WATER POLLUTION A Series of Monographs

# Water Quality Management under Conditions of Scarcity

## Israel as a Case Study

Hillel I. Shuval, editor

Academic Press
A Subsidiary of Harcourt Brace Jovanovich, Publishers

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D. T. O'Laoghaire and D. M. Himmelblau. *Optimal Expansion of a Water Resources System.* 1974

C. W. Hart, Jr., and Samuel L. H. Fuller (eds.). *Pollution Ecology of Freshwater Invertebrates.* 1974

H. Shuval (ed.). *Water Renovation and Reuse.* 1977

C. W. Hart, Jr., and Samuel L. H. Fuller (eds.). *Pollution Ecology of Estuarine Invertebrates.* 1979

H. Shuval (ed.). *Water Quality Management under Conditions of Scarcity: Israel as a Case Study.* 1980

IN PREPARATION

S. Mandel and Z. L. Shiftan. *Groundwater Resources: Investigation and Development.*

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Jerusalem, Israel

1980

ACADEMIC PRESS
*A Subsidiary of Harcourt Brace Jovanovich, Publishers*
New York London Toronto Sydney San Francisco

ACADEMIC PRESS, INC.
111 Fifth Avenue, New York, New York 10003

*United Kingdom Edition published by*
ACADEMIC PRESS, INC. (LONDON) LTD.
24/28 Oval Road, London NW1 7DX

**Library of Congress Cataloging in Publication Data**
Main entry under title:

Water quality management under conditions of scarcity.

Bibliography: p.
Includes index.
1. Water quality management--Israel. I. Shuval, Hillel I., Date
TD313.I75W37 363.7'3945'095694 80-17610
ISBN 0-12-641280-4

PRINTED IN THE UNITED STATES OF AMERICA

80 81 82 83 9 8 7 6 5 4 3 2 1

# Dedication

This book is dedicated to the memory of my father, the late Yehuda Shuval, who instilled in me the love of the traditions and ethical principles of the Jewish people and the inspiration to work for their fulfillment in Israel. It is likewise dedicated to my mother, Rachel Shuval, who still provides the warmth and emotional sustenance which is needed to lead a life in search of these goals.

The continued love and encouragement of my wife, Judith, and daughters Rama, Tamar, and Yael, provided warm support and inspiration.

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# Preface

This book is devoted to the study of the problems of water quality management under conditions of severe water resource scarcity, as it has evolved in Israel over the past 30 years. At the time of writing this book, Israel is, essentially, utilizing 100% of its replenishible water resources and has embarked on a program to develop less conventional water sources such as brackish water and renovated wastewater to meet its present and future water demands.

Over the past 30 years Israel has engaged some of its best engineers and scientists to deal with the development and management of its limited water resources. Its thriving agricultural economy, coupled with its rapid industrial development and population growth, has been dependent on the maximal utilization of the available water supplies. In the process the threat of serious water quality degradation has come to dominate the scene to such an extent that today the long-term continued utility of much of the country's water resources are at risk.

Israel is on the verge of a grave water crisis. By the year 2000, with an estimated population of 5,600,000, there will be insufficient water to meet the annual requirements from natural sources. In addition, if groundwater pollution by natural salts and nitrates continues unabated, some 80% of the wells in the coastal aquifer will have to be abandoned for municipal use and their utility for agriculture will be severely diminished.

This book presents an authoritative analysis of the antecedents of these problems and suggests strategies for their solution. The solutions will require in many cases a radical departure from present policies and may require a total restructuring of the water administration. The main pollution processes that threaten the country's ground and surface water sources are presented in detail. While most of these water quality problems are universal, in Israel they are severely exacerbated by growing conditions of scarcity. Unique and often innovative approaches to analyze and control water quality problems have therefore been developed which can be of general application in other areas facing similar problems. The book also devotes attention to some of the organizational, economic, legal, and political aspects of water quality management that have evolved in Israel. Here, too, much can be learned from the Israeli experience.

In selecting the authors for the various chapters I have chosen the persons who are most qualified to present an authoritative, credible, and independent analysis of the problems. Half of the authors are employed by official or quasi-official organizations which are part of the water establishment, including the Office of the Water Commissioner and Tahal–Water Planning for Israel. Their views as expressed in this book do not necessarily express the official position of their employers. Other authors employed by the Ministry of Health and Ministry of Interior likewise appear here in their individual capacity as do those from the academic and research institutions. The broad spectrum of disciplines and the depth of experience of the authors within and outside the water establishment provides a balanced presentation of the problems of water quality management under conditions of scarcity.

I have not edited out or censored conflicting points of view. I have not tried to produce a book solely to praise Israel's accomplishments in the utilization of water nor a book aimed solely at criticizing the water establishment. The aim has been to present an objective analysis and evaluation of the problems. I do feel strongly that the unique problems involved in dealing with water quality management under conditions of scarcity which have evolved in Israel are worthy of close scrutiny and careful analysis. This applies equally to the successes and failures. Only through such free and open scientific exchange can others learn what types of problems they may face in the not too distant future and of the experience gained, for better or worse, in coping with those problems.

On the personal side, this book provided an opportunity to sit back and critically review with a sense of perspective the exciting developments and progress made in Israel during the past 30 years in the field of water quality management with which I have been so closely associated. From 1949 through 1965 I had the privilege of being involved directly in an official capacity in the Ministry of Health, serving as Chief Public Health Engineer for the last 8 years of my period of public service. Since then my involvement has continued no less actively at the Hebrew University of Jerusalem as a researcher and advisor to governmental and public bodies in Israel.

Many persons and organizations provided valuable assistance in the preparation of this book. Particular appreciation is expressed to Dr. Aaron Wiener who participated actively in developing the concept and scope of the book and to his organization Tahal–Water Planning for Israel, several of whose senior staff members have participated in writing chapters and who willingly made available numerous unpublished documents and internal reports of vital importance. Special appreciation is also due to Professor Morton Hilbert and to the School of Public Health of the University

of Michigan, Ann Arbor, for providing me with the opportunity and facilities to complete the final drafting and editing of the manuscript during my sabbatical at Michigan in 1979.

It is my hope that "Water Quality Management under Conditions of Scarcity" will provide useful scientific and technical background and insight to those in other countries faced with similar problems and will as well provide a stimulus within Israel to take the difficult but urgent measures required to avert the impending water quality crisis that that country now faces. The eyes of the world will be watching and waiting for the outcome.

Hillel I. Shuval

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# 1

# Goals of Water Quality Control

HILLEL I. SHUVAL



## I. Introduction

While water is the most abundant natural resource on earth its distribution is not uniform, and many areas are facing growing problems of severe water scarcity. Chow (1976) has stated that the lack of water, rather than land, may become the principal constraint on efforts to expand world food output and keep the world peace.

As world population increases, the demand for water for food production, industrial activities, and domestic purposes grows and leads to heavier withdrawals of the limited renewable freshwater resources. Simultaneously these very same human activities generate wastes which are discharged into the depleted water resources, despoiling them. The world at large is facing the dual problem of increasing demands on limited freshwater resources coupled with the growing degradation of those very same water resources which may seriously reduce their utility at the quality required. Thus today the question of preserving and managing water resources is coupled intimately with the question of preserving and managing water quality.



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ISBN 0-12-641280-4

## II. General Goals of Water Quality Control

From the earliest writings of man, there are indications of an awareness of the impact that water quality may have on health and well-being. In the Old Testament reference is made to an act of purification of water, while early Indian writings refer to the need for filtration to remove impurities from turbid river water. Socrates includes water in his list of vital elements.

However, the modern understanding of the critical role that water may play in the mass transmission of communicable disease was first deduced in 1854 by John Snow in his famous studies on cholera. Since the individual, particularly in the urban setting, could do little to protect himself from detrimental exposures to the water environment, at the end of the last century the early hygienists such as Chadwick in England, Sedgewick in the United States, and Petinkoffer in Germany all urged that governments, both local and central, assume the responsibility for the protection of man's environment and the control of water quality. Over the years a body of science, technology, and administrative practice dealing with water quality control has developed; it has gone under a variety of names such as hygiene, sanitation, sanitary engineering, environmental health, and more recently "ecology" and environmental protection.

While the early goals of water quality control were limited almost exclusively to the protection of human health from acute water-borne disease and later to the prevention of serious esthetic nuisances in polluted surface water, today the scope has broadened with our increasing understanding of the complex interrelationships between man's well-being and the water environment.

The goals of water quality control have been extended through the years, and today many scientists and practitioners would agree they should include the following.

1. Assure the protection of human health and well-being from exposure to detrimental pathogenic microorganisms and toxic chemicals, having acute or chronic effects in: (a) domestic water supplies, (b) recreational water, (c) agricultural water, and (d) wastewater flows.
2. Assure that the water environment (including groundwater, streams, lakes, impoundments, and the sea) are properly protected from causes of environmental pollution which could lead to nuisances or degradation of their normal amenities and economic and cultural uses.
3. Protect and conserve natural aquatic ecosystems to an extent that is feasible with emphasis on maintaining the aquatic ecological balance

essential in preserving the food supply of man and the protection of essential global life supporting natural aquatic systems.

## III. Controversial Issues

Concerning goal 1 described above in Section II, some newer definitions of the requirements to meet this goal for drinking water are needed. While the need for control of drinking water quality to prevent the transmission of acute communicable disease is accepted by all, the question of long-term health effects of chemical carcinogens found in low concentrations in drinking water has only recently come to the fore. A study by the United States National Research Council (1977) reports on the detection of 20 known or suspected carcinogens in drinking water in the Unted States. Some of these compounds are also suspected of possessing mutagenic and teratogenic properties.

Schneiderman (1978) evaluated 13 epidemiological studies carried out in the United States on the association of the concentration of trihalomethanes (THM) in drinking water and cancer; he concluded that there is indeed evidence that THM (or chloroform alone) is likely to increase the incidence of cancer of the bladder and large intestine in population groups consuming water containing the chemicals. Trihalomethane develops in many water supplies containing organic pollution after undergoing chlorination. As a preventive measure the United States Environmental Protection Agency has recommended that heavily contaminated surface water be treated by granular activated carbon (GAC) filtration to remove the organic precursors of the carcinogenic compounds.

This requirement has led to an open controversy between the water supply industry and the health and environmental authorities over the issue of the costs and benefits that may accrue from such additional water quality improvement. The problem is particularly difficult since it involves concentrations of chemical carcinogens at the part per billion (ppb) levels and health effects that are not perceived in massive epidemic proportions, but rather low level increases in cancer, detectible only by sophisticated epidemiological methods.

The United States National Cancer Institute has estimated that about 80% of human cancer is associated with the exposure to chemicals in the environment. Since the latent period for cancer development from time of exposure may be 10 to 40 years, data on humans or epidemiological studies are not usually available. Often data indicating a potential risk are available only from animal studies. Since the expense involved in pre-

venting the discharge of toxic chemicals into the water environment or their removal by advanced treatment processes (such as GAC filtration) may be large in comparison to what people have been used to spending on water, some policy makers are reluctant to make definitive decisions in this new complex area of water quality control. However, a prudent policy should call for taking preventive steps within the framework of economic feasibility based on sound laboratory evidence, rather than waiting until the carcinogenic process in large exposed population groups is irreversible.

This concern with low levels of potentially carcinogenic, mutagenic, and teratogenic chemicals in drinking water has become particularly germane in Israel in relation to the decision of whether or not to use renovated wastewater effluent for domestic consumption (see Chapter 9).

Another newer problem associated with possible disease transmission by drinking water involves the question of enteric viruses. Scientific evidence is accumulating which indicates that viruses are not removed by wastewater and water treatment processes as effectively as are bacteria. This has led to situations where some treated water supplies derived from polluted surface sources are free from conventional bacterial pollution indicator organisms, such as coliforms, while viruses have on occasion been detected. A recent World Health Organization (1979) report recommends the establishment of a virus guideline for drinking water derived from polluted surface sources and the initiation of virus monitoring programs. This recommendation has yet to be accepted by most water quality control authorities, although the logic cannot easily be refuted. Many health authorities and environmental protection agencies, including the United States Environmental Protection Agency (EPA), often tend to adopt a wait and see attitude when new problems are identified which require a revision of conventional water quality management positions.

Not all the elements of the first goal are easily definable from a health risk and control point of view. For example, the protection of coastal waters for bathing and recreation has been widely debated. Epidemiological evidence of the risks of bathing in sewage contaminated sea water has for years been unclear (Mosley, 1975). Nevertheless numerous health authorities in the United States and elsewhere have opted early to establish microbiological guidelines for coastal bathing beaches based on the classical public health preventive approach that it is not reasonable to expose large population groups to fecal contamination, including numerous pathogenic bacteria and viruses. These numerical standards were usually based on the concept of engineering feasibility (Shuval, 1975) and served as a basis for the design and construction of wastewater treatment and sea outfall facilities capable of meeting the guidelines set.