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Water Treatment and Pathogen Control

*Process Efficiency in Achieving Safe
Drinking Water*

Mark W LeChevallier and Kwok-Keung Au



World Health Organization



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Contents

<i>Foreword</i>	<i>ix</i>
<i>Acknowledgements</i>	<i>xiii</i>
<i>Acronyms and abbreviations used in the text</i>	<i>xv</i>
<i>Executive summary</i>	<i>xvii</i>
1 Introduction	1
1.1 Purpose and scope	1
1.2 Multiple barriers	2
1.3 Process control measures.....	3
2 Removal processes	5
2.1 Pretreatment.....	6
2.1.1 Roughing filters.....	6
2.1.2 Microstrainers.....	7
2.1.3 Off-stream storage.....	8
2.1.4 Bank infiltration	10

2.2	Coagulation, flocculation and sedimentation.....	12
2.2.1	Conventional clarification	13
2.2.2	High-rate clarification	17
2.2.3	Dissolved air flotation	18
2.2.4	Lime softening.....	19
2.2.5	In-line coagulation.....	19
2.3	Ion exchange.....	20
2.4	Filtration	20
2.5	Granular high-rate filtration.....	21
2.5.1	Design of granular filtration	22
2.5.2	Mechanism of action of granular filtration.....	23
2.5.3	Importance of chemical coagulation pretreatment	23
2.5.4	Effect of filter media design.....	24
2.5.5	Importance of filter backwash	25
2.6	Slow sand filtration.....	26
2.6.1	Design and action of slow sand filters.....	26
2.6.2	Protection provided by slow sand filtration.....	30
2.7	Precoat filtration	32
2.7.1	Removal of microbes.....	32
2.7.2	Importance of chemical pretreatment	33
2.8	Membrane filtration.....	33
2.8.1	Microfiltration	35
2.8.2	Ultrafiltration.....	36
2.8.3	Nanofiltration and reverse osmosis	37
2.9	Bag, cartridge and fibrous filters	39
3	Inactivation (disinfection) processes.....	41
3.1	Factors affecting disinfection	41
3.2	Pretreatment oxidation.....	43
3.3	Primary disinfection	44
3.3.1	Chlorine	44
3.3.2	Monochloramine	50
3.3.3	Chlorine dioxide.....	52
3.3.4	Ozone	54
3.3.5	Ultraviolet light	58
3.3.6	Mixed oxidants.....	61

3.4	Secondary disinfection.....	62
3.4.1	Maintenance of water quality in the distribution system.....	62
3.4.2	Factors affecting microbial occurrence	62
3.4.3	Other non-chlorine disinfectants	65
4	Performance models	67
4.1	Removal process models	67
4.1.1	Transport	68
4.1.2	Attachment	68
4.1.3	Effects of process variables on removal efficiency	68
4.2	Disinfection models.....	72
4.2.1	Integrated disinfection design framework	74
5	Treatment variability	75
5.1	Effects of process variability	76
5.2	Relationships between treatment processes	76
5.3	Dynamic nature of treatment processes	77
5.4	Effects of changes in raw water quality	78
5.5	Variability due to process measurements	78
6	Process control	81
6.1	Risk assessment and process control	82
6.2	Source water protection	83
6.3	Coagulation, flocculation and clarification.....	85
6.4	Filtration	88
6.5	Disinfection	90
6.6	Distribution system.....	91
7	Reference list	93
	Index	107

Foreword

Microbial contamination of drinking-water contributes to disease outbreaks and background rates of disease in developed and developing countries worldwide. Control of waterborne disease is an important element of public health policy and an objective of water suppliers.

The World Health Organization (WHO) has developed *Guidelines for Drinking-water Quality*. These guidelines, which are now in their third edition (WHO, 2004), provide an internationally harmonized basis to help countries to develop standards, regulations and norms that are appropriate to national and local circumstances. The latest edition of the WHO *Guidelines for Drinking-water Quality* is structured around an overall “water safety framework”, used to develop supply-specific “water safety plans”. The framework, which focuses on health protection and preventive management from catchment to consumer, has five key components:

- health-based targets, based on an evaluation of health concerns;
- system assessment to determine whether the drinking-water supply (from source through treatment to the point of consumption) as a whole can deliver water of a quality that meets the health-based targets;

- operational monitoring of the control measures in the drinking-water supply that are of particular importance in securing drinking-water safety;
- management plans that document the system assessment and monitoring plans, and describe actions to be taken in normal operation and incident conditions (including upgrade and improvement, and documentation and communication);
- a system of independent surveillance to verify that the above are operating properly.

Understanding the effectiveness of water treatment is necessary for:

- design of cost-effective interventions
- review of the adequacy of existing structures
- operation of facilities to maximum benefit.

WHO has also developed a series of expert reviews covering various aspects of microbial water quality and health (listed below). This publication forms part of this series of reviews.

- *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)
- *Safe, Piped Water: Managing Microbial Water Quality in Piped Distribution Systems* (R Ainsworth, 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)
- *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)

Water safety management demands a quantitative understanding of how processes and actions affect water quality, which in turn requires an understanding of risk assessment. This volume is intended to provide guidance on using risk assessment when selecting appropriate treatment processes, to ensure the production of high quality drinking-water. It is hoped that it will be useful to water utilities, water quality specialists and design engineers.

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Acronyms and abbreviations used in the text

AOC	assimilable organic carbon
asu	areal standard unit
AWWA	American Water Works Association
AWWARF	AWWA Research Foundation
BDL	below detection limit
BDOC	biodegradable dissolved organic carbon
CC-PCR	cell culture-polymerase chain reaction
cfu	colony forming unit
DAF	dissolved air flotation
DE	diatomaceous earth
DNA	deoxyribonucleic acid
FAC	free available chlorine
FMEA	failure mode and effects analysis
HACCP	hazard analysis critical control point
HPC	heterotrophic plate count
IDDF	integrated disinfection design framework
IFA	immunofluorescence assay
MF	microfiltration

NA	not applicable
NF	nanofiltration
NR	not reported
NTU	nephelometric turbidity unit
PACl	polyaluminium chloride
pfu	plaque forming unit
PVC	polyvinylchloride
RO	reverse osmosis
RNA	ribonucleic acid
SFBW	spent filter backwash
THM	trihalomethane
UF	ultrafiltration
USEPA	United States Environmental Protection Agency
UV	ultraviolet
WHO	World Health Organization
WTP	water treatment plant