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Water Softening for Municipalities

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WATER SOFTENING FOR MUNICIPALITIES

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The first municipal water softening plant in the United States was put into operation on December 28, 1903, at Oberlin, Ohio. A plant was in operation in Winnipeg, Canada, at that time, but it was given up because the supply was too small and because of the scale formation in the water works system.

In 1910 I read a paper before the Indiana Sanitary and Water Supply Association, now the Indiana Section of the American Water Works Association, entitled "Water Softening for Municipalities." In that paper I recommended that provision for softening be made when new purification plants were built. I recommended that, wherever possible, in purification plants already installed, steps be taken to reduce the hardness of the water. I stated that it would be difficult because of the expense to consider softening water of undoubted purity from deep wells.

Since that time new plants have been constructed with equipment for water softening. Steps have been taken to soften water treated in purification plants already built, and plants have been constructed for the treatment of hard well water.

Consideration of a few of the modern up-to-date softening plants gives us an idea of the progress since the first water softening plant was put in at Oberlin in 1903, and since my paper was read at the meeting in Indiana in 1910.

The water supply of the city of Columbus, Ohio, described by Charles P. Hoover,[1] shows the possibilities of water softening on a large scale. The original supply from the Scioto river was not safe for drinking purposes. It was badly polluted with sewage, always turbid, the turbidity averaging 75 parts per million, but sometimes during floods carrying as much as 2,250 p.p.m. The bacterial count averaged 5,665 per cu. centimeter. The B coli sometimes reached 100,000 per 100 cc., and in 1908, the typhoid fever death rate reached 138 per 100,000. The original supply was highly mineralized, having an average hardness of 272 p.p.m. and a maximum of 495 p.p.m. It was estimated that there were 68,570 lbs. of hardening constituents in a day's supply. The calcium and

1 Proc. Am. Soc. Civil Engs. 54, 471-84, Feb., 1928.

magnesium salts to which the hardness is due formed deposits in boiler tubes and in hot water heating systems, resulting in large heat losses. They formed slimy insoluble compounds with soap and much soap was wasted when the hard water was being used.

Before the purification plant was built, cistern water was in general use for domestic purposes. These cisterns were hardly ever adequate. The water was almost always dirty and sometimes not even soft. Water from private wells was used for drinking purposes, but many of these were contaminated with sewage. The cisterns and wells have been put out of service by the purification plant.

The Columbus plant was built with facilities for softening as well as filtration. The design was so elastic that the operation processes could be modified in order to obtain the highest degree of efficiency. The plant was put in operation in 1908 and in 20 years of operation is operating as efficiently as many recently built plants, and there have been no extensive or costly additions.

Continuous chemical control is necessary because of the rapid fluctuations in the water of the Scioto River. For example on March 21, 22, and 23 of 1916, the turbidity was 22, 670, and 2,250 p.p.m. respectively; the hardness was 285, 196 and 64. The operator watching these changes varies the amount of chemicals to avoid too much lime, which would give the water a caustic reaction, or too little, which may prevent maximum softening.

To prevent the growth of sand grains in the filters and the formation of scale in the system due to after reactions from the lime, carbon dioxide gas is applied to the softened water, giving it the same pleasant taste of the natural water. There is no evidence to show that removal of salts causing hardness makes the water either more or less healthful.

The lime used in softening kills intestinal and pathogenic bacteria. It increases the efficiency of sedimentation because the large bulky precipitate of calcium carbonate and magnesium hydroxide absorbs fine particles of suspended matter, bacteria, and other impurities, and settles rapidly. The lime softened water is free from objectionable gases such as carbon dioxide and hydrogen sulfide. Iron if present is removed.

Water treated with chemicals is not "doped" as is often reported. In fact there is less mineral matter in the softened water than in raw water. The chemicals added combine with soluble mineral salts present in the water and form insoluble compounds which are removed by sedimentation and filtration.

It is impossible to reduce the hardness to much less than 35 or 40 parts per million without the use of an excessive amount of chemicals. At Columbus it was considered satisfactory to reduce the hardness to 85 parts per million (5 grains per gallon). If a softer water is demanded, other processes should be used.

The treatment of water at Columbus has cost $18.15 per million gallons, or less than 2 cents per thousand gallons. The typhoid fever death rate has been reduced to 1.7 per 100,000 from 138 per 100,000 in 1908 before the filter plant was installed.

The carbon dioxide is made by burning coke in a gas producer, which is a closed furnace with a controlled air supply furnished by a blower. The products of combustion pass from the gas producer to a gas burner, where they are mixed with air and burned to complete combustion under a boiler. The steam produced in this boiler is used to drive the air compressor and blower. The plant is located in the boiler room of the pumping station and the steam produced is connected to the main steam line. A small amount of steam from the main steam line is required for operating the compressor and blower. The air compressor takes its suction from the boiler stack of the producer gas-burning boiler, through a scrubber and drier, and forces the washed gases through diffusers into the water to be carbonated. Making producer gas from coke and burning it under a boiler is a most economical method of producing carbon dioxide gas. The steam generated is useful and it is possible to produce a gas containing as much as 17 to 18 per cent of carbon dioxide, thus requiring an air compressor of only one-fourth the capacity required if coke were burned in an open burner.

In 1923 the plant was enlarged so that it is possible to filter 55 million gallons per day at Columbus in the largest complete water-softening plant in the world.

Several smaller water softening plants have been recently placed in operation. At Oklahoma City, where the water supply is obtained from a river, the water is aerated, treated with alum and lime, and carbonated by gases from the stacks at the boiler plant.

An interesting method of obtaining carbon dioxide is given in a personal letter from M. E. Flentje:

"For carbonation we use stack gases, as you know. Our boilers are equipped to use either natural gas or fuel oil for fuel. Fuel oil gives a larger percentage of CO_2 gas (from 11 to 13 per cent) but contains phenols which give a taste in the water, especially after chlorination, in as low a concentration as 1 part in 90,000,000. In order to get around that we chlorinate the stack gases, when we are burning fuel oil, before the gases pass through a scrubber. The chlorinated phenols are more soluble and are dissolved out. We use from 8 to 16 lbs. of chlorine per day of 24 hrs. for this purpose. The gases are scrubbed, filtered, and forced through the settled water. In our carbonating chambers, we use a pipe with small holes in it. The chamber is baffled in order to have as long a mixing time as possible, baffling having raised the absorption efficiency from 50 to 65 per cent. Our carbonating chamber has only about 5 min. detention, while in most other places, 30 min. detention is allowed. We are burning fuel oil now in our boilers, and so far I haven't had a single taste complaint, showing that pre-chlorination of the gases is a practical method of taste control from this source. The gas entering the water contains from 3 to 5 per cent CO_2 and is pumped at the rate of from 180-200 cu. ft. per minute. Carbonating has kept our filter beds in good shape and free from mud balls.

"In water softening, with conditions similar to ours, it is possible to soften the water at very nearly the same cost as if clarification alone were attempted, due to the clarifying action of the precipitated salts. It is possible to get as clear a settled water as may be desired, at least during the summer months. (This had made me think that it might be possible to speed up the rate of filtration considerably by a proper selection of the filter sand as to effective size, etc.)"

At Springfield, Illinois, a similar process is followed. The water is treated with alum and lime, the sediment settled in Dorr clarifiers, and the clarified water treated with carbon dioxide.

At Decatur, Illinois, the water purification plant has recently been enlarged with provision made for softening. Only lime is used and the hardness is reduced from 12 or 14 grains per gallon to 6 to 8 grains per gallon. No provision has as yet been made for carbonization of the water.

In Iowa, as related by Professor Waterman and Professor Hinman, between 80 and 90 per cent of the water supplies are from wells and no purification plant is needed to remove suspended matter. If an iron removal plant is necessary and filters are used, arrangements could easily be made for the addition of chemicals for softening.

Water softening of well water supplies is not only possible but has been shown to be profitable in at least one case. Mr. H. Menold, Superintendent of the Water Department at Hinsdale, Illinois, presented a paper entitled "Water Softening At Hinsdale, Illinois," at the recent meeting of the Illinois Section of the American Water Works Association. Hinsdale, a city of 8,000 population, located 18 miles west of Chicago, is a prosperous and rapidly growing city. Its water, obtained from deep wells, has a hardness of 480 parts per million. There was much trouble in the homes because of the use of this hard water.

In 1915, a water softening plant was built. It consisted of a reaction tank, settling tanks, and filters. Lime and soda ash were the only chemicals used. Alum treatment was tried but it was not long continued owing to faulty feed mechanism. The softened water was very satisfactory, but troubles developed due to incrustation in pipes, valves and meters. After considering the defects of the old plant and considering the latest developments in the water softening industry, a new plant costing in excess of $100,000 was built and put in operation in September, 1925. This plant was designed for a maximum capacity of three million gallons per day, and was constructed on a unit plan, so that the present plant can be expanded when necessary.

It contains modern equipment, including mixing tanks, dry feed machines for chemicals, a clarifier for continuous removal of sludge, a pump for repumping the sludge, and a carbon dioxide machine.

The raw water carrying a hardness of about 468 and an alkalinity of 375 parts per million is treated with hydrated lime and soda ash. Alum was formerly added but has been replaced by sodium aluminate. The repumped sludge is added and the whole mechanically agitated. The water after clarification is treated with carbon dioxide gas and filtered.

The consulting chemist recommended a finished water having a total hardness of 85 p.p.m., total alkalinity of 85. Some difficulty was experienced at first but by use of sodium aluminate it was possible to reduce the hardness as desired. The use of sodium aluminate resulted in a reduction in cost of chemicals of 4.1 per cent, a marked reduction in the total amount of water used for back-washing of the filters, and a reduction of 21 per cent in the total amount of gas used for carbonation. When alum was used a scale of considerable thickness formed on the walls of the filters and basins. The continued use of sodium aluminate has removed practically all of this scale.

Mr. Menold reports that he hears few complaints from the users and has concluded that for household and drinking purposes he is supplying a finished product that is generally satisfactory. The people are proud of the water softening plant.

After the plant was put in, I personally had a resident of Hinsdale say to me that if they had to go back to the original hard water he would move away from the city.

The railroads have been developing the use of softened water for about thirty years. The chief chemist of the Santa Fe, Mr. Powers, stated that he wished softening if water had a hardness of more than 170 parts per million (10 grains per gallon). At the present time waters are treated which have a hardness of even less than 170 p. p. m. With the development of high pressure boilers and turbines, steam generators, a softened water is necessary. In many plants where the condensate is returned to the boiler, the make-up water is distilled water prepared from zeolite softened water. In other plants lime soda is used to reduce the hardness to 4 or 5 grains per gallon and base exchange or zeolite filters are used to reduce the hardness to as near zero as possible. Water thus treated still contains dissolved solids but there should be no trouble from scale if the plant is properly operated. With the railroads and industries demanding a soft water, it should not be many years before municipalities are making the same demand.

I am informed by Mr. Charles H. Spaulding, the superintendent of the purification plant at Springfield, Illinois, that estimates indicate the saving of about half the soap, the hardness of the water having been reduced 60 per cent. With soap ranging in price from 15 to 40 cents per pound, it does not seem unreasonable to expect a saving of 50 or 75 cents per month per family of five if the washing is done at home, or half as much if the washing is sent out. Since the average domestic water bill is less than 75 cents per month, it seems that in many cases the soap saving would pay the water bill. If such can be shown to be the fact, there should be no reason why the average community should not be willing to pay the additional cost of obtaining a soft water.

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