

**WATER QUALITY AND TREATMENT**  
**A HANDBOOK ON DRINKING WATER**

**American Water Works Association**

**James K. Edzwald, Technical Editor**  
**Professor Emeritus, University of Massachusetts**

**Sixth Edition**

**McGraw- Hill**

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American Water Works Association is the authoritative resource for knowledge, information and advocacy to improve the quality and supply of water in North America and beyond. AWWA is the largest organization of water professionals in the world. AWWA advances public health, safety and welfare by uniting the efforts of the full spectrum of the entire water community. Through our collective strength we become better stewards of water for the greatest good of the people and the environment.

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## PREFACE

This 6<sup>th</sup> edition of *Water Quality and Treatment: A Handbook on Drinking Water* serves as a handbook for scientists, engineers, and other professionals who study and work in drinking water; particularly, the quality of water supplies, the quality of treated drinking water, and water treatment processes. It is meant as a resource for those in academics (professors and students); consulting engineering practice; water utilities; federal and state regulatory agencies; and the water process and chemical industries. The book emphasizes principles (theory) and applications (practice). It serves as a companion to the book on design, AWWA–ASCE *Water Treatment Plant Design*; the 5<sup>th</sup> edition is in preparation with expected publication in late 2011.

This book is an activity of AWWA's Water Quality and Technology Division (WQTD). James K. Edzwald served as the technical editor and worked with the authors of the chapters in preparing the book. An ad hoc committee of the WQTD consisting of James P. Malley, Jr., Marilyn M. Marshall, and Dixie Fanning provided advice to the technical editor throughout the preparation of the book.

*Water Quality and Treatment*, 6<sup>th</sup> edition, differs greatly from the 5<sup>th</sup> edition published in 1999; it contains significant revisions, updating of material, and new chapters. Five new chapters expand the scope of this book: Chapter 4, Hydraulic Characteristics of Water Treatment Reactors and Their Effects on Treatment Efficiency; Chapter 15, Natural Treatment Systems; Chapter 16, Water Reuse for Drinking Water Augmentation; Chapter 18 UV Light Processes; and Chapter 19, Formation and Control of Disinfection Byproducts. A sixth chapter, Chapter 3, Chemical Principles, Source Water Composition, and Watershed Protection, replaces one from the 5<sup>th</sup> edition on source water quality management, and it is essentially another new chapter in that it contains new material on chemical principles and additional material on source water quality.

Since publication of the 5<sup>th</sup> edition in 1999, the drinking water field has faced new regulations and concerns about the health effects of some new and previously known contaminants. Furthermore, in the last 10 years we have seen the development of new technologies and refinements of older technologies that are now covered in this edition. The 6<sup>th</sup> edition covers the health effects and treatment technologies to remove some contaminants not covered previously such as nanoparticles, endocrine-disrupting compounds, and pathogens; it contains updated material on many other contaminants such as disinfection by-products, arsenic, and pathogens including viruses and protozoan cysts such as *Cryptosporidium*; and it addresses

subjects not adequately covered in the prior edition, such as water reuse, ultraviolet light processes, and natural treatment systems.

Several other new features are notable in this 6<sup>th</sup> edition. The International System of Units (SI) is used with U.S. units in parenthesis where appropriate. This makes the book useful to professionals outside the United States and to those within the United States working on water projects around the world. Each chapter has its own table of contents to aid readers in finding subject matter within chapters. Four new appendices provide quick references for atomic numbers and masses, physical and chemical constants, unit conversion factors, and the physical properties of water.

The book is organized beginning with five supporting chapters that contain material on drinking water standards and regulations (chapter 1), health effects (chapter 2), chemical principles, source water composition, and watershed protection (chapter 3), hydraulics of treatment processes (chapter 4), and an overview of water treatment processes (chapter 5). This is followed by coverage of various water treatment processes in chapters 6 through 14 that present principles and applications of the removal of various contaminants from water supplies. Chapter 15 covers natural treatment systems such as river bank filtration, and chapter 16 deals with water reuse. Chapters 17 and 18 follow with disinfection and UV light processes including disinfection and advanced oxidation processes. Chapters 19, 20, and 21 cover disinfection byproducts, corrosion, and microbiological quality in distribution systems, respectively. Chapter 22 ends the book with the properties, treatment, and management of water treatment residuals.

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## ACKNOWLEDGMENTS

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The revision of the book began with an assessment of the 5<sup>th</sup> edition. Several professionals from water utilities, consulting engineering firms, and academics were asked to review the 5<sup>th</sup> edition and to make recommendations for new material for inclusion in the 6<sup>th</sup> edition. I wish to thank the following: William C. Becker (Hazen and Sawyer), William D. Bellamy (CH2M Hill), Steve Bishop (Metcalf and Eddy), Howard Dunn (Vice President of Operations and Technology, Aquarion Water Company of CT), Harold T. Glaser (Kennedy Jenks), Raymond D. Letterman, (Syracuse University and Technical Editor of the 5<sup>th</sup> edition), Michael J. MacPhee (Malcolm Pirnie), Charles R. O'Melia (Johns Hopkins University), Vernon L. Snoeyink (University of Illinois), and John P. Walsh (formerly, Director of Operations and Distribution, Aquarion Water Company of CT, now with Tighe and Bond).

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Mine Closure Water Balance. Water Quality and Treatment. Water and Mass Balance Assessment. Contamination Assessment and Remediation. Our Experts. Water quality assessment is important for the duration of mining and infrastructure projects, from scoping and feasibility stages to mine closure. Our teams of specialists are experienced in a wide range of mining and process scenarios, including varied climatic and regulatory environments. We advise clients on mine and potable water supply, process water quality, environmental and social impact assessment, mine geochemistry and acid rock drainage (ARD), and water treatment. Our approach is pragmatic, thorough, and focused on solving even intractable water quality issues. Services. Potable wat... Only RUB 220.84/month. Water Quality and Water Treatment. STUDY. Flashcards. Coagulation Treatment. When alum is added to water, it reacts with the water and results in positively charged ions. Coagulation is a process used to remove turbidity, color, and some bacteria from water. settling basin. Water and the flocs sink to the bottom of the settling basin. Secondary filtration. designed to further reduce the B.O.D. of the organic material. It makes use of devices that agitate and aerate the sewage in order to promote the activity of naturally occurring aerobic decomposing bacteria. Chlorination. the process of adding chlorine to drinking water to disinfect it and kill Drinking-water quality regulation. Small water supply management. Household water treatment and safe storage. Recreational waters. Publications. WHO produces international norms on water quality and human health in the form of guidelines that are used as the basis for regulation and standard setting world-wide. The Guidelines for drinking-water quality (GDWQ) promote the protection of public health by advocating for the development of locally relevant standards and regulations (health based targets), adoption of preventive risk management approaches covering catchment to consumer (Water Safety Water treatment systems make a difference Spa-Like Showers and Baths. You may never want to get out of the shower... Softer & Brighter Clothes. A quality SoftPro or Fleck water softener will make you feel great everyday. GET STARTED. Get Your Free Water Score, Top Brand Comparisons & Custom Sizing Recommendations.