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THE SEWERAGE OF VILLAGE-CITIES.

An Address delivered before the American Social Science Association.

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Chairman of the Health Department of the Association.

I PROPOSE to consider the subject of the sanitary drainage of the smaller towns, which, whether they have city charters or not, are, in their physical characteristics, more like villages than like the larger cities.

It seems to me that the difference of conditions between large and small towns, so far as relates to the removal of their waste matters, has not been sufficiently considered in arranging plans for their drainage; our best drainage engineers have gained their experience and have formulated their practice in connection with works in large, populous, and prosperous towns, where much of the area is covered with buildings and with pavements, where the frontage of private property is short, and where the cost of extensive works may easily be borne. When such engineers are appealed to to furnish plans for the sewerage of the smaller places now under consideration, they quite naturally apply to the work the skill, experience, and judgment which they have acquired in their larger practice. As a result, the projects for the sewerage of these country towns are either not carried out because of the great expense that the work would entail, or, among other disadvantages, they are carried out at a cost which leads to the long-continued embarrassment of the community.

All things considered, it is safe to say that the question of the expense of such sewerage operations is of hardly less consequence than that of their sanitary efficiency. It is extremely important, not only that the work be well and properly done, but also that it be done in such a manner as to interfere as little as possible with the financial prosperity of the community. Inordinate outlay in one direction implies curtailed outlay in others. Sewers which are so costly as to embarrass the municipal government entail a restriction of necessary ex-

penses in other directions which have a more or less direct influence upon other aspects of the sanitary question.

In order to judge what is the best course to be pursued in arranging for the drainage of a town of limited population, limited wealth, and relatively large area, it is important to consider carefully the different offices which sewers are intended to perform, and the relative importance of these offices.

Public drainage works generally have for their object the removal of storm-water, of excessive soil-moisture, and of foul liquid wastes proceeding from private houses and from factories, slaughter-houses, etc.

It is no part of my present purpose to discuss the question as to the relations of these different elements of work in a large city. In considering the case of a small town, their relative importance covers the very basis of all our calculations. Certainly, no town, with wide, unpaved streets, with considerable land about most of its houses, and with a population of limited wealth, would think of constructing an expensive system of large sewers for the sake of getting rid of the storm-water which falls upon its surface. Such storm-water often produces inconvenience, and on rare occasions it does damage to public and private property; but, so far as my observation goes, there is not a small town in the country where this inconvenience might not be avoided, and this occasional injury remedied, for very much less than the interest upon the original cost of a comprehensive system of large sewers.

Sewers which are made of brick, or of pipes with imperfectly cemented joints, serve an excellent office as a means for the outlet of soil-moisture. That is, they make excellent under-drains. Occasionally, but not always, while they serve as under-drains in wet weather, they leak out contaminating sewage into the soil in dry weather, and they lose water which is needed to carry foul solids to the outlet. Considered with reference to their action in removing soil-moisture, they are extremely costly. The work which they perform in this way might be secured for an infinitely smaller outlay by an independent system of soil-drains. Then, too, in many cases, if not in the majority of cases, the soil is naturally of such a character as to render their action in this regard unnecessary. In these instances the *constant* effect of their porosity or leakage would be an injurious one.

Of the three offices of a system of sewers, the removal of domestic and manufacturing waste is not only by far the most important consideration, but it is, in many small communities, the only one which

is worthy of a moment's consideration. A town of twenty thousand inhabitants does not undertake the construction of a system of sewers to get rid of its rain-water or to get rid of its soil-water, but because it finds itself harassed on every side by the accumulation of foul organic matters, whose decomposition produces an immediately deleterious effect upon the health of the population, and a shameful and annoying nuisance. I shall assume, for the purposes of this discussion, that this latter consideration is the *only* one which need enter into the argument; that it is simply a question of removing household waste, the outflow of factories, chemical works, dye-houses, etc., and all other liquid or semi-liquid matters of which the organic constituents may undergo offensive and dangerous decomposition if retained within the limits of the town, — and a question of the efficiency and economy of doing this by the use of storm-water sewers or of small sewers.

In my studies and observations on this subject I have been very slow to withdraw from the conviction, universal some years ago, and still adhered to by many among the more experienced men of the profession, that the most efficient drainage of a town is to be secured by the use of sewers constructed and arranged to receive all or nearly all of the rainfall. While I do not, even now, altogether abandon this conviction with reference to all large cities, I believe that I have sound reasons for the faith to which I have slowly come: that in the case of the smaller towns the separate removal of the foul drainage only is as much better than the former practice as it is cheaper. I will take, as an illustration of my meaning, the case of a town in New England with a population of about twenty thousand, for which a plan has recently been prepared that contemplates the admission of storm-water to the sewers. The arguments used by the engineer in his report to the authorities are based upon a comprehensive review of the best that has been written on that side of the subject. His smaller branch sewers, even those extending into short streets with very few houses, are twelve inches in diameter. The collecting sewers are considerably larger, and the main outlet, which is of great length, is five feet in diameter. It is not necessary to consider in this connection the utility and importance of the larger sewers, but the arguments concerning the twelve-inch pipes are instructive. With reference to the cleansing capacity of the flow and the calculations of grade and size, we are repeatedly told that the assumed velocity, upon which thorough flushing must depend, is based upon an amount of discharge that will cause the sewer to run *half full.*

The rate given is three feet per second. Now a twelve-inch sewer, running half full and having a fall of one in three hundred (needed for a velocity of three feet per second), would discharge nearly half a million gallons per day. I assume that the outflow of the average of houses in such towns does not exceed thirty-three and one third gallons per day per head of population. It would therefore require a population of about sixteen thousand to fill, half full, a sewer of this size, and lying on this inclination, supposing the flow to be uniform day and night. If we assume that one quarter of the daily flow is discharged in three hours, — between eight and eleven in the morning, — the sewage of about eight thousand persons using such a quantity of water would fill the sewer half full at least once a day, and this would suffice for flushing purposes. Eight thousand persons would probably occupy over sixteen hundred houses, and, theoretically, it would require this number of houses to furnish sewage enough to keep the twelve-inch pipe in good condition. As in the case in hand, there is probably no instance where a population of five hundred is to be served by a twelve-inch pipe, we must assume that it was contemplated to depend entirely upon the rainfall to keep the minor sewers properly flushed. Did rain fall in sufficient quantity and at sufficiently frequent intervals to secure this result, this part of the difficulty would be overcome. But often many weeks elapse during which no storm-water whatever enters the sewers. This is, too, generally at the season when decomposition is the most active, and when its effect upon the atmosphere is the most injurious.

It is very well understood that sewage matters, if removed within twelve or even twenty-four hours after production, generate little, if any, injurious gas, and that if they lie longer than this they become increasingly dangerous and offensive. Therefore, in the present example, the sewers being all of a size which the household flow is by no means adequate to cleanse, and the rain-water cleansing being very intermittent, we should have, practically, throughout nearly the whole year, an accumulation of decomposing organic matter within the sewers, which every consideration should lead us to avoid.

Furthermore, the admission of surface-water from ill kept or from unpaved streets results in the carrying into the sewers of heavy earthy matters which the ordinary flow is incapable of moving forward to the outlet, and these are largely intermixed with horse-droppings and with other organic matters, which, so far as they remain within the sewers, cannot fail to be subject to the gravest objection. Whether or not the difficulty increases as we pass from the smaller

sewers to the larger ones will depend very much upon the gradient or inclination of these latter. If they are steep enough for an active current, most of the foul substances which they receive may be carried forward to the outlet though the flow be only a few inches in depth. If, as is very often the case, the land through which they pass is nearly level, and their gradient is very slight, they accumulate rubbish more and more until it becomes necessary to cleanse them by hand or by the use of mechanical appliances. During the whole time that this foul matter lies in the branch sewer or in the main it is necessarily undergoing decomposition. It is producing the condition which has given to ordinary city sewers the frequent appellation of "elongated cesspools." I believe that this condition is inevitably inherent in the character of all large sewers which are not furnished with such means of thorough flushing as will be adequate to sweep them entirely clean, from end to end, — and at intervals not longer than twenty-four hours, — of all earthy or organic matters which may have gained access to them. I believe that such sewers as are ordinarily used in large cities are, for the reasons stated, extremely objectionable, and that they can be made satisfactory only by the general introduction of the most copious flushing appliances, — with a completeness which has never been adopted, and which probably has never been contemplated, in this country.

I believe that for the smaller towns, such as we are now considering, storm-water sewers are not only inadequate to the work for which they are chiefly designed, but are absolutely injurious, — to such a degree that it sometimes becomes a serious question whether they do not do more harm than good. In other words, I believe, not only that these large unflushed sewers, when applied to the uses of scattered communities, are extravagant in cost, but that the injury which they are capable of working may far outweigh any advantage that they may secure. They remove, without injury to public and private works, the water of heavy rains, and so they do good. But, on the other hand, they do not remove, they only conceal from sight and store up in a most dangerous condition, foul matters which had much better be left to decompose on the surface of the ground in full exposure to sun and air. Better the absolute stink of dirty streets than the dangerous gases arising from unventilated accumulations of rotting filth.

So far as the removal of storm-water is concerned, nothing more need be said in this connection than has already been said, — It costs more than it comes to. I know of no instance, even where

the grades are steep and the soil subject to wash, where the injury done by the heaviest storms bears any proportion to the interest on the cost of such gigantic engineering works. In the cities of Albany and Troy (N. Y.) there were no sewers — arranged to take surface-water — until about the year 1854. Both of these cities have very steep grades descending to nearly level land. At no time was there serious inconvenience from storm-water, — which passed off over the surface without notable injury to public or private property.

Regarding these large sewers as out of the question for our purpose, I venture now to suggest what seems to me a satisfactory substitute for them.

I begin with the idea that the most costly and the most dangerous scavenger that a city can employ is the rain that falls upon the surface of its streets. Under proper municipal control the organic matter deposited in the streets may easily be confined almost entirely to the droppings of horses, and this material has a value which will go a long way towards paying the cost of its immediate collection and removal. Even were this not the case, the necessity for performing such work regularly and systematically, with a view to the preservation of the purity of the atmosphere of the town, needs no argument.

There are exceptional cases, where the surface flow of the streets, accumulating in valleys, may require some special means for its removal. But even here it will often be cheapest and safest to arrange the surface conformation and the pavement of the necessary street surfaces so as to secure its removal above ground. It may occasionally be necessary to construct underground sewers for its secure discharge.

These exceptional cases do not, of course, affect the main argument. So far as the sewers themselves are concerned, which it is proposed to furnish to a town of the class under consideration, we have *only* the sanitary question to regard. Our aim should be to collect all foul outflow from private houses and other establishments, in the most direct and immediate way, and to carry it, within the shortest time possible, to its final point of disposal beyond the limits of the town. The sewers should be adjusted to this work, and to no other ; and every pipe of the whole system should be swept entirely clean, at least once a day, leaving nothing to decompose and contaminate the confined atmosphere within it, except such matters as may attach themselves, as slime, to the walls of the pipes; and the amount even of this sliming should be as much as possible reduced.

These ends are to be secured by making absolutely tight sewers of sizes proportionate to the service which they are to perform; by giving these, so far as practicable, a uniform descent; by gathering the branch sewers into collecting drains and mains which are only large enough for the purpose; and by carrying the outlet of the whole system to a suitable point of discharge. There should be nowhere in the whole course of any one of the drains an opportunity for halting and decomposing by the way; no depression where the flow may at any time slacken, to deposit silt and gradually form a hardened accumulation, lessening the capacity and injuring the form of the channel.

Those who have not considered the subject have little idea of the discharging capacity of small pipes. The following calculation is suggestive: —

A pipe six inches in diameter, having an inclination of four inches in one hundred feet (a fall of one to three hundred), has a capacity of discharge of nearly two hundred gallons per minute, or twelve thousand gallons per hour; or between eight and eleven in the morning of thirty-six thousand gallons. If one fourth of the daily flow is discharged in these three hours, then the daily capacity of this sewer would be one hundred and forty-four thousand gallons. Suppose, now, that each household numbers five persons, and that the consumption of water or the amount of outflow is thirty-three and one third gallons per head per day. Suppose, too, that the sewer is to run at no time more than half full, a six-inch sewer on such a grade would then serve for the drainage of over four hundred houses. Allowing a width of only twenty-five feet for each house-lot, this six-inch sewer would suffice for a street nearly half a mile long, built up on both sides.

It has been amply shown by experience that the sectional area of a drain which receives numerous branches need not be increased in proportion to the combined capacity of those branches, for the reason that additions to the stream, if introduced at proper curves, add to the velocity of the flow, and increase the discharging capacity.

A computation of the capacity of collecting and main drains needed to discharge the outflow of a number of six-inch drains, conditioned as I have described, would show very much smaller sizes than would generally be supposed.

Until recently, the objection has existed to the adoption of so small a size as six inches diameter, that it was found necessary in order to remove the accumulation of deposit at the upper ends of sewers, where the flow is slight, to adopt some system for hand-

cleansing; and this cannot well be done in a six-inch sewer. More recently the adaptation to the flushing of sewers of the automatic siphon-tank of Rogers Field, of London, has so far removed this objection as to reduce the risk of obstruction to insignificance.

Sewers of this size should receive no inlet from any source more than four inches in diameter, and this should be the extreme limit of size of all connecting drains throughout their whole length. Any solid matter which could find its way through a four-inch drain would surely be swept on by a copious flow through a six-inch sewer.

The use of the Field flush-tank promises to lead to some radical modifications of sewerage practice. Briefly described, this tank is a vessel of any desired capacity, placed at the head of a drain or anywhere in its course, and receiving the outflow of several houses, or, better, where a small contribution from the public water-supply can be secured, receiving pure water. When it becomes filled, its stationary, automatic siphon comes into action and discharges its whole contents with great rapidity, producing a flow adequate to the thorough cleansing of the drain or sewer into which it delivers.

The tank being discharged, air is admitted to the siphon, and it remains inoperative until its reservoir is again filled, when a second discharge takes place. If properly protected against the admission of grease and coarse matters, this tank needs little, if any, attention. It is always on duty, retaining all that comes to it until full, and then discharging its contents with a cleansing flow. The contributions to it may be copious or slight, without affecting the regularity and promptness of its action.

I am not prepared to say that with the aid of the flush-tank it will be safe to do entirely without man-holes to give access to the sewers, but I *believe* (and I have some experience upon which to found my belief) that it will be safe entirely to avoid these expensive appliances; or, at least, to place them only at such long intervals as may be necessary to supply air for the ventilation of the sewer.

Aside from its sanitary advantage, the use of this small size of sewer will be very much cheaper than that of the large sizes now employed. I regard the economy, however, as less important than the cleanliness and rapid delivery which the smaller size must secure.

Not the least of its benefits is to be sought in the more thorough ventilation which even limited ventilating appliances would effect in a small pipe than in a large one. The reasons for this are that the

amount of air to be discharged is very much less ; that the rapidity of movement of an equal quantity of air is much greater ; that the air-space above the flowing stream is subject to a much greater fluctuation in proportion to its volume; and that from its smaller volume it is more susceptible to the impulse of differences of temperature in the water flowing through the drain, and of the friction of the stream.

The adoption of small and cleanly flushed sewers, furthermore, is of importance in the case of sewers which deliver into harbors or into rivers. It is an accepted standard of extremely foul sewage that it kills or drives away the fish which existed before the waters were contaminated. Such contamination is due, not to the introduction of organic matter, but to the introduction of organic matter in an advanced stage of decomposition. Leaving out of the account the effect of the outflow of chemical works, etc., recent sewage, — the fæces and kitchen waste of dwelling-houses, etc., — so far from being injurious to fishes, is welcome food for them, and all who have watched the outlets of house drains into streams of water must have noticed the avidity with which their solid contents are devoured. We are not now considering how this would affect the value of the fish for human food ; but even on this point, if we recall the diet of the barn-yard fowl, we need not be too severe in our condemnation. It is undoubtedly true, that if the whole of the organic wastes of the town could be delivered into a stream within twelve hours of the time of its production, the fishes of that stream would become its complete and efficient scavengers. Not relying, however, upon this means of disposing of town sewage, we have to consider the whole question from an engineering point of view.

The investigations made years ago in many of the larger towns of England where water-closets are used, as compared with those where water-closets are not used, showed, chemically, very little difference in the impurity of their outflow. This has long been taken as an argument for paying the same regard to street waste that we do to household waste. But this conclusion implies a condition which is never admissible in any well-regulated town ; that is, that the streets shall be allowed to become as offensive as the water-closets. What I desire to impress upon your minds is the obvious fact, that in one way or another the surface of the streets should be kept absolutely clean, and I would ask you to consider favorably my opinion that they may be much better cleaned by other means than by washing their dirt into sewers of deposit underneath them, and allowing it there to remain and decompose, to our great injury.

The street dirt and storm-water being set aside, we get rid of the chief engineering difficulty of the whole problem of disposal, which is *a great variation in the volume of the sewage*. The outflow of private houses, hotels, factories, etc., is pretty nearly uniform in its quantity. It varies but little from day to day, and scarcely at all from week to week. If, on the other hand, we attempt to admit floods of rain-water into our system of sewers, the volume is subject to fluctuations so enormous as to upset all our calculations. Ordinarily the flow will be far too little properly to employ the works which we have prepared to deal with it ; at other times these will be taxed to their utmost, and whether our means of disposal be agricultural or chemical, we are sure to have too great a volume at times, and a relatively insignificant quantity as a rule.

The importance of this branch of the subject when sewage is delivered into water-courses is trifling, but the time is coming, and in some places it has come already, when the rights and requirements of our neighbors further down stream must be respected to the extent of purifying our sewage before we deliver it into water which flows to them.

These troublesome fluctuations in the quantity of the sewage being eliminated from our problem, it is a very simple matter to make provision for chemical or agricultural treatment in such a way as to prepare for the gradual increase of outflow which will accompany an increase of population. The quantity with which we have to deal being a fixed one, it becomes a simple matter to adjust our works to the duty to be performed. It will then be easy to manage the question of river pollution, and we shall have saved enormously in the cost of construction.

For example, in the village of Lenox, in Massachusetts, it was found that the only stream to which the sewage could be carried was the Housatonic River, some miles distant, over a difficult country. To lay an outlet sewer to the Housatonic would cost much more than the whole fund available for drainage purposes. Storm-water being excluded from the sewers, it became easy, with the help of the flush-tank, to establish a system of subsoil irrigation in a field near the town, and the whole work was completed in a satisfactory manner for less than the expenditure that had been contemplated. This has been working steadily and regularly and well since its construction, several years ago.

At the Reformatory Prison for Women, near South Framingham, Massachusetts, the delivery of sewage was into a stream which found

its way into the water-supply of the city of Boston. The daily outflow is between twenty-five thousand and thirty thousand gallons. There was no means by which this could be carried to an unobjectionable river outlet without an inordinately large outlay. Had the amount of sewage to be treated been subject to such variations as occur in towns where rainfall is admitted to the sewers, this would have been the only recourse. The quantity being practically uniform, it was easy and economical to establish a system of sub-irrigation disposal upon the limited grounds of the establishment, in such a way as to overcome every objection.

While on this question of sewage disposal it may be well to describe briefly the sub-irrigation process which is now promising such good results. The principle upon which it works is this: All soil has a very considerable power to extract and withhold organic impurities from water which passes through it. That is, all soils in their fresh condition are good filters, — more or less good according to their composition and drainage. If a foul stream flows constantly through any soil, the accumulation of organic matter clogs it, obstructs its action as a filter, and makes it increasingly foul. The great purifier of all filters is the oxygen of atmospheric air. A mass of earth, which would become foul under an uninterrupted addition of organic matter, will become entirely purified by oxidation, if the same quantity of impurity be added in a short time, if it be spread over a wide surface, and if the soil be left for a sufficient time subject to the oxidizing process.

In the sub-irrigation system, as applied in practice, the outflow of the sewer or drain is caught in a Field flush-tank, and held there until the tank is filled. It then discharges itself into common agricultural drain-tiles laid only ten or twelve inches below the surface of the ground and having open joints. The discharge flows on through the various ramifications of the system of drains, leaking away at every joint, until the whole discharge from the tank has settled into the ground and has more or less saturated it. The water of the liquid settles down by its own weight to the drains or into the porous earth below, leaving its impurities attached to the surfaces of the interior particles of the earth. As the water of saturation settles away, fresh air enters the soil, and the oxygen sets up that slow combustion of organic matter which is its great purifying office the world over. In due time the earth has become cleansed, the flush-tank has again filled itself, and a fresh volume of sewage is delivered into the drains. This description is hardly more simple

than is the process itself; and it must seem absurd to those who are not familiar with it, to suppose that it is capable of dealing with the troublesome problem of purifying the sewage of a town. I have come to believe that its capacity is almost unlimited, and I am sure that for those towns which may properly be called "village-cities," it offers almost universal relief.

The use of agricultural drains in this way was the invention of the Rev. Henry Moule, the originator of the earth-closet. The value of an intermittent discharge in the application of sewage to the soil is the suggestion of Dr. Frankland. The combination of the two was the natural outgrowth of observation and ingenuity.

I believe that the system was first introduced in this country, in a systematic manner, in the grounds about my own house at Newport, in 1870. It has gradually worked its way, as experience has indicated its capabilities, until, in 1876, I did not hesitate to apply it for the whole sewage of Lenox; and it is now accepted, I believe, by all who have given attention to it, as being entirely reliable, economical, and efficient.

We must not forget the very important question of the ventilation of public sewers, which it seems to me is less adequately treated than any other branch of the work to which attention has been given. Concerning the large sewers of cities opinions vary, and there is no occasion for me to express my own here, further than to say that I regard what are called "perforated" man-hole covers as an ineffective attempt to carry out the system of man-hole ventilation which is so much and so justly commended. Nothing less than a coarse iron grating whose spaces are at least equal to its solids will answer the purpose.

Much reflection on the subject has convinced me that, were it possible to enforce the regulation, no means of sewer ventilation can be nearly so effective as that of connecting every house-drain which joins it, without the intervention of a trap anywhere in its course, with an open soil-pipe, reaching above the roof of the house. To be efficient this system must be compulsory and universal. If the authorities of a town have the right to assess private property for the construction of sewers, and to establish the conditions under which private persons may connect with them, they surely have the right to make it one of those conditions that this open ventilation shall be given, and to impose as severe penalties as may be necessary to protect itself against any interference with the ventilating action of each connection.

Could this system be carried out in connection with the small sewers which I have described, we should have a small volume of air contaminated only by the decomposition of the slight sliming of the walls of the sewers in open connection with the atmosphere at the outlet or outlets, and at the occasional man-holes, and through a tall and somewhat heated soil-pipe in every house along its course, connected in such a manner as to secure a constant and efficient change of the atmosphere of the whole system of sewers and connections.

In judging of the advisability of this system we must dismiss from our minds the sort of air with which we are familiar as escaping from the limited vent-holes of the foul public sewers common in our cities. The sewers which I am now recommending will at no time contain organic matter in an advanced stage of decomposition. They will contain at no point any accumulation of solid matter. They will be frequently flushed to the height at which their current may deposit a slimy coating, and they will be constantly swept by a movement of fresh air supplying oxygen for completing an immediate decomposition, rendering putrefaction and fermentation impossible, and diluting and removing, as fast as it is formed, the slight amount of resulting gas. They will not be sweet. Their contained atmosphere will not be suited for admission into a living-room; but they will be so infinitely less foul than the common sewer of the present day that there will be no objection to discharging their air above the roofs of our houses.

I venture the opinion that within ten years this system of sewerage and sewer ventilation, or its equivalent, will be universally accepted as the best, at least for our smaller and more sparsely built towns.

I have still a word to say concerning the removal of soil-moisture, and the thorough under-drainage of the sites of our towns. I fully endorse all that has been said in its favor, and I fully accept all that Dr. Bowditch and others tell us of the enormous and fatal disadvantage — so far as our national disease, consumption, is concerned — of its absence. I only protest against the use of public sewers for this purpose. They may properly afford an outlet for water brought to them by suitable under-drains, but they should never, under any circumstances, act as absorbent drains themselves. Where the inclination of the surface is sufficient it is an excellent plan, so far as possible, to lead the outflow of under-drains into the flush-tanks by which the sewers are to be cleaned. Where this is not possible they may be led to man-holes, or to special branches of

the sewer, the connection being so arranged as to prevent sewage from flowing back into them and leaking out through their open joints into the soil.

As I am speaking upon my own specialty I shall, I trust, be excused for attaching greater importance to it, and for according it wider advantages than are recognized by those who are less familiar with it. I would not underestimate the benefit of a public water-supply, but I think that we may, by the system of sewerage herein described, to a certain extent weaken the *sanitary* argument in favor of introducing extraneous water for the supply of a village. This sanitary argument is based upon the contamination of drinking-water wells by infiltration from private vaults and cesspools.

I would abolish absolutely and totally, by compulsory public enactment, every form of private vault and cesspool, and make sure that all outflow from every house, good or bad, rich or poor, should be carried immediately quite outside of the town by a system of perfectly tight and impervious sewers and drains. I would leave nothing within the limits of the town which could act as a source of well-water contamination. The cause being removed, the effect must cease. There being no longer a source of foulness in the soil, there will soon be no contamination of the water.

In all cases the introduction of sewers must follow if it has not preceded the introduction of a public water-supply. In some cases, at least, the introduction of sewers would render the introduction of a public water-supply unnecessary.

I have now sketched, hastily, as one must on such an occasion, the general features of the plan of sewerage that I propose, and the leading reasons upon which the recommendation is based. I am sure that there are those in my audience who utterly disagree with the doctrines that I have advanced, or who doubt the soundness of my position. I hope that they will not hesitate to express their objections or their doubts, to the end that we may secure such light as comes of free discussion.