## *CHAPTER XXI*

# Taste and Odor Control

Aside from the elimination of disease germs from drinking water, no achievement in the history of water purification has been greater than the control of tastes and odors. Strange to relate, the crowning triumph in the conquest of water-borne disease germs, chlorination, accelerated to a high degree the tastes and odors borne by some waters, such as those laden with algae and, worse yet, those into which certain industrial wastes, particularly phenol, were poured. Efforts to cope with tastes and odors, chronologically arranged, have been: boiling, aeration, dosing with vegetable, chemical or mineral substances and ozonation. Some of these efforts have been direct attacks upon tastes and odors; some have been aimed at the prevention of growths of nuisance-producing substances, particularly algae and other organisms.

Attempts to prevent tastes and odors have been recorded from time to time during the past 2,400 years. They became more numerous toward the close of the nineteenth century, began to achieve notable success in the first decade of this century, and pointed the way toward victory at the end of the third decade.

In earlier chapters there are reviewed many aspects of taste and odor troubles and of control methods employed up to the early twentieth century.

Sanskrit lore, probably dating back to 2000 B.C., recommended filtration through charcoal and exposure to sunlight, as well as boiling, followed by exposure to sunlight and the dipping of hot iron into it seven times. The earliest authenticated written recognition of bad odor in water is accompanied by a prescription for removal by boiling and straining and is found in the books of Hippocrates, the Greek physician (460–357 B.C.). Additional correctives are found in later literature of Greek and Roman origin (see Chap. I).

Lowitz, the Dutch chemist, announced at St. Petersburg, Russia, in 1789–90, the results of experiments which demonstrated that powdered charcoal, either alone or supplemented by a few drops of sulfuric acid, would cure putrid water. Partly on the strength of these experiments, charcoal in various forms was often used in water treatment, usually as a filter medium, alone or with other materials, from the 1790's onward, until the general adoption of sand alone for both slow and rapid or mechanical filtration. The activated carbon of recent years is an improvement on the findings of Lowitz more than a century earlier. In 1807, Cavallo, Italian by birth, English by adoption, prescribed adding freshly-made powdered charcoal to water, followed by agitation and subsequent removal by filtration (see Chap. III).

Paulus Aegineta, seventh century A.D., recommended boiling to cure bad water. Boerhaave (1668–1738) wrote that when water has "spontaneously grown putrid, give it only one boil in the fire, [whereupon] the animals that are in it will be destroyed." Ozonation, originally and still used almost exclusively for disinfection in Europe, was applied to taste and odor control at Hobart and Long Beach, Ind., in 1930 and 1932, and at Whiting, Ind., in 1940 (see Chap. XIV).

Distillation of bad water for its "preservation sweet on shipboard," was the subject of British patents late in the sixteenth century. It has been used under special conditions on two Texas water supplies (see Chap. XV).

### *Two Thousand Years of Aeration*

As with boiling, aeration has appeared in the literature on taste and odor removal or prevention for well over 2,000 years, and is attributed to much earlier Sanskrit traditions. For centuries, the benefits of natural aeration were the theme of many writers, culminating in Sir Francis Bacon's dicta: one negative—"Running Waters putrefy not"; the other positive—"Motion or stirring" prevents putrefaction, which "asketh rest." The first-known apparatus contrived for artificial aeration, a device to force air through water, was described by Hales in 1755. In contrast, Lind, at about the same time, described a method of dropping water into air. A number of patents on apparatus and processes for odor removal were granted in Great Britain in the first half of the nineteenth century, and in the United States during the second half. Of the latter the most notable were the Leeds and the Hyatt patents of the 1880's: the Leeds method was to force air through or discharge it into water in reservoirs; the Hyatt process covered the induction of air into tubes of water either below or above ground. Vigorous exploitation of the Leeds and the Hyatt systems resulted in their adoption by a few water works as described in Chap. XVI, but sooner or later their use was abandoned. Various types of cascade, jet and other open-air aerators are also described in Chap. XVI. Cascade aerators were used at the Quai des Celestins filters, Paris, in the 1820's or earlier; at the Gorbals water works, Glasgow, Scotland, in the 1850's; and at Little Falls, N.Y., in 1888. A fountain-discharging trough was installed at the Elmira Water Works Co. in 1860–61. Multiple-jet aerators were put into use at Rochester, N.Y., in 1876, and at the Utica, N.Y., Water Works Co., in 1890. There were many others. Pan aerators, with or without coke filling, were used at Winchester, Ky., in 1901 or 1902. A cluster of spray nozzles, controlled automatically by utilizing that portion of the head between the water on the filters and in the clear well was developed by Pirnie and used in 1927 at Providence, R.I., and at Poughkeepsie, N.Y. An induced-air system, known commercially as "Aeromix," was installed at Waukegan, Ill., in January 1929. It bears a family resemblance to the device patented by Hyatt in 1885. Porous tubes or plates for air diffusion, similar to those used in the activated-sludge process of sewage treatment, have been used at a few water works, beginning at Brownsville, Texas, in 1931 (see Chap. XVI).

### *Algae Troubles and Their Control*

Since early in the nineteenth century, city water supplies have been growing in number and size, and there has resulted an increased use of storage for both surface and ground water supplies. As a rule, storage was in open reservoirs, thus exposing the water to sunlight. Underground waters, however satisfactory until brought aboveground, usually contain enough mineral matter to afford abundant food for algae and other odor- and taste-producing organisms when exposed to the light. With surface waters the danger depends largely upon the nature and amount of organic matter on the reservoir bottoms or growing in coves or other shallows along shore. Whatever the origin of the algae, their life- and death-processes may give rise to tastes and odors intolerable to water consumers, and not only intolerable, but producing fear of disease and death.

The earliest known experience with bad tastes and odors in a ground water supply, occurred at Toulouse, France, in the early 1820's and was recorded in detail by D'Aubuisson. Many decades later, at Brookline, Mass., F. F. Forbes, Engineer and Superintendent, and his microscope, had a long struggle with algae in ground water. In both cases exclusion of light from the water stopped the trouble. At Toulouse, an open filter basin infested with algae was converted into a covered filter gallery from which water went to pumps; at Brookline, the storage reservoir was covered to exclude light.

Notorious among instances of algae nuisances arising from surface waters stored in large open reservoirs is the experience of Springfield, Mass., with its Ludlow reservoir. After almost annually recurring plagues, a new supply, also of surface water, but filtered, was introduced. Many other American cities suffered from the algae plague before and after Springfield (see Chap. XVII).

### *Modern Developments in Taste and Odor Control*

Two factors have intensified the need for improvements in water treatment practices related to taste and odor control. The first is the rapid increase in the amount and complexity of industrial wastes coupled with the general indisposition of industry to stabilize the waste material it produces. The rapid growth of the heavy chemical industry, especially in the field of organic chemistry, has resulted in the discharge of a great variety of waste products into the streams of Europe and America, the removal of which, from a water later handled by a purification plant, calls for a high degree of technical skill on the part of the water treatment plant operator.

The second factor responsible for the increase in taste and odor problems is chlorination. No material has contributed so greatly to the production of safe water supplies. Adequate removal of bacterial contamination from water has been achieved by chlorination to a remarkable degree. But with its ability to destroy bacteria, chlorine also tends to form objectionable compounds with organic materials in water and to produce odors which in some instances would not be present if the water had not been chlorinated.

Houston in 1912, was the first to find, during an emergency, that the addition of a large or *super* dose of chlorine could be used to destroy odors as well as to disinfect. The excess chlorine was then removed and a satisfactory water resulted. Not until 14 years later was the process applied on a large and permanent scale by Howard in treating the Toronto supply. This will be discussed later.

*Chloramination.*—Race (1), at Ottawa in 1917, applied ammonia with chlorine with resultant reduction of end tastes. During the early twenties, Harold (2) and Adams (3) in England found that the use of ammonia with chlorine not only corrected the unpalatability but suppressed the production of chlorophenol tastes which by that time had begun to affect many water supplies. Chlorophenols are unstable and highly odorous products derived from the addition of chlorine to water which contains phenols, etc., derived from coke oven wastes.

McAmis (4), at Greenville, Tenn., began the regular application of ammonia with chlorine in 1926 and was soon followed by Spaulding (5) at Springfield, Ill., Ruth (6) at Lancaster, Pa., Harrison (7) at Bay City, Mich., and Lawrence (8) with Braidech (9) at Cleveland. The growth of chloramination was rapid; in 1933, 35 per cent of all treatment to correct odor and taste in the Middle-West involved the addition of ammonia to water.

Later experience has shown that taste in water polluted by industrial wastes derived from coal-tar plants can be controlled by chloramination. Its value is limited when other taste-producing substances are present.

*Superchlorination.*—At Toronto in 1926, Howard (10, 11) began regular superchlorination of the supply. In its earlier form, the process involved the addition of approximately one part per million of chlorine to the water. A contact period of one to one-and-one-half hours was followed by dechlorination with sulfur dioxide. Variations in the dosage used have followed, but at this writing the procedure is essentially the same as it was first developed: high rate chlorination, contact, and then dechlorination. For the treatment at Toronto of water derived from Lake Ontario, the process has been a successful one. Only a few operators adopted superchlorination in the fashion practiced at Toronto. The process requires very careful control or the results will be unsatisfactory. Obviously also the conditions in many waters do not respond to this type of treatment.

In the late thirties, studies of Howard (10), Scott (12) and Gerstein (13) were reviewed by Faber (14) and Griffin (15) and later by Hassler (16). It was ascertained that the primary difficulty of high rate chlorination as previously practiced derived from the failure of the operator to satisfy the chlorine demand of the water completely. It has since been found that if chlorine is added to water to such an extent that practically all of the residual chlorine is "free" instead of "combined" many of the taste-producing substances will be destroyed and the remaining free chlorine does not, in many instances, manifest itself as odor.

This method of adding high doses of chlorine has been called "break-point" chlorination (15) because it was found that, in many supplies, after a certain amount of chlorine had been added, the residual curve "broke" and a lower residual of chlorine ensued. Successive additions of chlorine thereafter resulted in increased residuals. Scott (12) first reported this phenomenon in 1928, but not until more than ten years had passed was its real importance apprehended. Now it is becoming well understood that the significant factor is the complete satisfaction of the chlorine demand of the water and the presence in the finished product of free, rapidly reactive chlorine.

This form of chlorination has been widely applied since 1940 and the process, when better understood and properly applied, gives promise of correcting offensive tastes and odors in many water supplies which have previously not responded satisfactorily to earlier processes.

*Activated Carbon.*—The beginnings of the use of charcoal to improve the taste of water are lost in pre-history. The adaptation of charcoal in the modern form—activated carbon—has been both rapid and spectacular since the late twenties. While Baylis (17, 18) was conducting tests of its use in this country, Sierp (19, 20) in Germany was using activated carbon to remove chlorophenolic tastes in water. The material was used in granular form at the Hamm Water Works in 1929 and independently at Bay City, Mich., by Harrison (7) in 1930. Meanwhile at the Hackensack Water Company plant in 1929, Spalding (21) used powdered activated carbon to remove odors in water caused by wastes from an alcohol denaturing plant. By 1932, 400 plants in the United States were using activated carbon in odor control; and by 1943, nearly 1,200 plants were using it. Much of its popularity as an odor corrective lies in the fact that while the material is dust producing, it is easily applied. If it is added to the water in such a manner as to disperse it thoroughly, it is generally effective. Within limits of cost, it cannot be added to an overdose point. The material is nontoxic and is not a health hazard.

At this writing, the removal of taste and odor from water is the most severe problem facing the treatment plant operator. In extreme cases, reliance is not placed upon a single method or material. The water may be superchlorinated, dechlorinated, its pH adjusted, treated with carbon and even given final treatment after filtration by adding more chlorine. Ammonia may be used either as a phase of pretreatment or at the end of the process in order to form chloramine in the distributed water. No phase of water treatment is being given more intensive study and in no aspect of water supply practice does the consumer maintain a more active interest. Progress is being made and greater progress appears imminent.

This may be said in closing. Too much has been left to the magic touch of the water purification technician. Too little has been done to restrain industries and municipalities in their discharge of untreated wastes and sewage into streams which later must be used as sources of water supply. Water works engineers and chemists have achieved great results in their production of bacteriologically safe water. But there is a limit beyond which they cannot go in removing from waters the odorous materials derived from industrial wastes and municipal sewage. Nothing has so adverse an effect upon the attitude of the water user as a supply which has an offensive odor or taste. He may be told that it is safe but his sense of smell disagrees. Too long have modern cities demanded that water purification correct the evils of unrestrained stream pollution. The time has come for the pollution to be corrected.

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