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**HARDNESS REDUCTION vs. REMOVAL
A CRITICAL EVALUATION**

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Hardness Reduction vs. Removal

A Critical Evaluation

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IT IS universally recognized that municipally softened water is wholeheartedly approved by the consumers where such water is provided. It is a fact that such water can be further improved for specific purposes. But even zero hardness water is not ideal, and other types or forms of treatment are required. The purpose and desirability of providing municipally softened water are economically justified and desirable, just as are the purpose, desirability and even the need for further "polishing up" or "finishing" treatments for specific applications of such water.

The water treatment industry still has much to do in order to provide an acceptable product to the major percentage of the population. Municipal hardness reduction, home service and home owned hardness removal, and synthetic as well as soap detergents are here to stay. No one of these practices will replace another, but all supplement each other in general water treatment. Recognizing this fact, we may orient our thinking on water treatment for the individual by summarizing some data regarding water consumption in the United States and providing particular reference to water treatment in Illinois.

United States

In 1945 there were 15,400 water works plants supplying approximately 94.3 million persons, or about 70 per cent of the 1940 population, with an average of 127 gallons per capita per day. Currently it may be estimated that there are 16,500 plants in the United States.

A census in 1945 also indicated that there were some 665 municipal softening plants supplying 12 million people, or approximately 9 per cent of the total population of 1940. Currently, it has been estimated that some 15 million persons are provided with municipally softened water, or approximately 10 per cent of the 1950 population.

In addition, it has also been estimated that there now are approximately one million privately owned softeners supplying approximately 3.6

million persons, or 2.3 per cent of the total population, and 900,000 soft water services supplying 2.1 per cent of the population. Therefore, if these percentages may be totaled, it would appear that some 14.4 per cent of the population is provided with soft water by treatment; or on the basis that treatment is provided only in hard water areas, 20 per cent of the 112.5 million people living in these areas are provided with soft water treatment.

Illinois

Illinois is classed as a hard water state. A recent publication, Circular No. 31, issued by the Illinois State Water Survey and titled "Mineral Content of Public Groundwater Supplies in Illinois" has shown that 88.7 per cent of these groundwater supplies have a hardness greater than 200 parts per million. (Table I). Only

17 per cent of these are municipally softened. A little less than 50 per cent of the supplies have a hardness greater than 325 ppm., and 22 per cent of these supplies are municipally softened. It is interesting to note that only 24.6 per cent of the 61 supplies which have a hardness greater than 500 ppm. are municipally softened.

No data are available on the extent of softening for surface water supplies. However, with the exception of supplies obtained from Lake Michigan, the median hardness for surface water supplies is approximately 300 ppm.

The extent to which the general public desires clear, soft water is perhaps no better exemplified than by the fact that \$1.35 to \$4.05 per thousand gallons is currently being paid for soft water service on supplies having 200 ppm. and 600 ppm. hardness, respectively. This cost is in addition to the cost of purchase of the particular municipal water of such quality as is provided. These costs for municipal-water range from 35 cents to approximately \$1.50 per thousand gallons and in no case is the water delivered with a hardness less than about 60 ppm.

A questionnaire sent to home service operators in Illinois showed, Fig. 1, that no operator provided service to more than 50 per cent of the population in the city served. Four oper-

Table I
MUNICIPALLY SOFTENED HARD WATER SUPPLIES IN ILLINOIS

Hardness	Percent of 532 Supplies	Percent of These Supplies Softened
201 ppm. or more	88.7	17.0
251 ppm. or more	77.8	17.4
301 ppm. or more	60.2	20.2
326 ppm. or more	48.7	22.4
351 ppm. or more	41.6	22.8
401 ppm. or more	27.0	25.2
501 ppm. or more	11.5	24.6

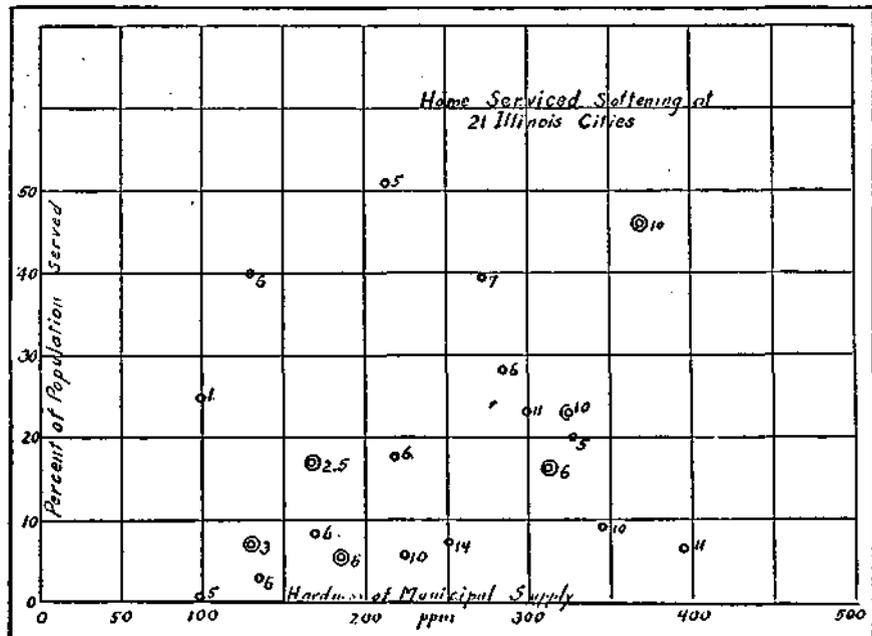


Fig. 1—Wafer softening by home service operators in 21 Illinois cities. Data show no evident relation between hardness and population served.

This paper is a revision of one presented by the author before a meeting of the National Assn. of Water Conditioning Equipment Manufacturers.

ators, after ten years, provide service to less than 10 per cent of the population. The number of years in business are indicated numerically at each point in Fig. 1. The double circles represent operators who have no competition in their community. It appears that it makes little difference whether the hardness of the city supply is 100 or 400 ppm., home serviced softening can be made desirable. No data were available on the funds used for increased capital expenditures and for advertising.

Residential Use

A recent publication by Larson and Hudson of the Illinois State Water Survey staff has provided a detailed analysis of residential water use as compared with family income. These data on 15 Illinois cities of population ranging from 900 to 900,000 show a per capita residential use of 21 to 52 gallons per day for family net buying incomes of \$2,000 to \$7,500 per year respectively.

If complete sanitary facilities were available to the lower income residences, it was estimated that the \$2,000 income residential use would be increased to 37 gallons per capita per day.

No correlations were found between residential use and size of community, water rates, pressure, use of meters, or quantity or quality of the water supply. The hardness of these supplies ranged from 125 to 313 ppm., and the iron content from 0.0 to 0.5 ppm.

These data should be of particular value in the general design of completely soft water service for full line installations as well as for hot water installations, but should be used with great caution for specific individual installations.

The quantity of "completely soft" water provided by 28 day service is shown in Fig. 2 for different family sizes and with different family incomes when provided with waters of specific hardness.

A family of 3 can obtain completely soft water for all its requirements if the city water has a hardness of 100 ppm. If 60 ppm., a family of 5 can so be serviced. A family of 4 can be provided with its soft water requirements only when the hardness is 250 ppm. and only a family of 2 can obtain such service if the hardness is 450 ppm. With 40,000 grains per exchange, the values of hardness in Fig. 2 would be doubled.

Municipal Softening

It would be rather pointless to discuss in detail the cost of providing

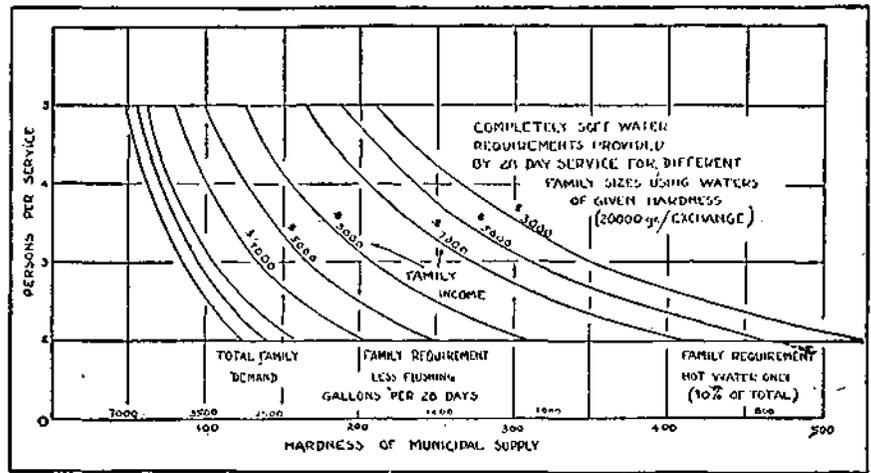


Fig. 2—"Completely soft" water provided by 28-day home service. Hardness of municipal supply related to family size and income.

municipally softened water at this time, since this has very ably been indicated by L. R. Howsoir. Suffice to say that his conclusions state: "Reduction in hardness down to 5 grains per gallon can most economically be made available to the greatest number through softening of the municipal supply, and for those who wish completely softened water, the individual softeners are the best solution." In addition, it might be pointed out that municipally softened water benefits those in the lower income bracket more than those in the middle or high income bracket since the net savings obtained thereby are less frequently supplemented or accomplished by the aid of home softeners.

This is borne out by the fact that a recent survey by one of the soft water service companies has indicated 27 per cent of the services are provided to high income families (6 per cent of the spending units, buying income greater than \$7,000/yr.); 57 per cent of the services are provided to the middle income families (64 per cent of the spending units, buying income \$2,000 to \$7,000/yr.); and 16 per cent of the services are provided to the low income families (30 per cent of the spending units, buying income less than \$2,000/yr.).

Only the misinformed can deny these conclusions and the fact that no water is ideal in quality for every purpose. It is for this reason that there are so many different "finishing" or "polishing up" treatments currently in use by industries, as well as by private consumers, for the many various purposes for which water is used.

It is indeed unfortunate that, discussions on the relative merits of municipal softening and home-owned or home-serviced softening frequently are biased, and thereby prove to be harmful to the proponents of both sides.

A careful analysis of the overlapping factors indicate that each treatment supplements the other for the ultimate benefit of the user. Home softening finishes the job of providing a completely soft water which is started by municipal softening. Municipal softening (hardness reduction, if you please) provides more hardness reduction per householder's dollar than any other method and reduces the hardness to a point where the home-owned and home-service softeners (or hardness removal units) can handle more water for a lesser cost.

A strong educational program is in order to inform the home unit operators whether home-owned or home-serviced, of the very definite advantages of municipal softening. Likewise, an equally strong educational program should be established for the proponents of municipal softening to insure that their discussions indicate municipal softening reduces substantially but does not eliminate hardness.

It should be pointed out that municipal softening not only removes the major proportion of the ingredients which are responsible for hardness in the water supply but also removes color, odor, iron and manganese, all of which are of important nuisance value to the serviced soft water operators and to home owned softeners.

Corrosion Problem

It is entirely impractical to completely soften water on a municipal basis, since its resultant effect on the distribution system and the effect of the system on the quality of the water would thereby both be detrimental. For transportation and distribution municipally softened water can economically be made relatively non-corrosive, which is one thing that cannot at the present time be said for

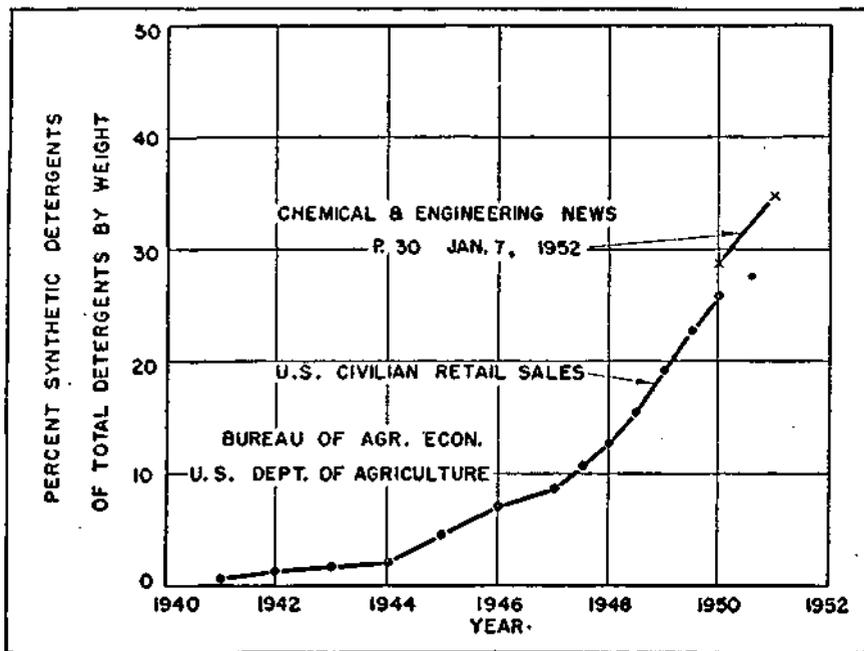


Fig. 3—Rate at which synthetic detergents displace soap.

completely softened water. Municipal water (softened or not) is never made non-corrosive by complete softening. If relatively non-corrosive before complete softening, such treatment may cause the water to become corrosive (or less protective). If corrosive before complete softening, water will become no less corrosive but probably more corrosive (again less protective) by such treatment.

Proper municipal softening" practically eliminates the tendency for water to form scale deposits. These deposits are responsible for burned spots in water heating where direct fire is applied on the opposite side of the metal. Complete softening removes all scale forming tendencies and also renders the water less protective.

Complete softening, therefore, presents a major problem—a problem which water works technicians have wrestled with for over 100 years. The problem has become more acute in recent years with the development and use of small high capacity water heaters. By and large, proper proportioning of hardness, alkalinity and pH offers the best general solution; but specific uses and after treatments frequently can destroy all efforts previously made by the "wholesale" distributor. It is significant that the National Association of Soft Water Service Operators is devoting particular attention to this problem from the standpoint of providing a non-corrosive water to the consumer as a service as well as reducing maintenance and replacement costs on their own equipment.

Soap and Synthetic Detergents

Although the majority of the objectionable constituents have been removed, municipally softened water obviously still leaves something to be desired when used for particular purposes. Additional "polishing up" treatment is advantageously provided for some purposes by use of soap or synthetic detergents with or without the use of serviced or home-owned softeners. By comparison, either soap or synthetic detergents may be of greater advantage for different water qualities and for specific purposes.

Even among the many synthetic

detergents, some are better for specific purposes than others. No synthetic detergent has been found to be an improvement on the use of soap with completely soft water for the purpose of washing cottons and linens. Beauty shop operators are thoroughly sold on completely soft water, regardless of whether the shampoos are made from special soaps or synthetics. On the other hand, synthetic detergents have proven to be of particular value for washing woolsens, nylons, silk, and, to a large extent, dishwashing even in hard water.

A word of caution may be of value at this point. In the study and interpretation of comparative test data on the effectiveness of soaps and synthetic detergents for various uses with various waters, particular attention must be given to the conditions of the test and the methods of evaluation of the results. For example, reliable authorities on detergency have long known that foam height is not a measure of detergency power. In recent years, secondary "experts" are also recognizing this fact and currently many of the consumers are becoming so educated. However, foaming ability is still, altogether too frequently, being cited as the criterion of relative detergency efficiency. The factors involved are so numerous that laboratory tests must be considered as indicative only under specific conditions and then only on the basis of end results on repeated representative washings.

An example of one factor of water composition lies in the alkalinity and

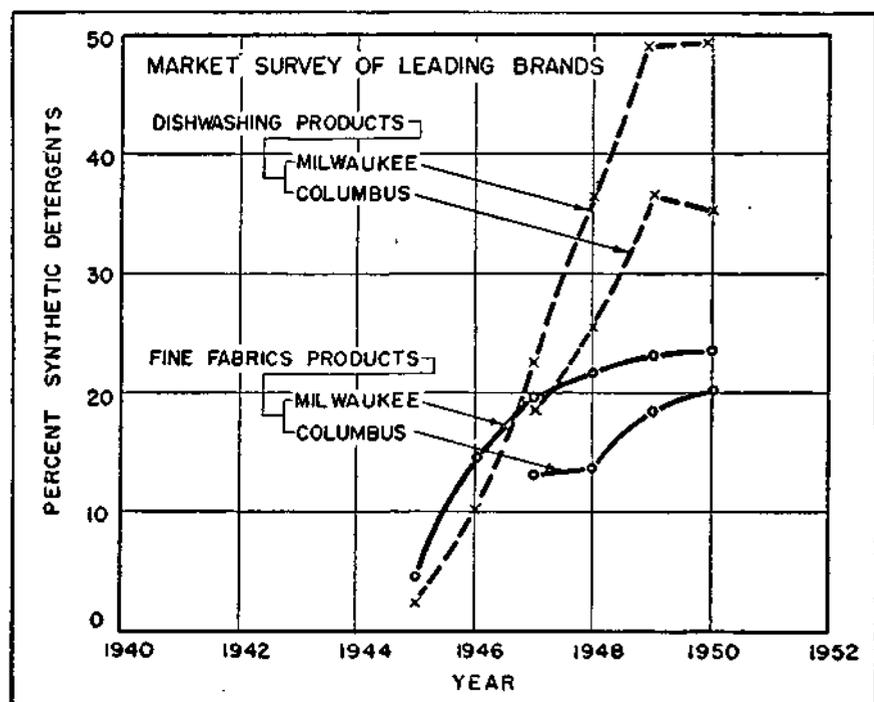


Fig. 4—Rate of household synthetic detergent utilization in two cities.

pH of the water used. It is possible that a superior detergent for water of zero hardness, 50 pptn. alkalinity and pH S.O may not be superior for a water with zero hardness, 300 ppm. alkalinity and pH S.O, and even less so if the latter water had a pH of 7.0. The acidic or neutralizing properties of free CO₂ and of sodium bicarbonate do not appear to be fully recognized in all of the laboratory tests now being reported.

The extent to which synthetic detergents will be further developed for specific applications is difficult to determine, since the industry is still in a growing stage. It is significant, however, that synthetics continue increasingly to displace soap in retail detergent sales. See Fig. 3. In 1951, 35 per cent of the retail sales of detergents on a pound basis were synthetic detergents.

On the other hand, a market survey³ of leading brands of products sold for dishwashing and products

sold for washing fine fabrics in Milwaukee and in Columbus, appears to show that the synthetic market in these two cities. has leveled off. See Fig. 4. However, it would be wise to reserve opinion until at least one more year of confirmatory data has been obtained. As a sidelight, it is interesting to note that 35 per cent of the detergents used for dishwashing in Columbus were synthetics, whereas in Milwaukee (where the hardness is 130 ppm., compared to 85 ppm. in Columbus) 50 per cent of the detergents used for dishwashing were synthetic.

General Futility of Cost Discussions

It would be possible to discuss extensively the many uses and specific treatments for utilizing each of the many possible qualities of water. It is rather pointless to discuss the economics of such treatment from a cost of chemicals standpoint, since the

chemical cost for iron removal, for instance, is often zero and the chemical cost for making distilled water is often zero; and, omitting any consideration of investment in capital equipment and maintenance, the cost of iron removal is practically negligible, whereas the cost of distilled water may be as high as \$90 per thousand gallons. And think of the bonanza of canned drinking water at 15 cents for a 10.5 ounce can—\$1,830 per 1,000 gallons.

The important conclusion that can be drawn from these data is that *Service* and *Quality* of product are the keys to the purse strings controlled by the American housewife.

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