

## CHAPTER I

# From the Earliest Records Through the Sixteenth Century

The quest for pure water began in prehistoric times. Into those recordless millenniums only speculation can enter. Sanskrit medical lore and Egyptian inscriptions afford the earliest recorded knowledge of water treatment.

"It is good to keep water in copper vessels, to expose it to sunlight, and filter through charcoal." So wrote Francis Evelyn Place (1) from India in 1905, crediting the quotation to "*Ousruta Sanghita*—a collection of medical lore in Sanskrit, probable date 2000 B.C., Chap. XIV, verse 15." In the same letter, Place cites, as from another Sanskrit source "of about the same date, . . . it is directed to heat foul water by boiling and exposing to sunlight and by dipping seven times into it a piece of hot copper, then to filter and cool in an earthen vessel. The direction is given by the god who is the incarnation of medical science." This citation is attributed to "the *Naghrund Bhuson*—a collection of medical maxims from the *Ayura Veda*, the earliest Sanskrit work on medicine extant . . . in the chapter on water, in the last *sloka* but two." Both citations were translated by Kundan Jugendia Pal Singh, of Jaipur, India, where Place was located in 1905.\*

The *Sus'ruta Samhita*, a body of medical lore said to date from 2000 B.C., but not known to have been put into manuscript form until 400 A.D. (2), declares: "Impure water should be purified by

\* Being unable to find an English translation of the works named by Place, I appealed to the Library of Congress for aid. Miss Gerda Hartman, Division of Indic Studies, replied that Place's *Ousruta Sanghita* must be the same as the *Sus'ruta Samhita* (see below) and that *Naghrund Bhuson* may be corrupted from *Nighantu Bhusana*, "nighantu" being part of the name of several medical glossaries, probably of recent date, possibly one of the latest of these. *Ayura Veda* may have been intended for the traditional fifth Veda, or "Veda of Longevity," the preservation of which has not been proved. The passages cited by Place have been repeated again and again in journals and books, sometimes with and sometimes without credit to him, but with no attempt to authenticate the material. Place's chapter and verse citations were probably derived from a contemporary translator, Singh, who, Miss Hartman suggests, may have drawn from one of numerous extant manuscripts.

being boiled over a fire, or being heated in the sun, or by dipping a heated iron into it, or it may be purified by filtration through sand and coarse gravel and then allowed to cool." Other methods of purifying water include the use of "Gomedaka"—a kind of stone—and a number of vegetable substances, most notably seed of *Strychnos potatorum*. These statements may be regarded as a summary of methods of water purification known and used by the Aryan and Indic



FIG. 1. EGYPTIANS SIPHONING OFF WATER OR WINE CLARIFIED BY SEDIMENTATION

Pictured on wall of tomb of Amenophis II at Thebes, 1450 B.C.  
(From Wilkinson's *Manners and Customs of the Ancient Egyptians*, 1879)

priests and physicians down to 400 A.D. They include some of the methods cited by Place as having been taken from Sanskrit literature of a much earlier date.

### *Egyptian Customs*

The earliest known apparatus for obtaining clarified liquids was pictured on Egyptian walls in the fifteenth and thirteenth centuries B.C. The first picture, in a tomb of the reign of Amenophis II, represents men siphoning off either water or settled wine (3); the second, in the tomb of Rameses II, shows assorted sizes of wick siphons in an Egyptian kitchen (4).

"In porticoes of Egyptian temples," says Hero of Alexandria, "revolving wheels . . . are placed for those who enter to turn around, from an opinion that bronze purifies [water]." The apparatus was connected behind an entrance pillar. It included a wheel attached to a perforated horizontal tubular axis placed beneath and in contact with the perforated bottom of a [bronze?] water container. When the wheel was revolved, the holes in the tube and the axis came opposite each other and water was sprayed upon the worshipper through a small tube extending through the wheel. This was not a device invented by Hero himself, nor does he say how long it had been in use. He probably lived in the last half of the first century A.D. (5).

### *Bible Lore*

In view of the well-deserved fame of the sanitary and hygienic code of the early Hebrews, directions for water treatment might be looked for in the Old Testament. None appears. But three incidents may be cited as examples of the quest for pure water in dry or alkaline lands: At Marah, Moses is said to have sweetened bitter waters by casting into them a tree shown him by the Lord (6). During the forty years' wandering in the wilderness, he is said to have brought forth water by smiting a rock (7). Much later, Elisha is said to have "healed unto this day" the spring water of Jericho by casting "salt" into it (8).

### *Greek and Roman Records*

For convenience there are assembled here, out of chronological order, a number of similar later instances of water conditioning. Diophanes (first century B.C.) advised putting macerated laurel into rain water (9). Paxamus (first century A.D.) proposed that bruised coral or pounded barley, in a bag, be immersed in bad-tasting water—evidently to cure taste due to mineral salts (9). Vitruvius (15 B.C.) recommended that cisterns be constructed in two or three compartments and the water transferred from one to another of them, thus allowing the mud to settle, and insuring clearness and limpidity. Otherwise, he wrote, it would be necessary to clarify the water by adding "salt" (10). Pliny (c. 77 A.D.) said that polenta, a kind of food, added to nitrous or bitter water would render it potable in

two hours, and that a similar property is possessed by chalk of Rhodes and the argilla of Italy (11). This is the first mention found of lime and aluminous earth as precipitants. Referring to well water, Palladius (fourth or fifth century A.D.), in his rhymed work, *On Husbandrie*, wrote that "If water be lymous or infest admystion of salt wol it correct" (12).

A drinking cup which hid badly colored water from the sight of the drinker and caused mud to stick to its side was devised by Lycurgus, the Spartan lawgiver and reformer (ninth century B.C.), according to Plutarch (13). This is the earliest recorded instance of an attempt by the Greeks to purify water. More credible is the earliest specific instance of treating water for human consumption found on record. Herodotus tells us that Cyrus the Great, King of Persia (sixth century B.C.), when going to war, took boiled water in silver flagons, loaded on four-wheeled cars drawn by mules (14). A later Greek writer, Athenaeus of Naucratis (third and second centuries B.C.), says that the water was boiled in these instances to make it keep—which reflects the opinion if not also the custom of his time (15).

That the use of wick siphons was well known in the days of Socrates (469–399 B.C.) and Plato (427–347 B.C.) is shown by the simile in Plato's *Symposium*, wherein Socrates is represented as saying it would be well if wisdom would flow from a person filled with it to one less wise, as water flows through a thread of wool from a fuller to an emptier vessel (16). Common knowledge of filtration through porous vessels is indicated by Aristotle (384–322 B.C.) in his *De Generatione Animalium* (17). He says that the nutriment which produces flesh is deduced through the veins and pores in the same way as water through earthen vessels not thoroughly baked.

Hippocrates (460–354 B.C.), the father of medicine, wrote in *Air, Water and Places*—the first treatise on public hygiene—that "who-soever wishes to investigate medicine properly should consider the seasons of the year, the winds and the waters in relation to health and disease." As the "qualities of the waters differ from one another in taste and weight," he said, "so they differ much in their [other] qualities." One should "consider the waters which the inhabitants use, whether they be marshy and soft, or hard and running from elevated and rocky situations, and then if saltish and unfit for cooking . . . for water contributes much to health." Hip-

pocrates' discussion of the qualities of water centers on the selection of the most health-giving sources of supply rather than on rectifying the waters that were bad. The only exception to this is an assertion that rain waters should be "boiled and strained for otherwise they would have a bad smell" and cause hoarseness. For straining he mentions a cloth bag which became known in later ages as "Hippocrates' sleeve" (18).

In 168 B.C., a thousand years after the siphons were depicted on the walls of Egyptian tombs, Athenaeus of Naucratis wrote his account of the voyage of Antiochus on the Nile (15). On this journey, says the author of *The Deipnosophists*, water from the river was exposed to sun and air; strained; settled overnight in jars the outsides of which were kept cool by being kept wet by slaves; and then, in the morning, drawn off and placed in chaff for use as needed. Thus the water was made clear and healthful.

When Caesar began taking possession of Alexandria, in 47 B.C., it is said that he found the city underlaid with aqueducts bringing water from the Nile to cisterns in which it became clarified by sedimentation for the use of the masters and their families. The Egyptians cut off the river water and turned in salt water from the other side of the city. Whereupon, Caesar, firmly believing that all sea-shores naturally abounded with fresh springs, ordered his centurions to lay aside all other works and dig wells day and night. The very first night an abundance of water was found. This incident, related with zest by Hirtius (19), is doubly significant: it affords an early instance of clarification by sedimentation and shows that Caesar did not suppose, as was almost universally assumed for centuries before and afterwards, that salt water could be freshened by percolation through sand.

Not all the citizens, soldiers and slaves of Alexandria were supplied with water brought underground to cisterns. Athenaeus of Attilia, writing about 50 A.D. on *Purification of Water* (20), mentioned Alexandria as a city where water was purified by jars called "stacta." He also cited a single, double, and even triple filtration as producing water of the greatest purity. Channels were dug along the sea to draw off water or along lakes to produce water free from mud and leeches. These channels may be regarded as prototypes of the infiltration galleries of the nineteenth century in England, France and Germany.

Pliny credited to his contemporary, the Emperor Nero (reigned 54–68 A.D.), the device of pouring boiled water into glass and incasing it in snow, adding that it was generally admitted that water was more wholesome when boiled. Pliny also said that sea water may be freshened by filtration through argillaceous earth. Perhaps most remarkable of Pliny's assertions is that water in which iron had been plunged was useful as a potion in many diseases, particularly dysentery (11).

None of the writers thus far cited was an engineer. None of them mentioned the treatment of public water supplies. But Sextus Julius Frontinus, who in 97 A.D. became *curator aquarum* or water commissioner of Rome, deserves to be called an engineer and he was the author of a treatise on public water supply. He had previously filled many important civil and military positions and, on assuming a new office, he wrote, he always considered that "the first and most important thing to be done [was] to learn thoroughly what I have undertaken." Accordingly, in 98 A.D., he produced *De Aquis Urbis Romae Libri II* [*Two Books on the Water Supply of Rome*], the first known detailed description of a water works system. It was made available to English readers by the noted American hydraulic engineer, Clemens Herschel, in 1899 (21).\*

Of particular interest is Frontinus's description of a settling reservoir at the head of one of the aqueducts supplying Rome and of the *piscanae* or ingeniously designed pebble catchers built into most of the aqueducts.

Albert Neuburger, in *The Technical Arts and Sciences of the Ancients*, mentions the "piscana mirabilis" at Baiae, Italy, which "served the double purpose of storing and clarifying the water simultaneously" (22).

In the writings of Galen, the noted Greek physician (130–200 A.D.), we find that the Egyptians used water filtered through earthen jars (23).

\* The study of Frontinus was Herschel's avocation for many years. He made a "pious journey" from New York to Cassino, Italy, and there had photographed the oldest known manuscript of Frontinus. Besides reproducing this in facsimile, Herschel printed on facing pages the text in Latin and his own translation into English. These versions were supplemented by explanatory chapters based on wide library research and on personal inspection of the remains of the aqueducts of Rome.

Paulus Aegineta, a Greek physician of the seventh century A.D., a great traveler and a writer of works on medicine that were chiefly compilations and commentaries, noted that water containing impurities or having a fetid smell might be made fit to drink by boiling or by mixing with judiciously selected wine (24). Marshy, saltish or bituminous waters, he said, were benefited by straining.

### *Arabia and Persia*

We come next to the highly specialized treatise on distillation by the noted Arabian alchemist, Geber, of the eighth century A.D. (25). He described not only various stills for water and other purposes but also a filter leading from one stone vessel to another, which must have been a wick siphon. This also he called a still. The object of distillation, by whatever means, Geber said, was the "purification of liquid matter from its turbulent feces, and conservation of it from putrefaction." The "invention of pure water," he said, was for "the imbibition of spirits and clean medicines."

Avicenna, an early eleventh century Persian physician of the Arabian school, gathered in his *Canon of Medicine* what he thought were the most important and practical means of water purification (26). Needs of travelers were his chief concern. He did not mention filtration but he advised travelers to strain all their drinking water through cloth. Boiling he thought more efficient than distillation or sedimentation in overcoming objectionable matter. If a thick water were left to stand for a long time, he said, hardly anything would be deposited, while boiling produced an abundant precipitate, rarifying the water and leaving it light and clear. Aeration by the force of gravity in aqueducts, or by agitation resulting from lifting water from wells, he deprecated, not realizing that water flowing through closed aqueducts instead of being aerated loses its free oxygen and that when well water is bad it needs *more* aeration than the little that is given by drawing it to the surface. Particularly significant was Avicenna's declaration that acetous water added to rain water corrects putrefaction and provides immunity from the possible ill effects on human beings.

### *Another Engineer*

In 1591, some fifteen centuries after Frontinus, an engineer again appears in the quest for pure water. This is the Italian military engi-

neer and soldier of fortune, Federigo Gianibelli, who, while in the service of Queen Elizabeth, floated "fire-ships" down the Scheldt, blew up a bridge and a thousand Spaniards, and thus relieved the besieged city of Antwerp. Afterwards, while at London in 1591, and still in Elizabeth's service, Gianibelli prayed Lord Burghleigh to make known to the queen an "invention" for cleaning certain "filthy ditches round about the city" and displacing their contents with "plenty of wholesome clean water for the use of the inhabitants" and for fighting fire. Strype, in his 1720 revision and extension of Stow's *A Survey of the Cities of London and Westminster*, does not say how the waters were to be cleansed (27). Later writers have asserted that filtration was proposed but they cite no authority in support of their statement.

## CHAPTER I

From the Earliest Records Through the  
Sixteenth Century

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## CHAPTER II

## Seventeenth Century

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