking-water, as described in the third edition of the *WHO Guidelines for Drinking-water Quality* (WHO, 2004). They are also relevant to engineers and scientists responsible for water supply planning, operations and monitoring.

Many of the practices described in this review relate to the wider aspects of maintaining the fabric and integrity of the network, not just the prevention of health risks. For example, the removal of internal pipe deposits is often undertaken to increase hydraulic capacity or reduce water discolouration. Similarly, the prevention of pressure surges is normally undertaken to reduce bursts that are expensive and inconvenient to repair. However, this review shows that there are often public health reasons for adopting a more proactive approach to many of the traditional practices used in designing, operating and maintaining distribution networks.

The first six chapters address:

- the microbiology of piped distribution systems and public health;
- composition of treated waters to minimize potential for microbiological changes;
- design and operation of distribution networks;
- planned maintenance and survey of distribution systems;
- precautions during construction and repairs;
- small animals in drinking-water distribution systems.

Chapter 7 draws together this information in the context of a framework of risk assessment and risk management, adapted for application to drinking-water supply. This approach is consistent with the water safety plans described in the third edition of the *WHO Guidelines for Drinking-water Quality* (WHO, 2004).

This review is confined to distribution networks based on pressurized pipes fed by either gravity or pumps. Open-channel networks are not considered here because they provide little or no protection from contamination.

The microbial quality of water may also deteriorate in the plumbing systems of domestic and public buildings. These plumbing systems, and the service pipes connected to the supplier's distribution pipes, have the potential to greatly affect microbial and chemical quality. Plumbing systems and service pipes may not be the direct responsibility of the water supplier, and both cross-connections and backflow situations are a threat. These issues are addressed in Chapter 3. In a typical distribution system, plumbing and services account for 82% of the total pipe length and 24% of the total surface area in the system, yet contain only 1.6% of the total storage volume (Brazos, O'Connor & Abcouwer, 1986).

Therefore, the selection of service pipe and plumbing materials, and their correct installation, is important in controlling the microbial, chemical and aesthetic quality of water at the point of supply to the consumer. These issues are not covered in this review but are the subject of another text on safe plumbing practice, presently in development (see below).

This publication forms part of a series of expert reviews developed by WHO. The reviews, which are listed below, cover various aspects of microbial water quality and health.

- *Managing Water in the Home: Accelerated Health Gains from Improved Water Supply* (M Sobsey, 2002)
- *Pathogenic Mycobacteria in Water: A Guide to Public Health Consequences, Monitoring and Management* (S Pedley et al, eds, 2004)
- *Quantifying Public Health Risk in the WHO Guidelines for Drinking-water Quality: A Burden of Disease Approach* (AH Havelaar and JM Melse, 2003)
- *Water Treatment and Pathogen Control: Process Efficiency in Achieving Safe Drinking Water* (MW LeChevallier and K-K Au, eds, 2004)
- *Toxic Cyanobacteria in Water: A Guide to their Public Health Consequences, Monitoring and Management* (I Chorus and J Bartram, eds, 1999)
- *Upgrading Water Treatment Plants* (EG Wagner and RG Pinheiro, 2001)
- *Water Safety Plans* (A Davison et al., 2004).
- *Assessing Microbial Safety of Drinking Water: Improving Approaches and Methods* (A Dufour et al., 2003).

Further texts are in preparation or in revision:

- *Arsenic in Drinking-water* (in preparation)
- *Fluoride in Drinking-water* (in preparation)
- *Desalination for Safe Drinking-water Supply* (in preparation)
- *Guide to Hygiene and Sanitation in Aviation* (in revision)
- *Guide to Ship Sanitation* (in revision)
- *Health Aspects of Plumbing* (in preparation)
- *Legionella and the Prevention of Legionellosis* (in preparation)
- *Protecting Groundwaters for Health — Managing the Quality of Drinking-water Sources* (in preparation)
- *Protecting Surface Waters for Health — Managing the Quality of Drinking-water Sources* (in preparation)
- *Rapid Assessment of Drinking-water Quality: A Handbook for Implementation* (in preparation)
- *Safe Drinking-water for Travellers and Emergencies* (in preparation).

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- WHO (2004). *Guidelines for drinking-water quality*, 3rd ed., World Health Organization, Geneva.

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Acronyms and abbreviations used in the text

AIDS	acquired immune deficiency syndrome
AOC	assimilable organic carbon
ATP	adenosine triphosphate
AWWA	American Water Works Association
AWWARF	AWWA Research Foundation
BDOC	biodegradable dissolved organic carbon
BFP	biofilm formation potential
CCTV	close circuit television
cfu	colony forming unit
CV	check valve
DCDA	double check detector assembly
DOC	dissolved organic carbon
GAC	granular activated carbon
GIS	geographical information system
HACCP	hazard analysis critical control point
HPC	heterotrophic plate count
ISO	International Organization for Standardization
NAS	national approval scheme

NASA	National Aeronautics and Space Administration
NTU	nephelometric turbidity unit
psi	pounds per square inch
RDOC	refractory dissolved organic carbon
RPZA	reduced pressure zone assembly
THM	trihalomethane
TOC	total organic carbon
UKWIR	United Kingdom Water Industry Research
USEPA	United States Environmental Protection Agency
UV	ultraviolet
WHO	World Health Organization
WHOPES	World Health Organization Pesticide Evaluation Scheme