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Third Edition

Water Supply and Pollution Control

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PREFACE

The third edition of WATER SUPPLY AND POLLUTION CONTROL has been modernized to reflect state-of-the-art practices and recent trends in federal, environmental, and pollution control legislation. Emphasis is on application of scientific methods to solve problems related to the development, transportation, distribution, processing, and treatment of water and liquid wastes.

The chapters on "Water Quality" and "Systems for Treating Water and Wastes" have been updated to reflect changes in attitude toward environmental issues as reflected in the National Environmental Policy Act of 1969 and the Federal Water Pollution Control Act Amendments of 1972 (PL92–500). These chapters act as integrating mechanisms to acquaint students with the nature of water and waste treatment systems before presenting the details of systems components.

A new chapter on "Water-Quality Models" is designed to relate the treatment of waste flows to the overall environment of the receiving body of water. The material is organized to acquaint students with techniques for combining individual pollution control facilities into integrated systems for regional water quality control and management. Both model structuring and conceptualization are presented.

The treatment of principles of physical, chemical, and biological treatment processes necessary for designing and managing modern water and waste-water facilities has been extensively revised. "Processing of Sludges" now reflects the increasing importance of solid waste handling in the pollution control field.

"Advanced Waste-Water Treatment Processes" has been rewritten to focus on the removal of pollutants not affected by conventional processes. Changes in subject matter reflect the goals of PL92–500 and the trend toward a higher degree of waste-water reuse. Chapters on water reuse and water law have been revised to incorporate advances in technology and changes in federal laws.

The authors wish to acknowledge the advice and assistance of many students and teachers who have reviewed and commented on previous editions. Specific recognition is given to Helen Hudson and Mary Lou Wegener for their help in preparing the manuscript and to Russell C. Brinker and Norma Jean Viessman for editorial assistance.

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CHAPTER

1 Introduction

Air, water, food, heat, and light constitute the five essentials for human existence. Environmental engineering concerns itself, to some degree, with all of these. This book is primarily concerned with the development, transportation, processing, and disposal of water and waste.

Water and liquid wastes must be considered simultaneously, as there is but a fine line of distinction between them. One community's waste may constitute part of another's water supply. The ultimate goal in water management is the maximum economic use of the total water resource.

1-1 HISTORY

Man's search for pure water began in prehistoric times. Much of his earliest activity is subject to speculation. Some individuals might have led water where they wanted it through trenches dug in the earth. Later, a hollow log was perhaps used as the first water pipe.

Thousands of years must have passed before our more recent ancestors learned to build cities and enjoy the convenience of water piped to the home and

drains for water-carried wastes. Our earliest archeological records of central water supply and wastewater disposal date back about 5000 years, to Nippur of Sumeria. In the ruins of Nippur there is an arched drain with the stones set in full "voussoir" position, each stone being a wedge tapering downward into place.[1]* Water was drawn from wells and cisterns. An extensive system of drainage conveyed the wastes from the palaces and residential districts of the city.

The earliest recorded knowledge of water treatment is in the Sanskrit medical lore and Egyptian Wall inscriptions.[2] Sanskrit writings dating about 2000 B.C. tell how to purify foul water by boiling in copper vessels, exposing to sunlight, filtering through charcoal, and cooling in an earthen vessel.

There is nothing on water treatment in the sanitary and hygienic code of the early Hebrews in the Old Testament, although three incidents may be cited as examples of the importance of fresh water. At Morah, Moses is said to have sweetened bitter waters by casting into them a tree shown him by God.[3] During the wandering in the wilderness, the Lord commanded Moses to bring forth water by smiting a rock.[4] At a much later date, Elisha is said to have "healed unto this day" the spring water of Jericho by casting "salt" into it.[5]

The earliest known apparatus for clarifying liquids was pictured on Egyptian walls in the fifteenth and thirteenth centuries B.C. The first picture, in a tomb of the reign of Amenhotep II (1447–1420 B.C.), represents the siphoning of either water or settled wine. A second picture, in the tomb of Rameses II (1300–1223 B.C.), shows the use of wick siphons in an Egyptian kitchen.

The first engineering report on water supply and treatment was made in A.D. 98 by Sextus Julius Frontinus, water commissioner of Rome. He produced two books on the water supply of Rome. In these he described a settling reservoir at the head of one of the aqueducts and pebble catchers built into most of the aqueducts. His writings were first translated into English by the noted hydraulic engineer Clemens Herschel in 1899.[2]

In the eighth century A.D. an Arabian alchemist, Geber, wrote a rather specialized treatise on distillation that included various stills for water and other liquids.

The English philosopher Sir Francis Bacon wrote of his experiments on the purification of water by filtration, boiling, distillation, and clarification by coagulation. This was published in 1627, one year after his death. Bacon also noted that clarifying water tends to improve health and increase the "pleasure of the eye."

The first known illustrated description of sand filters was published in 1685 by Luc Antonio Porzio, an Italian physician. He wrote a book on conserving the health of soldiers in camps, based on his experience in the Austro-Turkish War. This was probably the earliest published work on mass sanitation. He described and illustrated the use of sand filters and sedimentation. Porzio also stated that his filtration was the same as "by those who built the Wells in the Palace of the Doges in Venice and in the Palace of Cardinal Sachett, at Rome."[2]

* Superscript numbers refer to references at the end of the chapter.

The oldest known archeological examples of water filtration are in Venice and the colonies she occupied. The ornate heads on the cisterns bear dates, but it is not known when the filters were placed. Venice, built on a series of islands, depended on catching and storing rainwater for its principal freshwater supply for over 1300 years. Cisterns were built and many were connected with sand filters. The rainwater ran off the house tops to the streets, where it was collected in stone-grated catch basins and then filtered through sand into cisterns (see Fig. 1-1).

FIGURE 1-1 Venetian cistern head located at Dubrovnik, Yugoslavia, showing a stone grating.

A comprehensive article on the water supply of Venice appeared in the *Practical Mechanics Journal* in 1863.[6] The land area of Venice was 12.85 acres and the average yearly rainfall was 32 inches (in.). Nearly all of this rainfall was collected in 177 public and 1900 private cisterns. These cisterns provided a daily average supply of about 4.2 gallons per capita per day (gpcd). This low consumption was due in part to the absence of sewers, the practice of washing clothes in the lagoon, and the universal drinking of wine. The article explained in detail the construction of the cisterns. The cisterns were usually 10 to 12 feet (ft) deep. The earth was first excavated to the shape of a truncated inverted pyramid. Well-puddled clay was placed against the sides of the pit. A flat stone was placed in the bottom and a cylindrical wall was built from brick laid with open joints. The space between the clay walls and the central brick cylinder was filled with sand. The stone surfaces of the court yards were sloped toward the cistern, where perforated stone blocks collected the water at the lowest point and discharged it to the filter sand. This water was always fresh and cool, with a temperature of about 52 degrees Fahrenheit (°F). These cisterns continued to be the principal water supply of Venice until about the sixteenth century.