CHAPTER XX

Iron and Manganese Removal

Considering the widespread use of ground water for centuries and the possibilities of iron and manganese troubles from it and from some surface supplies, it is remarkable that so little attention was given to remedial measures until late in the nineteenth century.

In 1868, Salbach (1) announced that "certain ground waters could be freed from iron by aeration followed by filtration through gravel and sand." Charlottenburg, Germany, in 1874, seems to have been the first city to build an iron-removal plant. Among other German cities that followed suit were Breslau (see below), Dresden, Hamburg, Koenigsburg and Leipzig (2).* Hazen says (3), without giving dates: "Among the earliest plants for the removal of iron were the filters constructed at Amsterdam and The Hague, Holland (3) (see below)."

In the United States, the first iron-removal plants were installed at Atlantic Highlands in 1893 and Asbury Park, N.J., in 1895. Next came Reading, Mass., and Far Rockaway, N.Y., in 1896. Ground water was treated at all those plants. The iron at Asbury Park was in the form of sulfate of the protoxide. There and at Atlantic Highlands the iron was removed by double filtration (sand, then animal charcoal) in rapid Continental filters, without aeration or chemical treatment; but at Asbury Park the compressed air used for air-lift pumps supplied air (4). At Reading, water from a filter gallery contained sulfate of iron; at Keyport, water from artesian wells carried bicarbonate of iron. Each plant used milk of lime, aeration and rapid filtration, in the order named, the filters being of the Warren

* A summary by Goetz of the early history of deferrization in Germany follows: Salbach, at Halle on the Saale, while aerating and filtering water for removal of algae, found that iron was also removed. Anklam, of the Berlin water works, in 1880, showed that aeration and filtration would eliminate iron from the wells being studied, but Lake Tegel was adopted instead. Oesten, in 1886, was refused a patent for aerating water with atmospheric oxygen, followed by filtration; he continued experiments at Berlin in 1888–89 under Koch and Proskauer. In 1890, Piefke erected his first plant for aeration by trickling water down over coke. In 1893, Oesten obtained a patent for aerating water in the form of rain. After 1893 iron-removal developed rapidly, but the methods used were based more or less on those of either Oesten or Piefke. (Notes supplied by Frank Hannan, Toronto, Ont.)

type (5). At Far Rockaway slow sand filtration was employed (6). Seven iron-removal plants in Massachusetts were described in 1931 in a paper by Sterling and Belknap (7). In the illuminating general discussion that followed, Robert Spurr Weston stated that the tendency was toward the upward-flow type of aerator, which saves head and is easily cleaned.

In Canada, only five iron-removal plants were known to be in use in 1942, all recent: Etobicoke Township, London, Newmarket and Simco, Ont.; and Yorkton, Sask. The Etobicoke plant employs zeolite for both softening and iron removal. At London, Newmarket and Yorkton a modified form of the Reisert rapid filter is used.

Great Britain had 30 or more iron-removal plants on public water supplies in 1939, most of which used polarite in Candy rapid filters according to an advertisement in *Water and Water Engineering*, London, October 1939, and reports in *Engineers Handbook and Waterworks Directory*, 1939.

Poland, most of whose city water supplies are drawn from the ground, seems to lead the world in percentage of water works employing iron removal. Statistics furnished for use here in January 1937, by A. Szniolis of Warsaw, showed that of about 170 water works in that country (not including Upper Silesia) about 45 used deferrization, employing "exclusively aeration, open or closed, and filtration."

In French Indo-China at the twin cities of Saigon and Chalon (8), an American driven-well company adapted the German Reisert iron-removal system to local conditions in 1933–35 and subsequently applied it to ground-water supplies at three cities in Canada (9), already named, and on the works of the Jamaica Water Supply Co., Long Island, N.Y., and at Bridgeton, N.J. (10). Ten plants, with a combined capacity of 30 mgd. (Imp.) were built to serve groups of wells at Saigon-Chalon. They combine in a single closed tank: (a) contact aeration by passing water downward and compressed air upward through a layer of broken lava at the top of the tank and (b) filtration in the lower part of the tank. At Jamaica, the filter media are sand and calcite [98 per cent calcium carbonate], 1 to 1, mixed.

Demanganization

Frequently, but not always, both manganese and iron give trouble in the same source of supply. The earliest instance found on record is at Zutphen, Holland, where a pre-aeration and double filtration

plant was completed in 1889. The water was aerated by cascading over a weir. The prefilters were of coarse river sand and the final filters of fine river sand. In 1923, this plant, which had become too small and exposed to possible contamination, was replaced by a larger one, inclosed, which was still in use in February 1940. In the new plant, a spray aerator was used, with fine gravel for the prefilters and sharp sand for the afterfilters. Aeration is designed to remove carbon dioxide and by oxidation change the iron and manganese compounds from a soluble to an insoluble state so they will be removed by filtration (11).

A sudden outburst of manganese and iron trouble at Breslau, Germany, in 1906, gave rise to the term "Breslau calamity." Before that time, wrote Weston (2) in 1914, "when the manganese in the well supply rose suddenly to 220 ppm., little attention was paid."

In the United States, Middleborough, Mass., put into use on September 26, 1913, a plant for removing both iron and manganese. Sprinkling nozzles discharged water upon a coke trickling aerator after which it was passed to a settling basin. Large iron-and-manganese-removal plants were put in use at Lowell and Brookline, Mass., October 16, 1915, and August 20, 1916. The Lowell plant had a capacity of 10 mgd. It included coke prefilters 10 ft. deep, upon which water was sprayed, settling reservoirs, and slow sand filters (12). Providence, R.I., began removing iron and manganese from surface water in August 1931.

In the Central West, plants for removing both iron and manganese were built at Brainerd, Minn., in 1931, and at Lincoln, Neb., in 1935. At the Brainerd plant, water from wells is forced up through finely ground pyrolusite, containing about 70 per cent of manganese dioxide, then sprayed upon a bed of coke, then passed through a filter composed of a layer of fine silica sand resting on crushed sandstone. A description of this plant by Carl Zapffe, Manager of the Iron Ore Properties of the Northern Pacific Railway and President of the Brainerd Water Board (13), contains a review of manganese in water supplies, with 74 source references, divided into five chronological groups: (1) Bacteriological, 1836–1906; (2) Inorganic Chemistry, 1906–14; (3) Physico-chemistry, 1914–22; (4) Catalysis, 1922–30; (5) Present Practice, 1930. The plant at Lincoln, put into use in December 1935, employs aeration, chlorination, upward flow through gravel contact beds, sedimentation and rapid sand filtration (14).

Unique among recent plants which utilize zeolite for softening and manganese removal is one put into use in 1937 by the Edgeworth Water Co. in Pennsylvania. The two objects are effected separately and by different procedures, after which the effluents are mixed and sent to consumers. Ordinary greensand zeolite is used in each case. Manganese is removed by upward filtration, at a rate of 10 to 12 gal. per sq.ft. per min. under a total head of a little over 5 ft. Regeneration is effected by drawing in permanganate of potassium and permitting it to remain in contact several hours while the plant is out of use at night. The regenerated unit can then demanganate for a long time. Softening is effected in another set of zeolite units regenerated with common salt. This removes all the manganese so long as the softener effluent is in the zero zone. When the demanganized water and the softened water are mixed the combination has about 85 ppm. of hardness, is free from manganese and is entirely potable (15).

Latest Summary for the United States

Early in 1941, plants in the United States for the removal of either iron or manganese, or both, totaled 598, located in 36 states. Fifty were combined with softening plants. The majority of the total number were small, as the combined output of the 598 plants was only 220 mgd., giving an average of only 0.37 mgd. By far the largest plants are those which serve Providence, R.I., and Memphis, Tenn., the populations of which in 1940 were 253,000 and 293,000 respectively. The output of the Providence plant averaged 26 mgd., and of the Memphis plant, 20 mgd., compared with rated capacities of 67 mgd. and 40 mgd. Surface water is treated for Providence and artesian well water for Memphis (16).

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CHAPTER XX

Iron and Manganese Removal

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