RELATION OF PUBLIC WATER SUPPLIES AND SEWERAGE TO PUBLIC HEALTH

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Public water supplies of one sort or another are of great antiquity, and the most notable examples of the early public water supplies are those built by the Romans, the most notable feature of which were high and beautiful stone aqueducts for crossing valleys. The aqueducts were necessary in those days because suitable piping had not been devised. The remains of these aqueducts cannot but excite admiration for the engineering courage of those days. During the middle ages public water supplies practically ceased to exist, and even the purpose of the Roman acqueducts was forgotten. In the sixteenth century, however, public water supplies were installed in London and Paris, but the distribution systems were limited, and the water was not delivered to houses.

Practically no advance was made until the early part of the nineteenth century, when the introduction of cast iron pipe, and the development of pumping machinery made possible the public water supply as we now understand it. Even so, during the early part of the century, progress was very slow, and in 1850 there were but 83 public water supplies in the United States. Beginning about 1870 water works were installed in rapidly increasing numbers. The Manual of American Waterworks for 1896 shows a total of about 3200 water supplies, and a recently published Waterworks Directory indicates that there were in 1914 over 5,000 public water supplies. We are now beginning to accept the viewpoint that no municipality is too small to have a public water works.

Notwithstanding the fact that even in ancient times there was an appreciation of danger to the public health from the use of impure water, this danger was generally disregarded until very recent times. As late as 1905 or 1906 most public water supplies, instead of being a protection to public health, constituted an exceedingly great menace to public health. Water supplies were installed primarily for fire protection and general convenience, and not as a means for securing a pure drinking water. Generally an adequate quantity for large cities

could be more cheaply and readily obtained from rivers than from the ground by means of wells or springs, or from carefully guarded watersheds, and as the health danger was little appreciated, river water was generally used.

The first effort at treating a water for purification purposes was made in London in about 1830, when some sand filters were installed which were not very different in design from some of our modern plants. The object of these filters, however, was primarily to remove the visible turbidity, and little thought was given to the possibility of removing disease germs. However, it was a matter of observation that the filtration of the water improved the public health and this gave an impetus to the further use of purification works. In the 70's, following the clear enunciation of the germ theory of disease by Pasteur, there developed an appreciation of why filters produced an improvement in health conditions, and methods were developed, principally by Frankland, for examining the bacterial efficiency of water purification works.

Even so, progress lagged discouragingly behind knowledge and it required the frightful epidemic of Asiatic cholera in Hamburg in 1892 to thoroughly awaken the world to the dangers of impure public water supplies, and to give an object lesson in the difference between filtered and unfiltered water. The epidemic at Hamburg is an oft-repeated story, and while the lesson of the epidemic has been retold by many other epidemics, yet the magnitude, the dramatic character, and its influence upon water works practice and public health activity, renders it pardonable to again repeat the main facts.

Hamburg adjoins Altona. Hamburg obtained at that time its water supply from the Elbe River, and delivered it to the consumers without purification. Altona also obtained its water supply from the Elbe River, but the water was passed through slow sand filters before being delivered to the consumers. In some way the river water became heavily infected with the organisms of Asiatic cholera. An epidemic broke out in Hamburg involving within a period of two months 16,800 cases, and 8,600 deaths. In Altona there were approximately 500 cases and 300 deaths, most of which gave a history of having used water in Hamburg. As a bit of confirmatory evidence of the effect of the public water supply, there was a block of

buildings in Hamburg housing 400 people, and supplied with water from Altona. These people were exempt from the disease. As in the case of all communicable diseases, its ravages were not confined to Hamburg, but tongues of the outbreak shot out to other places and even reached the port of New York.

Stimulated by the example of the Hamburg epidemic, there developed a movement in the United States for better water supplies, and it also caused certain legislatures, notably that of Ohio, to empower state boards of health with authority to supervise the installation of water supplies with a view to protecting the public health.

The early filtration works were of the so-called slow sand type, and were extensive in area, costly to build, and not readily adaptable to the treatment of very turbid waters. American ingenuity came to the rescue of this situation in the early 80's by the invention of the so-called rapid sand filter, assisted by preliminary chemical coagulation. These filters were able to give good results when operated at rates approximately forty times as great as rates permissible with the slow sand filters. Because of their small size, it was practicable to introduce means for flushing the filters, thereby thoroughly cleaning the sand at frequent intervals.

At first these filters were regarded with skepticism by engineers, but a series of experiments in Louisville, Kentucky, in 1897, conducted by Fuller, showed that when correctly designed, they could produce results equal to those obtainable with slow sand filters, and moreover they could handle waters of very high turbidity. Rapid sand filters were thus firmly established as an acceptable and satisfactory means for the treatment of municipal water supplies.

Following the Louisville experiments numerous filtration plants were installed in various cities of the United States, all of which, unfortunately, were not efficiently designed, or efficiently operated. Even the poorest, however, unquestionably constituted a great protection to the public health, and assisted in the growing movement for purified water supplies. It is but proper that acknowledgment be made to the various filter companies that built and installed these filters for much

educative work incident to their promotional activities, and it is perhaps pardonable that sometimes their zealousness in making sales warped their better engineering judgment.

As the basic patents on rapid sand filters expired, rapid sand filters were built more and more according to the designs of technically trained engineers, and we find the best examples of filter practice among filter plants installed in this way.

As an indication of the rapid progress in the purification of the public water supplies in this country, it may be stated that in 1892 not over 500,000 people in the United States were supplied with filtered water and most of the filters were of very questionable efficiency. According to figures compiled by Johnson, about 2,000,000 people in the United States were supplied with filtered water in 1900. At the present time approximately 20,000,000 people are supplied with filtered water, and these plants built since the earlier period show a marked improvement in both design and operation.

Striking as the above figures are, they do not tell the whole story of progress towards securing pure water supplies, because many cities have abandoned impure supplies in favor of supplies naturally pure, and others have protected existing supplies by storage and watershed patrol and diversion of sewage in a manner to adequately protect their purity.

In the year 1906, a hitherto unused means for protecting the purity of water supplies was developed, namely sterilization by means of hypochlorites. It was found that a very high bacterial reduction in a water could be obtained by the application of six to twelve pounds of hypochlorite of normal strength to a million gallons of water. The means for applying the hypochlorite are very simple and so there became available a method for treating any water supply so as to render it at least safe at a trifling expense. Soon afterward chlorine gas was used for sterilizing water, with effects equal to those obtained by means of liquid chlorine. Chlorine did not come into general use, or threaten to displace hypochlorite until within the past few years, because only recently have reliable and effective means been devised for applying the chlorine gas to the water. The use of chlorine is now generally regarded as more satis-

factory than the use of hypochlorites, and with present war prices for chemicals, it is considerably cheaper than treatment with hypochlorites.

The use of cheap sterilizing agents has not, as was at one time feared, displaced filtration as a means of water purification for several reasons. First, the public having been educated to the superiority and ready availability by means of filtration of a clear and limpid water, now as a rule demands that such water be furnished, and in fact, muddiness has been as great a friend to water supply improvement as has the fear of disease. In the second place, sterilization with chlorine and hypochlorites has its limitations in that it usually imparts a taste and odor to the water to which it is applied, especially when large quantities must be used to counteract the effect of heavy pollution, much organic matter, and high turbidity.

It is therefore becoming the custom in connection with all public water supplies where turbidity and color must be removed, to place the main reliance upon filtration, and to use a sterilizing agent as an auxiliary or finishing treatment, and as an additional factor of safety.

The real test of the effect of purified water supplies on the public health is to be found in its influence upon communicable diseases that may be water-borne. The most important of these diseases in the United States at the present time is typhoid fever. Because of the relative hardiness of the organism of typhoid, this disease has not been so easy to eliminate from the country as cholera.

In a survey of vital statistics relating to typhoid fever in the United States, Johnson has shown that in 1900 the typhoid fever death rate in the registration cities of the United States was 36 per 100,000. In 1915, the typhoid fever death rate in registration cities was 15. Thus there has been a reduction of 58 per cent. This remarkable reduction is believed to be due entirely to improvements in public water supplies, because these cities that have always had a pure water supply show only a slight decrease in the typhoid fever death rate.

We see better the real effect of the improvement in the public water supplies by considering individual cities. In Philadelphia the typhoid death rate before the installation of

filters was approximately 50 per 100,000. At the present time it is about 13 per 100,000. In Cincinnati the typhoid death rate before the installation of filters was about 50 per 100,000, and at the present time it is approximately 8 per 100,000. Many other instances could be cited, but the limitations of this paper will not permit.

With present knowledge regarding the influence of public water supplies on the public health, and the methods whereby water supplies may be purified, the maintenance of an impure public water supply can be due only to ignorance and negligence. Unfortunately there are a number of communities, principally of small size, which exhibit either this ignorance or negligence. There are 20 such cities in the state of Illinois, When it is considered that an impure public water supply not only affects the citizens of the community in which the supply exists, but also affects visitors to that town, and causes the town to become a focus of infection throughout a wide area, it is perfectly plain that the state at large has an interest in the matter, and that state boards of health should have ample power to demand that no public water supply be installed unless it is obtained from a source of assured good quality, and that any existing public water supply that does not measure up to modern sanitary standards, should be purified or replaced by a supply of naturally good quality. This power exists in most states east of Illinois, and in many west of Illinois, but has not been specifically granted in Illinois. The public of the country is now fully educated to the desirability of such regulation and there is no reason why it should longer be withheld.

Sewerage systems seem to have quite as great an antiquity as waterworks, as evidenced by the world-famous Cloaca Maxima of Rome and the supposed tile pipe sewers recently discovered on the Island of Crete, which were used by a pre-Grecian civilization. These earlier sewers very nearly approximate in their character and purpose the modern sewerage system. But like water works, the sewerage system as we understand it in modern times, is a relatively recent development very closely paralleling the development of public water supplies. In fact both from the sanitary and utilitarian point of view a sewerage system should be regarded as a concomitant part of a waterworks system, and vice versa, a waterworks

system should be regarded as a concomitant part of a sewerage system, for the reason that neither of these utilities can be properly operated or give satisfactory service without the other.

The prime object and advantage of a sewerage system from a sanitary point of view is to quickly, inoffensively and effectively remove human wastes, thereby preventing them from constituting a nuisance or endangering public health. Notwithstanding the fact that the best of engineering ability has been devoted to the perfection of sewerage design and construction, and that it is now possible to design and build such systems that are economical, good in operation, and an absolute guarantee against danger to public health, insofar as such works can affect the public health, yet in our practices, especially in the rural communities and smaller cities, we are little further advanced than the most primitive savages.

Many efforts have been made to show by statistics the effect of a sewerage system on public health, but these efforts have not generally been successful, because it has not been possible to separate the influence of the sewerage system from other influences, and moreover it is very rare that full advantage is taken of the presence of a sewerage system by compeling the use of the system by all property owners, wherever the sewers are available. In many instances, also, the sewerage system is not sufficiently extensive to permit full advantage being taken thereof. However, it is possible to observe tendencies, even though an exact numerical value cannot be placed upon such tendencies, and there seems to be no room to doubt that a properly designed and properly operated sewerage system has a very great value in protecting the public health.

On the basis of extensive observations throughout the United States, the United States Public Health Service has reached the conclusion that in cities where the public water supply may be regarded as safe, the installation of a complete sewerage system will reduce the typhoid fever death rate in northern cities to ten or under, per hundred thousand, and in southern cities the reduction will be to twenty or less per hundred thousand.

The principal evil growing out of the extensive installation of modern sewerage systems is the pollution of streams. Many streams in the United States have been so grossly polluted as to be fit for no other purpose than as a receptacle and an open drain for putrefying wastes. This situation is due entirely to the fact that benefit from the installation of adequate sewage treatment works accrues to the down stream neighbors of a community using the sewerage rather than to the community itself. Once in a while a city may modify its method of sewage disposal in order to prevent polluting its own water supply, and befouling its own water front; but rarely does a city of its own volition do anything to protect the water supply or the water front of its neighbors.

It would therefore appear very clearly that the matter of sewage disposal, has an inter-community relation, and by virtue of this fact, becomes a matter that should be regulated by the state, or in the case of interstate streams, by the nation.

By way of summary it may be said that with a pure public water supply serving all of the people in a given community to the exclusion of private supplies less pure, and with a complete sanitary sewerage works serving all the people and used to the conclusion of human waste disposal methods less efficient, typhoid fever will be virtually wiped out, and other communicable diseases of an intestinal character will be reduced in like proportion. Complete extermination of these diseases may be expected when food supplies, more particularly milk, are under absolute sanitary regulation, and when persons harboring the germs of this disease, may be properly controlled.