



**PHARMACEUTICALS
IN DRINKING-WATER**

A large, light blue, semi-transparent graphic of a globe is positioned on the left side of the page. It features faint white lines representing latitude and longitude. The globe is partially cut off by the right edge of the page.

PHARMACEUTICALS IN DRINKING-WATER

WHO Library Cataloguing-in-Publication Data

Pharmaceuticals in drinking-water.

1. Water pollutants, Chemical. 2. Pharmaceutical preparations. 3. Water purification. 4. Potable water. I. World Health Organization.

ISBN 978 92 4 150208 5

(NLM classification: WA 30.5)

© World Health Organization 2012

All rights reserved. Publications of the World Health Organization are available on the WHO web site (www.who.int) or can be purchased from WHO Press, World Health Organization, 20 Avenue Appia, 1211 Geneva 27, Switzerland (tel.: +41 22 791 3264; fax: +41 22 791 4857; e-mail: bookorders@who.int).

Requests for permission to reproduce or translate WHO publications – whether for sale or for noncommercial distribution – should be addressed to WHO Press through the WHO web site (http://www.who.int/about/licensing/copyright_form/en/index.html).

The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted lines on maps represent approximate border lines for which there may not yet be full agreement.

The mention of specific companies or of certain manufacturers' products does not imply that they are endorsed or recommended by the World Health Organization in preference to others of a similar nature that are not mentioned. Errors and omissions excepted, the names of proprietary products are distinguished by initial capital letters.

All reasonable precautions have been taken by the World Health Organization to verify the information contained in this publication. However, the published material is being distributed without warranty of any kind, either expressed or implied. The responsibility for the interpretation and use of the material lies with the reader. In no event shall the World Health Organization be liable for damages arising from its use.

Design by paprka-annecy.com

Printed in France

Contents

List of acronyms and abbreviations	vi	3. Treatment technologies for removal of pharmaceuticals from water	15
Acknowledgements	vii	3.1 Introduction	16
Executive summary	viii	3.2 Removal of pharmaceuticals by wastewater treatment processes	16
1. Occurrence of pharmaceuticals in water	1	3.3 Removal of pharmaceuticals by drinking-water treatment processes	18
1.1 Advances in analytical and detection methods	3	3.4 Conclusion	20
1.2 Occurrence of pharmaceuticals in surface water	4	4. Preventing pharmaceuticals in drinking-water	23
1.3 Occurrence of pharmaceuticals in drinking-water	6	4.1 Improved regulations and guidance on pharmaceutical waste management	24
1.4 Conclusion	6	4.2 Pharmaceutical take-back programmes	25
2. Human health risk assessment for pharmaceuticals in drinking-water	7	4.3 Raising consumer awareness	26
2.1 Introduction	8	4.4 Conclusion	26
2.2 Assessing risks associated with pharmaceuticals in drinking-water	8	5. Conclusions, recommendations and knowledge gaps	27
2.3 Applying the MTD approach: a Drinking Water Inspectorate study	10	5.1 Conclusions	28
2.4 Applying the ADI approach	12	5.2 Recommendations	28
2.4.1 Awwa Research Foundation study	12	5.3 Knowledge gaps and future research	29
2.4.2 Australian Guidelines for Water Recycling	13	References	30
2.5 Conclusion	13		

List of acronyms and abbreviations

ADI	acceptable daily intake
DWEL	drinking-water equivalent level
EDC	endocrine disrupting chemical
FAO	Food and Agriculture Organization of the United Nations
GAC	granular activated carbon
GC	gas chromatography
LC	liquid chromatography
LOAEL	lowest-observed-adverse-effect level
LOQ	limit of quantification
MF	microfiltration
MOE	margin of exposure
MS	mass spectrometry
MS/MS	tandem mass spectrometry
MTD	minimum therapeutic dose
nd	not detected

NF	nanofiltration
NOAEL	no-observed-adverse-effect level
NSAID	non-steroidal anti-inflammatory drug
PAC	powdered activated carbon
PoD	point of departure
PUB	Public Utilities Board (Singapore)
RO	reverse osmosis
SF	sand filtration
TDI	tolerable daily intake
UF	ultrafiltration
USA	United States of America
USEPA	United States Environmental Protection Agency
UV	ultraviolet
WHO	World Health Organization
WSH	Water, Sanitation, Hygiene and Health unit (WHO)



Acknowledgements

The World Health Organization (WHO) wishes to express its appreciation to all those who contributed to the preparation and development of this document through the provision of their time, expertise and experience.

WHO thanks the United States Environmental Protection Agency (USEPA) and Public Utilities Board (PUB) Singapore for their financial and technical support in developing this guidance to address an emerging issue for drinking-water.

WHO acknowledges the contributions of the members of the Working Group on Pharmaceuticals in Drinking-water, who provided important technical inputs for WHO's consideration in the development of this document. The working group members are:

- Dr Joe Cotruvo, Independent Consultant, Joseph Cotruvo and Associates, United States of America (USA)
- Dr Mary Couper, formerly Quality Assurance and Safety: Medicines, WHO, Switzerland
- Dr David Cunliffe, Department of Health, Environmental Health Service, Australia
- Mr John Fawell, Independent Consultant, England
- Ms Michèle Giddings, Water, Air and Climate Change Bureau, Health Canada, Canada
- Dr Edward Ohanian, USEPA, USA
- Professor Choon Nam Ong, National University of Singapore, Singapore
- Dr Hans Sanderson, Danish National Environmental Research Institute, Aarhus University, Denmark
- Dr Dai Simizaki, National Institute of Public Health, Japan
- Professor Giampaolo Velo, University of Verona, Italy

Special appreciation is extended to Mr John Fawell, independent consultant, England, who provided valuable time and technical expertise in the development of this document. Appreciation also goes to Dr Emma Goslan, Cranfield University, England, who contributed technical inputs to the chapter on the efficacy of removal of pharmaceuticals during wastewater and drinking-water treatment.

The development and production of this document were coordinated and managed by staff of the Water, Sanitation, Hygiene and Health (WSH) unit of WHO, including Mr Robert Bos (Coordinator, WSH), Mr Bruce Gordon and Mr Chee-Keong Chew (technical officers). Ms Carolyn Vickers and Dr Angelika Tritscher, WHO Headquarters, provided valuable inputs related to chemical risk assessments.

The professional editing services of Ms Marla Sheffer of Ottawa, Canada, and the secretarial support provided by Ms Penny Ward are also gratefully acknowledged.

Executive summary

Background

In the last decade, traces of pharmaceuticals, typically at levels in the nanograms to low micrograms per litre range, have been reported in the water cycle, including surface waters, wastewater, groundwater and, to a lesser extent, drinking-water. Advances in analytical technology have been a key factor driving their increased detection. Their presence in water, even at these very low concentrations, has raised concerns among stakeholders, such as drinking-water regulators, governments, water suppliers and the public, regarding the potential risks to human health from exposure to traces of pharmaceuticals via drinking-water.

Following requests from several Member States for information regarding the potential health impacts of residual concentrations of pharmaceuticals in drinking-water, this issue was added to the work plan of the World Health Organization (WHO) Drinking-water Quality Committee in 2005. It was proposed that a working group of experts be assembled to undertake a rapid review of the state of the science of pharmaceuticals in drinking-water and develop guidance and recommendations in a report and fact sheet.

A WHO working group that comprised experts in toxicology, water chemistry, water quality and health, water treatment, pharmacology, and drinking-water regulation and policy was formed in 2009. Consultations were held in 2009 and 2010 with the Drinking-water Quality Committee and additional experts to review and summarize the available scientific knowledge and evidence.

A literature review was a key source of evidence. This examined the fate and

More importantly, it emphasizes the need to prioritize this emerging issue in the overall context of water safety management, which includes microbial and other chemical risks that may threaten the safety of drinking-water.

Scope

This report focuses primarily on reviewing the risks to human health associated with exposure to trace concentrations of pharmaceuticals in drinking-water. It does not discuss the potential impacts on aquatic ecosystems or the broader physical environment.

Occurrence of pharmaceuticals in water

Pharmaceuticals are synthetic or natural chemicals that can be found in prescription medicines, over-the-counter therapeutic drugs and veterinary drugs. Pharmaceuticals contain active ingredients that have been designed to have pharmacological effects and confer significant benefits to society. The occurrence of pharmaceuticals in the environment and the water cycle at trace levels (in the range of nanograms to low micrograms per litre) has been widely discussed and published in literature in the past decade. The increase in detection is largely attributable to the advances in analytical techniques and instrumentation. Many surveys and studies have confirmed the presence of pharmaceuticals in municipal wastewater and effluents, and these have been identified as a major source of pharmaceuticals in drinking-water (Figure ES1).

Routine monitoring programmes to test drinking-water for pharmaceuticals

预览已结束，完整报告链接和二维码如下：

https://www.yunbaogao.cn/report/index/report?reportId=5_28473

