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Waterworks Laboratories

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WATERWORKS LABORATORIES.

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The material which I have put into this paper is a part of the data which I have been gathering for an article on the control of waterworks plants by laboratory methods. The audience which I am considering in the preparation of that paper is one which is interested specifically in the problems and technique of the waterworks plant. Numerical results of operation and quantity weights are naturally of greater interest to them than they are to you. Indeed, the tabulations and deductions which I have to offer to you today are of a rather special interest.

My hope is that my data on the laboratories themselves may not prove uninteresting to you, although they are based almost entirely upon the figures upon a single chart.

To begin with, I sent out a very comprehensive questionnaire to every town in the United States and Canada that had a population of 25,000 or more at the time of the 1910 census. A few additional questionnaires were sent to a number of other towns in adjoining states. These towns were selected on account of the method of water purification employed.

My percentage of replies has been excellent. I have data on an average daily pumpage of more than 3,000 million gallons of water of which more than 2,800 million gallons, supplying a population of nearly 17 million people, on the basis of the 1910 report, is protected by laboratories directly under the control of the waterworks officials or their superior officers. Plants which are more or less completely controlled by contract chemists or special arrangements with local concerns or institutions are, for the time being, omitted.

In the control of the 90 plants which supply the 2,800 million gallons of water daily, 195 laboratory workers are employed. Of these, 91 have the title of chemist or assistant chemist. Many of the others have the title superintendent of filtration or laboratory director, and so on. Some of these men I know have had chemical training. Some are engineers who have picked up the rudiments of water examination and carry on such determinations as are necessary for their plants. The preponderance of one-man laboratories is significant and the variety of

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the work which must be performed is worthy of notice. In addition to the widely differing subjects of bacteriology, microbiology and chemistry of water, miscellaneous chemical and bacteriological work must be entered into. If the laboratory man is also an engineer, so much the better.

I was surprised on first preparing my chart to see how recently the laboratories listed had been installed. Beginning with the one maintained by the city of New York since 1897 and that of Utica, New York, established in the same year, we have a rapidly increasing number of laboratories established during the succeeding nineteen years. Six plants with a combined average pumpage of 32.5 millions gallons per day are now installing laboratories.

Twelve plants with a combined pumpage of 45 million gallons per day have daily examinations made at outside laboratories. The Metropolitan Water District which supplies Boston and some neighboring communities is a State Commission. It maintains its own laboratory and supplies a little more than 100 millions of gallons of water daily.

Of the plants reporting twenty-one are owned privately, sixty-eight municipally and one by the United States Government. The employees of twenty-eight of the municipally owned plants and those of the Government plant are selected by civil service methods.

Rivers and streams form the direct source of sixty-two plants out of the ninety that have their own laboratories, the remaining sources are lakes, impounded waters from more or less satisfactorily protected watersheds and in a few instances wells and infiltration galleries. Those plants which do not maintain laboratories are nearly all using the water of wells, or impounding reservoirs. None of them supplies more than an average pumpage of 16 million gallons per day. One or two pump direct from streams without treatment.

Artesian waters and the waters of great impounding reservoirs are to be expected to be of uniform composition and quite constant in their bacterial contents. Occasional growth of algae may require copper treatment to avoid odors and tastes, but otherwise the water should be very uniform. Rivers, small reservoirs and lakes and shallow wells are very likely to be inconstant. Raw water from such sources is subject to very sudden alteration with consequent need for an immediate readjustment of the treatment. In small plants and those using water from unchanging sources laboratory control has, for the most part received little attention. Reliance has been placed upon the examinations made by the state laboratories at irregular intervals. For constant supplies this will probably continue to be sufficient. But plants of all sizes which treat the water of rivers and the other variable waters will have increasing difficulty in keeping the water supplied for their consumers satisfactory according to the accepted standards of efficiency.

That these standards are constantly becoming more rigid can

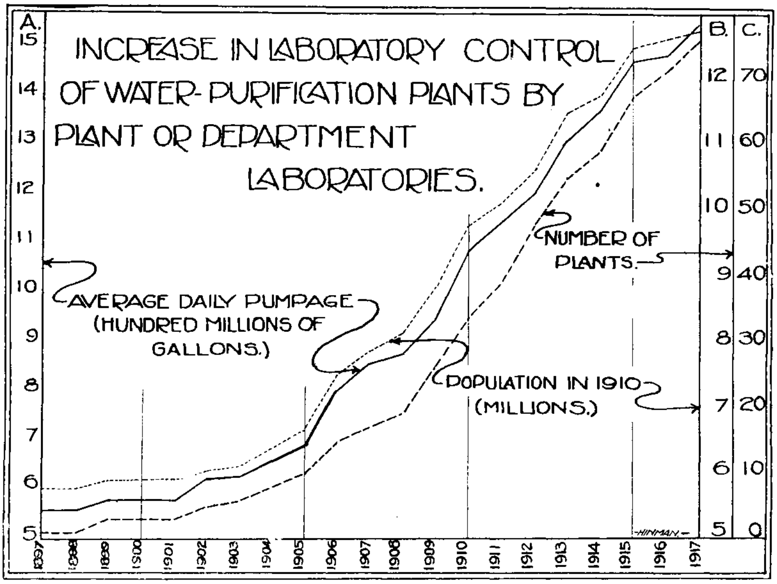

FIGURE 99

easily be shown. To be sure, when bacterial standards came into vogue, the old arbitrary standard of 100 bacteria per cc. was almost universally used for all supplies, treated and untreated. Then it became customary to set a certain per cent removal of bacteria when treating water. Then it was said that in addition, the colon bacillus should be constantly absent in one cc. of the treated water. A few years ago the Treasury Department issued a bacterial standard for water supplied to passengers in interstate traffic. The standard which was adopted —not by the unanimous consent of the committee appointed to draft the standard—is now regarded as a very rigid one. The

Department held that inasmuch as the quantity of water required by the passengers is small the railroad companies could afford to furnish a better water than a city water plant. As a matter of fact the Treasury Department Standard is rapidly becoming the working standard of the waterworks operators in this country. In effect it requires a maximum count of 100 bacteria per cc. on agar at 37° and not more than one positive tube out of five ten cc. plantings into lactose broth for the colon group. Acid colonies on Litmus lactose agar of typical colonies on Endo's medium are given as authorized confirmatory tests for the colon bacillus. Of the ninety plants listed in the chart fourteen already claim this standard for the water they supply. Many of the others use a standard differing only slightly.

The percentage standard of plant efficiency is not satisfactory because as the raw water becomes higher in bacteria the number of bacteria in a water which is up to the standard, may become very large. For instance 99 per cent efficiency at one time during the past winter (1916-17) when the raw water of our local plant showed 880,000 bacteria per cc. would have allowed a bacterial count of 8,800. Wohlman has recently proposed a standard based upon the ratio of the logarithms of the numbers of bacteria in the raw and treated water. It requires higher bacterial-removal efficiency.

There are very few plants in my list which are content to work merely with a view to the removal of the turbidity and color. It is very necessary, especially in connection with the chlorination treatment, to have as much as possible of the color and turbidity removed, but that is not the aim of the water treatment. The waterworks superintendent who "didn't believes in these here bacteria, anyway" is almost extinct.

A glance at the table will show you that in spite of the excellent work which has been done in the preparation of our Standard Methods of Water Analysis, the bacteriological procedure of the water plants is far from uniform. This is due in part to the changes recommended in the 2d Edition of the Standard Methods. It was recommended that the bacterial counts be made on agar at 37°, dropping the gelatine count at 20°. In view of the great amount of work which had already been done on gelatine, this was objected to quite strenuously and gelatine has been officially reinstated in the 3d Edition which has just come from the press. The Confirmatory tests for *B. coli* have been confused. The new Edition of the Standard Methods provides a uniform scheme which will doubtless be extensively followed.

Chemical standards based upon the ordinary factors of a sanitary analysis often mean very little when applied to a treated water in routine examination. This is due to the fact that there is usually very little oxidation in passing through a filter and a purified water will still show evidence of its former pollution and unsafe condition. With a stored water there is greater oxidation and therefore the individual determinations of the sanitary analysis probably mean more. There are a number of papers which have been written upon the amount of useless work which has been done on the routine water samples from a single plant. In connection with the operation of the plant a very few factors are usually sufficient. Alkalinity is probably of the greatest importance because it sets a limit upon the amount of alum or iron sulphate which can be added to a water. Free carbon dioxide is especially important in iron removal plants. An iron determination can show at once whether the iron is being removed. Where waters are softened the total hardness, erythrosine or methyl orange and phenolphthalein alkalinities, magnesium, etc., may be determined advantageously every day. Most of us, however, run a few thousand nitrite and nitrate determinations on the product of a water plant before we realize that the numerical variation throughout the year is too small to give important information from day to day.

It is understood, of course, that the really important factor is the bacterial data which on account of cultural methods must of necessity be one or two days behind at all times. In work with a treated water the chemical substances present which are determined in a sanitary analysis usually are of little importance. It may be, however, that bog water and the colored water of the early spring may contain some toxic substances. Occasionally the plumbosolvency of a water will be important in soft water districts. A weekly or monthly sanitary water analysis in the complete form ought to satisfy any demands. Quarterly minerals analyses ought to meet industrial conditions as a rule.

LABORATORIES FOR THE STATE BOARD OF HEALTH,
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