POTABLE WATER FROM WASTEWATER

Edited by M.T. Gillies

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Foreword

The idea of obtaining potable water from wastewater is a psychologically difficult one for many people to accept. The tendency is to think that wastewater is "dirty" and cannot be converted to "clean" water. This book describes significant advances in wastewater treatment technology which make possible the control and/or removal of conventional pollutants, thus making potable water from wastewater technically feasible today.

Water is one of our few renewable resources. It can be and is reused continuously due to natural hydrologic cycling powered by solar energy. However, as populations grow, as water demands increase, and as temporary water shortages develop, due either to natural or manmade disasters, the need for supplementary, reclaimed sources of water will become more widespread.

The book covers direct and indirect water reuse. Direct reuse implies the piping of wastewater directly to a user after appropriate intervening treatment; indirect reuse occurs when water from a particular source, such as a river, serves more than one community and/or industry, one after another, as it moves from its origin to its outlet.

Methods of wastewater treatment and purification in varying stages of development are presented. Ongoing experimental and pilot studies around the world have been described. Analytical testing methods for water purity are detailed, and a discussion of contaminants associated with municipal wastewater reuse as well as a chapter on health effects of reuse have been included. Possible approaches to educating the public about water reuse are also considered.

This book will be of interest to anyone involved with problems relating to water reuse for potable purposes—water treatment personnel and environmental engineers, municipal and public health officials.

The information contained here is based on studies and conferences sponsored by various government agencies. Because the material was obtained from multiple sources, it is possible that certain portions may disagree or conflict with other parts of the book. These differing points of view have been included, however, to make the book more valuable to the reader.

Advanced composition and production methods developed by Noyes Data are employed to bring these durably bound books to you in a minimum of time. Special techniques are used to close the gap between "manuscript" and "completed book." Industrial technology is progressing so rapidly that time-honored, conventional typesetting, binding and shipping methods are no longer suitable. We have bypassed the delays in the conventional book publishing cycle and provide the user with an effective and convenient means of reviewing up-to-date information in depth.

The expanded table of contents is organized in such a way as to serve as a subject index and to provide easy access to the information contained herein. The primary sources are listed at the end of the volume under the heading Sources Utilized. The titles of additional publications pertaining to topics covered in this book are listed at the end of several chapters and sections.

A List of Abbreviations has been included to aid in the use of this book.

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Introduction

The material in this chapter has primarily been excerpted from the following papers delivered at the Water Reuse Symposium held in Washington, DC in March 1979. The collected symposium papers, *Water Reuse—From Research to Application. Proceedings of Water Reuse Symposium Held at Washington, DC on March 25-30, 1979* [Volume 1 (NSF/RA-790224) is hereinafter referred to as "Conference I," Volume 2 (NSF/RA-790225) as "Conference II," and Volume 3 (NSF/RA-790226) as "Conference III"], were prepared by the American Water Works Association Research Foundation for the National Science Foundation, March 1979.

Each paper used in this chapter has been assigned a letter which appears in parentheses before the paper title. At the end of each paragraph taken from one of these papers or at the end of a title, the letter reference will be found, also in parentheses. When only one or two sentences have been quoted, the reference has been omitted.

(A) "Water Reuse: It is Time for Implementation," by T.C. Jorling, of the U.S. Environmental Protection Agency.

(B) "The Environmental Protection Agency's Research Program for Water Reuse," by S.J. Gage, of the U.S. EPA.

(C) "Treatment Technology for Water Reuse," by R.B. Williams, G.C. Culp and J.A. Faisst, all of Culp/Wesner/Culp.

(D) "Toward the Goal of Direct Water Reuse—What Should We Do Next?" by J.-C. Huang, the University of Missouri—Rolla.

(E) "Applied Science and Its Role in Addressing Problems Relating to Renovation and Reuse of Water," by J.T. Sanderson, of the National Science Foundation.

(F) "OWRT's Water Reuse R&D Program," by R.S. Madancy of OWRT, Dept. of Interior.

(G) "Wastewater in Drinking Water Supplies," by M.D. Swayne et al.

(H) "Water Reclamation Efforts in California," by K. Wassermann and J. Radimsky of the Office of Water Recycling, State Water Resources Control Board, CA.

Water used to be one of our cheapest natural resources. In recent years, we have discovered that water is no longer an abundant commodity in many places in the U.S. and in other countries of the world. Reasons for this include population growth, increases in the average water consumption for domestic and industrial purposes, pollution, and climactic changes. Although there are annual changes in our water reservoirs, the long-term trends show that shortage of water is going to be a problem in many places that have not experienced this phenomenon before.

NECESSITY FOR REUSE

Water can no longer be considered a stepchild among the resources—taken for granted and used without thought. It is a reclaimable resource of inestimable value and increasing scarcity. Like clean air it is basic. Inadequate water supplies limit the quality of life and limit municipal and industrial growth.

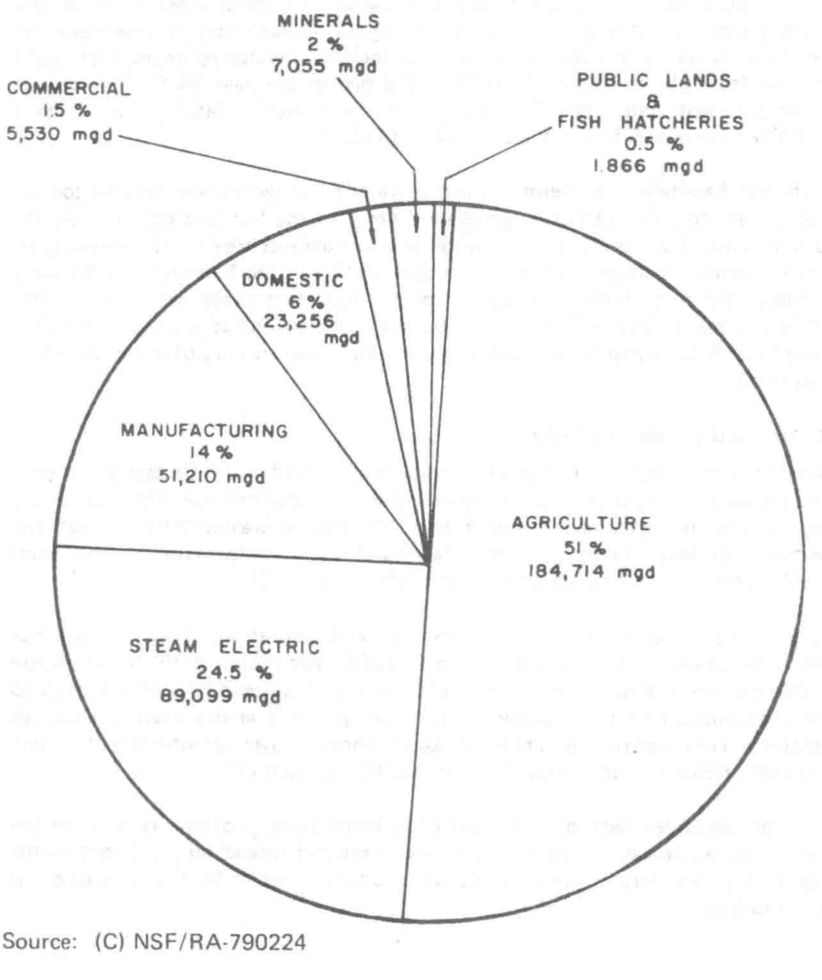
There is increasing recognition at every level of society that water reuse is a fundamental component of the wise and efficient management of an increasingly scarce, but essential, natural resource. A number of things have led to this recognition. Foremost has been the experience of a series of droughts in the mid-seventies which taught us that our best laid plans for water storage are no match for nature's uncertainties. We are reminded almost daily that water is not an exhaustible resource. Reports of steadily declining aquifers and completely appropriated stream flows mount on the one hand even while the memories of recent droughts have not faded. Studies at every level demonstrate this to be a major national problem and point toward the inadequacy of conventional, technological solutions. We are running out of acceptable reservoir sites and areas with surplus water for inter-basin transfers. The costs for developed water have increased enormously in recent years. If not addressed quickly the situation may erupt into an economic and legal competition . . . . Reclaimed water will increasingly become too valuable a commodity to simply use once and dump. Moreover, reclaimed water supplies are much more reliable than stream flows which vary seasonally (A).

How Much Water Do We Use?

The Water Resources Council indicates that total freshwater withdrawals in 1975 in the U.S. were 362 bgd (see Figure 1.1). Of these, about three-quarters are from surface supplies and the remainder from groundwater sources. The demand for potable water represented 7.5% of the total or about 27 bgd. On a per capita basis, domestic use is estimated to be about 75 gallons per capita per day; this includes bathing, lawn watering and sanitary waste disposal. Commercial, industrial and public uses of water range from 30 to 130 gpcpd, depending on local conditions. A typical figure for overall municipal potable water consumption is 160 gpcpd (C).

According to a recent House Science and Technology Subcommittee report, the nation's withdrawals of groundwater have more than doubled over the past 25 years and are increasing at the rate of 4% annually. In many areas, these withdrawals cause severe problems, including increased drilling and pumping costs due to declining water levels, conflicts between urban and agricultural use, and contamination of the aquifers both by salt and by disposal of pollutants on the surface. Some areas may eventually run out of groundwater (E).

Figure 1.1: National Freshwater Withdrawals—1975



Source: (C) NSF/RA-790224

Future Demand

Estimates of future water withdrawals vary widely. According to Dr. Huang, natural runoff averages about 1,200 bgd and our total water demand is about 500 bgd now and is expected to increase to 1,370 bgd by 2020, thus exceeding the natural runoff (D).

On the other hand, the Second National Water Assessment by the Water Resources Council and an evaluation of reuse needs and potential done by OWRT indicate that total freshwater withdrawals of more than 362 bgd in 1975 are expected to decrease to about 330 bgd in the year 2000. This hopeful projection is based upon the continuation of present trends in industrial recycling and improved irrigation efficiency. Increasingly stringent wastewater discharge limitations, coupled with recurring drought periods in water-short areas of the country can provide major impetus for going considerably beyond these current trends. It is now estimated that the total industrial water recycling rate could increase from about 1.9 bgd in 1975 to 8.8 bgd in the year 2000. The reuse of municipal wastewaters could increase from the present relatively insignificant quantity to almost 5 bgd in the same period (E).

Technical Feasibility for Reuse: Is direct water reuse technically feasible today? The answer to this question is generally "yes." In the last two decades, significant advances have been made in water and wastewater treatment technologies. The conventional types of pollutants such as BOD, SS, coliforms, pathogens, nitrogen and phosphorus, etc. can all be removed effectively from wastewater. In fact, some treated effluents may have lower concentrations of these pollutants than those considered satisfactory in raw water sources of domestic water supply (D).

Planned and Unplanned Reuse

Planned, direct reuse of wastewater has been practiced in the United States on a small scale to date, primarily for agricultural and industrial use. The widespread and continued unplanned, indirect reuse of treated wastewaters through the discharge of these waters to streams, lakes and reservoirs for reuse to other communities has been a long accepted practice in the U.S. (C).

One of the major constraints to effective implementation of water reuse has been the aversion to any kind of identifiable association with human waste within our immediate environment. Ironically, this concern has not extended to the transmission of the wastewater to other people's environments. Thus, an upstream community has rarely exhibited concern over transferring its waste products, treated or otherwise, to residents downstream (A).

Even groundwater, which is thought of as being pure, is often "reused" in the sense that wastewater from septic tanks or ground spread by treatment plants leaches into aquifers which feed the wells supplying water for the same or other communities.

Table 1.1 presents a list of twenty-five population centers estimated to have the greatest loading or exposure to municipal wastewater in drinking water supplies. The cities are ranked according to product of population and conservative estimate of percent of wastewater (G).

Table 1.1: Source Water Impact According to Population and Percent Wastewater

State	City	Line	Source Water	Population (x 1,000)	Conservative Estimate of Percent of Wastewater*
PA	Philadelphia	155	Schuylkill River	1,950	3.5
SC	Columbia	259	Saluda River	228	16
PA	Bryn Mawr	149	Neshaminy Creek	820	3.8
IN	Indianapolis	464	White River	680	4.3
PA	Middletown	140	Neshaminy Creek	759	3.8
TX	Dallas	539	Lake Ray Hubbard	878	2.8
AL	Birmingham	207	Cabaha River	650	3.6
NJ	Elizabeth	166	Delaware-Raritan Canal	500	4.3
MD	Baltimore	124	Susquehanna River	1,755	1.2
NJ	Little Falls	055	Passaic River	333	4.9
MO	St. Louis	381	Mississippi River	600	2.2
LA	New Orleans	525	Mississippi River	550	1.8
NJ	Millburn	054	Passaic River	234	4.8
OH	Cincinnati	447	Ohio River	850	1.3
LA	Marrero	524	Mississippi River	600	1.8
MD	Hyattsville/ Wash., DC	178	Potomac River	1,300	0.8
KY	Louisville	454	Ohio River	700	1.4
MO	Kansas City	359	Missouri River	750	1.2
TX	Fort Worth	538	Ben Brook Lake	490	1.6
MO	St. Louis	362	Missouri River	600	1.3
CO	Pueblo	495	Arkansas River	95	7.6
SC	Rock Hill	266	Catawba River	426	1.4
NJ	Elizabeth	167	Raritan and Millstone	500	1.1
IL	East St. Louis	382	Mississippi River	215	2.2
GA	Columbus	237	Lake Oliver	134	3.2

*Cumulative percent wastewater estimates under average source water flow conditions.

Source: (G) NSF/RA-790224

Obstacles to Reuse

For a long time, the word "wastewater" has been linked with a psychological implication of "filth" and "dirtiness" no matter how well it has been treated. Although there is concrete evidence that impurities and harmful substances can be removed from wastewater by today's treatment technologies, the public has not been convinced, and the sanitary engineering profession has not actively tried to convince them, that properly treated effluent can be reused for domestic purposes (D).

Steps to Overcome the Psychological Barrier (G): In order to overcome the public's deeply-rooted psychological rejection, or at least reluctance, toward direct water reuse, intensive public education plus enthusiastic professional campaign are necessary so that the public can be convinced that wastewater, like a piece of equipment or other merchandise, can be "repaired" or "renovated" to make it clean and wholesome again. In carrying out the public education and professional campaign, the following actions should be seriously considered.

(1) Consideration should be given to change some of the common terminologies used today which either explicitly or implicitly link wastewater with a sense of feeling of filth and dirtiness, such as:

Existing Terms	Suggested New Terms
Wastewater or sewage	used water (making it synonymous to used car or other merchandise that can be fixed and reused)
Waste treatment plant	water renovation plant or water reclamation center
Treated sewage effluent	renovated water or reclaimed water
Sewage sludge	municipal humus
Sewage treatment plant operator	water renovator

The main objective of using the above new terminologies is to impress the public that "wastewater" is just like a "used car" or a "used typewriter," that can be fixed and reused. It is hoped that with these terminologies the public will gradually be convinced that wastewater is really not that bad at all. It is only temporarily "used" and can be reused again after it is cleaned up.

(2) The public must be informed clearly that "water reuse" is not new at all. We have been reusing our wastewaters for decades! Of course, the reuse is neither deliberate nor direct; it merely occurs from one community to another as water flows downstream through surface or underground drainage systems. However, in any dry season, much of the water in a natural stream may be from municipal sewage effluents. Under such extreme situations, a practice of direct reuse has already been in effect.

(3) The sanitary engineering professional group should take the lead in publicizing the fact that today's advanced water and wastewater treatment technologies are absolutely able to convert wastewater to potable water. They should also take the lead in demonstrating their willingness to drink the treated sewage effluent first.

(4) More intensive research must be taken immediately to assess the real toxicological implications of the various impurities present in wastewater effluent. At the present time our knowledge in this field is still in the stage of infancy. Because of this, many new standards established today may be unduly conservative. This definitely makes direct water reuse more difficult. It must be pointed out here that in many underdeveloped countries people are still drinking water from fairly polluted sources without having adequate treatment. Yet there is