

Sewage of towns : preliminary report of the Commission appointed to inquire into the best mode of distributing the sewage of towns, and applying it to beneficial and profitable uses / presented to both Houses of Parliament by command of Her Majesty.

Contributors

Great Britain. Royal Commission on Sewage.
Royal College of Surgeons of England

Publication/Creation

London : H.M.S.O., 1858.

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SEWAGE OF TOWNS.

PRELIMINARY REPORT

OF THE

COMMISSION

APPOINTED

TO INQUIRE INTO THE BEST MODE

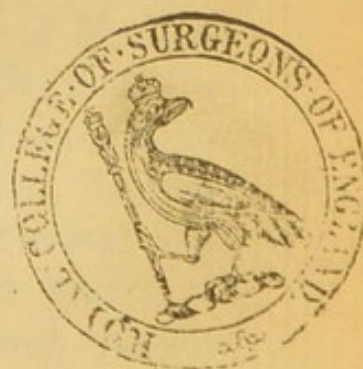
OF

DISTRIBUTING THE SEWAGE OF TOWNS,

AND

APPLYING IT TO BENEFICIAL AND
PROFITABLE USES

Presented to both Houses of Parliament by Command of Her Majesty.



LONDON:

PRINTED BY GEORGE E. EYRE AND WILLIAM SPOTTISWOODE,
PRINTERS TO THE QUEEN'S MOST EXCELLENT MAJESTY,
FOR HER MAJESTY'S STATIONERY OFFICE.

1858.

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LONDON:

PRINTED BY GEORGE & JOHN AND WILLIAM BROTHWOOD

PRINTERS, 15, ABchurch Lane, E.C. 4.

THE NEW SYSTEM OF SEWAGE DISPOSAL

1882.

SEWAGE COMMISSION.

WHEREAS the Commissioners of Our Treasury have represented unto Us, that it is expedient that Commissioners should be appointed to inquire into the best mode of distributing the sewage of towns, and applying it to beneficial and profitable uses, and that such Commissioners should be authorized to enter upon all investigations into all matters relating thereto which may appear to them to be necessary, and should be directed to report to the Commissioners of Our Treasury the results of such investigations, with such suggestions on the subject as the said Commissioners of Inquiry may have to offer : Now, therefore, We, reposing full trust and confidence in Our right trusty and well-beloved Edward Buckley, Baron Portman, Our trusty and well-beloved Henry Ker Seymer, Esquire, M.P., Isambard Kingdom Brunel, Esquire, Civil Engineer, Robert Rawlinson, Esquire, Civil Engineer, Professor John Thomas Way, John Bennett Lawes, Esquire, Southwood Smith, Esquire, Doctor of Medicine, John Simon, Esquire, and Henry Austin, Esquire, Civil Engineer, are hereby pleased to nominate and appoint you, the said Baron Portman, Henry Ker Seymer, Isambard Kingdom Brunel, Robert Rawlinson, John Thomas Way, John Bennett Lawes, Southwood Smith, John Simon, and Henry Austin, to be Commissioners for such purpose, hereby giving you full power and authority to make such investigation and inquiry in such manner as you shall deem most expedient, and to take such evidence and call for such papers, accounts and other documents in relation thereto, as shall in your judgment be necessary, from all officers and others employed in Our service, and from all other persons whatsoever.

And We do order and command you, the said Commissioners of Inquiry, to report to the said Commissioners of Our Treasury upon all matters and things in the premises which shall become the subjects of your investigations under the authority hereby given to you, and to make such recommendations from time to time as may appear to you to be proper. And, in order that you may have such assistance as you may deem necessary in conducting the said enquiry, We do hereby authorize you to appoint J. F. Campbell, Esquire, Barrister-at-Law, now Assistant Secretary to the Board of Health to be your Secretary, and to employ such clerks and others as may appear to you to be required for such purpose, subject to the approval of the Commissioners of Our Treasury.

And for so doing this shall be your warrant.

Given at Our Court at Windsor, this Fifth day of January 1857, in the Twentieth year of Our reign.

By Her Majesty's Command.

(Signed) H. BRAND.
DUNCAN.

On the 12th of the same month Mr. Brunel addressed a letter to the Secretary, stating that he had written to the Chancellor of the Exchequer requesting to be relieved from serving upon the Commission.

On the 6th July Lord Portman announced his resignation; and on the 15th of the same month Lord Essex was formally appointed in the room of Lord Portman.

PRELIMINARY REPORT.

TO THE LORDS COMMISSIONERS OF HER MAJESTY'S
TREASURY.

MY LORDS,

WE, the undersigned, having by Her Majesty's Commission, bearing date 5th of January 1857, been appointed "to inquire into the best mode of distributing
" the sewage of towns, and applying it to beneficial and
" profitable uses; to investigate all matters relating
" thereto, and to report to your Lordships the results of
" our investigations, with such suggestions on the subject
" as we may have to offer," beg, in accordance with our instructions, to present to your Lordships a statement of the measures we have taken to accomplish the objects above recited, and of the conclusions to which our inquiries and deliberations have led us.

In entering upon our duties, our first object was to determine the scope and limit of our functions. After a careful examination of the terms of the Commission, we decided that we were empowered and required, not only to consider the application of sewage to agriculture, or in the words of the Commission, "the best mode of applying it
" to beneficial and profitable uses," and under what circumstances such application is economically practicable, but further to examine the position in which town populations are placed with regard to the disposal of their sewage, and to devise, if possible, some means of relieving them from the very serious difficulties under which they now labour in this respect.

The importance and urgency of the case of London in particular induced us to give to this part of our inquiry special and earnest consideration. We felt that if it were practicable to devise a satisfactory scheme for dealing with the sewage of the metropolis, a highly important

result would be attained. We have appended to this report the outline of a plan which seems to us adequate to the accomplishment of this object.

We also felt, that in order to fulfil the whole intention of the inquiry intrusted to us, it would be necessary, not only that we should visit, and personally examine the different localities where sewage is employed in agriculture, or treated with a view of neutralizing its offensive and noxious properties, but that a series of distinct experiments should be undertaken to test the efficacy of existing methods, and if possible to improve upon them.

To effect this, however, would require much time, and, in concurrence with the opinion of your Lordships, it was decided that it would be better to divide the subject into two parts, and that we should, in the first instance, make ourselves personally acquainted with the existing conditions of things, leaving it to a later period to institute practical trials of the methods that have already been proposed for the treatment of sewage, and of other processes which might possibly present themselves in the course of such an inquiry. We, therefore, appointed a committee of five of our number to visit and inspect all works in operation up to the present time, and to examine such witnesses as might seem necessary; and it is the result of these inspections and inquiries, which have been made with great care, and the conclusions at which we have arrived by frequent deliberations, that we desire now to communicate to your Lordships in this our Preliminary Report.

The appointment of a Commission to inquire into an evil and to seek for means of remedying it may be taken as conclusive evidence of its existence and importance, and we may state at the outset that in the course of our inquiries we have had abundant opportunity of confirming the fact—of which, indeed, we were before perfectly well aware—that the present state of sewage outfalls in many towns gives rise to nuisance and danger of a formidable character. Our official inspections have confirmed and strengthened the impressions which we individually entertained that the successful prosecution of town drainage and of other measures for the improvement of the Public Health is in a great measure dependent upon the satisfactory disposal of town sewage.

The evil in question is of comparatively modern growth, and in alluding to it we do not wish to imply that there

has been, on the part of the public, any negligence or indifference as to its nature and extent. The problem of the disposal of sewage has only quite recently forced itself on public attention, for until within a comparatively short time sewage, as we now know it, did not practically exist. The commencement of the evil, which is fast acquiring such magnitude, dates with the first steps which were taken towards the abolition of cesspools and the introduction of waterclosets. It need hardly be stated that until recently the great bulk of the excrements of town populations was received in pits or reservoirs attached to each house or group of houses. These reservoirs, known as cesspools, were in some cases provided with overflow channels, which allowed a partial escape of the liquid into the public sewers; but in many instances, especially where the ground was of a porous character, such an overflow was deemed unnecessary. The liquid readily soaked away into the sub-soil, carrying with it much of the lighter part of the solid matter—a result which was not over-zealously guarded against, as it diminished the frequency, and, therefore, the expense and annoyance, of emptying these receptacles.

At the time we speak of, waterclosets were comparatively rare; they were confined to houses of the wealthy, and even then they were used in conjunction with cesspools. So that the sewers of a town received and discharged little more than the washings of the streets, brought to them by rain, the waste water of dwelling houses, and a limited quantity of the urine of the population, derived, as we have mentioned, from the overflow of cesspools. The water supply also being limited to that required for washing, cooking, and other household purposes, and not being generally employed in the form which causes at the present day so large a proportion of its consumption, that is to say, in the waterclosets, was very small compared with that which towns now enjoy.

Such were the conditions which formerly influenced the nature and quantity of sewage. It is, undoubtedly, in a gradually growing acquaintance with the laws of health which we have derived during the present century from the devoted labours of eminent men, principally of the medical profession, that we must seek for the origin of those extensive changes which have brought us to the present condition with regard to town sewage.

These labours have led to certain practical conclusions, which we may sum up very shortly in the shape of two or three axioms:—That the offensive effluvia given off by animal and vegetable substances in a state of decay are highly prejudicial to health, and productive of diseases of the worst forms ; that decaying human excrements, solid and liquid, are among the most injurious of such substances ; that the retention in cesspools of such decaying matter beneath and around the dwellings of crowded populations is a serious nuisance, and that, for the rapid and regular removal of such substances immediately after their formation, and before they can become a source of offence and disease, the only practicable means is an abundant employment of water, that is to say, the adoption of some form of watercloset.

These conclusions were not arrived at all at once, nor did they find a rapid acceptance amongst all classes ; but we may safely say, that few people will now be found who would venture to dissent from them, and where such dissent is expressed, it may generally be traced either to ignorance of facts which have been so convincingly brought to light, or to the existence of interested motives ; to the dislike, for instance, of owners of house property to any interference with the existing arrangements of that property or to changes which involve expense ; to the dislike of the inhabitants of towns to a new imposition of rates ; to personal or political animosity, and to many of those other causes which are known to retard the progress of improvements of which the utility and desirableness are otherwise not called in question.

Practically, however, it matters not whether there be or be not any ground for questioning the propriety of the abolition of cesspools, and the transference of their contents to the public sewers ; the matter has gone so far, and the truth of the axioms just enumerated is so generally received and acknowledged by the public, that any idea of a return to cesspools, and to the evils which they engender is out of the question.

When once these views found currency and general adoption, the changes to which we have referred rapidly followed. The abolition of cesspools led to the adoption of waterclosets and to house drainage ; the adoption of waterclosets to the want of a fuller supply of water ; a fuller supply of water and general house drainage to the necessity for more sewers, and, in some instances, to

sewers of greater capacity; and lastly, these sewers, more numerous and of greater capacity, delivered to their outfalls a much larger quantity of liquid of a totally different character from that which sewers formerly contained, inasmuch as they were now charged, not with a small proportion only, but in effect with the whole of the excrementitious matter, solid and liquid, of the inhabitants of a town. Add to these influences the highly important fact of the enormous increase of population in most towns, the subdivision of tenements thereby induced, and the consequent overcrowding of the population, and we have abundant evidence of the urgent necessity of providing for the disposal of town refuse, which the altered state of public feeling, on questions of Public Health, peremptorily requires shall be removed to a safe distance from the spot of its production, and from the residences of human beings.

The discharge of a large body of sewage into a river or watercourse is frequently not only productive of nuisance and disease to the neighbourhood where it takes place, but its influence extends to distant populations. Many rivers, especially in the crowded districts of the North of England, pass through several towns in their course seawards, and receiving from each its complement of sewage filth, are even now little better than sewers themselves, although comparatively few of those places have yet carried out any complete works of water-supply and sewerage.

The increasing offensiveness of the Medlock and the Irwell at Manchester, of the Mersey at Stockport, of the Tame at Birmingham, and of many other rivers, proves that a national evil is fast growing up which demands immediate and serious attention.

The last-named river, the Tame, before it reaches Birmingham, receives the sewage of a number of towns, containing a total population of no less than two hundred and seventy thousand persons. A small stream in itself, it may, without exaggeration, be said, during dry seasons, to contain at Birmingham as much sewage as water.

That such a stream, traversing a densely populated town and exposing to the air a large surface of putrid liquid, must be very injurious to health no one can doubt. But this is not all. It must be remembered that the natural source to which town populations resort for a supply of water would be the nearest river or watercourse; and though engineers, well knowing the contamination to which the water of rivers is liable, have

in many instances had recourse to other sources of water, such as springs or deep wells, frequently inferior in point of softness, as well as deficient in quantity, it still remains difficult or impossible for many towns to obtain water otherwise than from the rivers on whose banks they are situate.

In many cases, therefore, we find the inhabitants of a town under the necessity of obtaining water from a river which in its passage through densely populated districts has received the filth of thousands and tens of thousands of human beings, together with other various but equally disgusting additions, contributed by the trades and manufactures carried on along its banks. Thus, in the case of Birmingham, before mentioned, the river Tame supplies water for all purposes, including the drinking water of no less than fifty thousand people.

The Thames, which at a high point is supposed to yield a supply of pure water to London, before it reaches the recently adopted point above the tidal influence, receives the sewage and drainage water of towns and villages containing more than seven hundred thousand inhabitants. In the great majority of these places little or nothing has yet been done with a view to an improvement of the Public Health, but looking at the rapid extension of drainage operations, it will readily be conceived that in the absence of general measures to prevent the pollution of rivers, the state of the Thames will soon become seriously affected, even by the sewage of these places alone.

That water so polluted is a fruitful source of disease we know, but setting aside the higher grounds upon which this state of things must be emphatically condemned, the very idea that any population should be compelled to resort to such sources for drinking water is revolting in the extreme.

We are aware it is said that the evil is really much less than it seems; that there are natural causes at work, as the influence of the air, aquatic vegetation, fish, &c., which materially diminish the quantity of offensive matters thus mixed with the water. Granting that such causes may to a certain extent mitigate the evil, we still say that as a matter of common sense and public decency it is not to be tolerated that the sewage of one town shall flow through and still less be the water source of another.

It is evident, from what has already been said, that the evil to which we desire to call earnest attention is one

that must be steadily progressive. If towns thickening in population and with increasing manufactures are to be thoroughly sewered, and in the course of time they will be thoroughly sewered; if the great bulk of their refuse is to be brought to some point in a river and there cast in, all idea of resorting to rivers for a supply of water must be abandoned, and then will these rivers become a curse instead of a blessing to the districts through which they flow.

We must here be understood to speak of the usual position of towns. It is quite conceivable, and indeed cases in point are known to us, that a town may be so situated that the discharge of its sewage into a watercourse may not even remotely affect any other population, but in a country thickly studded with centres of population such cases are quite exceptional.

Other evils of a less public but still important nature are caused by the pollution of watercourses by town sewage. Even in the absence of large towns within a moderate distance below the outfalls, many small villages or hamlets, and country residences, are situated on the banks of streams. When such streams are largely polluted by sewage the comfort and health of the inhabitants are interfered with, and the value of their properties greatly deteriorated.

The destruction of fish is another, and in some places a very important consequence of the conditions we have described.

The salmon fisheries of Scotland and of Ireland not only represent a property of large annual value, but they form the occupations and livelihood of a very considerable population. Apprehensions are already entertained of serious injury by the daily increasing quantity of sewage thrown into the rivers, and efforts have been made with a view of arresting the evil. And that it can be arrested by means already within our reach is shown in the case of Leicester, where the river had become so bad that fish had entirely disappeared, but since the adoption of the process for neutralizing the offensive and noxious properties of the sewage discharged into the river, the fish, it is said, have returned to their old haunts.

We have said that the evil of the present state of sewage outfalls, especially where new drainage works have been completed without any means of preventing the pollution of the streams, scarcely admits of exagge-

ration. It is acknowledged by all who have concerned themselves with the matter; but if any further proof were necessary it would be found in the records of our law courts. Within the last few years many suits at law have been entered against the authorities of different towns on account of injury alleged to be produced by outfalls of drainage. The results of these trials present great anomalies, and have left the law on the subject in a very unsatisfactory state.

Another proof of the pressing necessity of action in the case of sewage is found in the fact that in as many as twelve towns in the United Kingdom works on a more or less extensive scale have been erected for the purpose either of applying sewage to land, or of treating it by chemical means so as to deprive it of its offensive character before allowing it to mix with the water of rivers. To some of these cases we shall have occasion presently to refer.

We would now call attention to the worst feature in the whole case, namely, that the difficulty of dealing with sewage is in many places neutralizing, if not altogether suspending, the efforts of town populations to carry into effect improvements which are known to be so essential to public health and comfort.

It is hardly reasonable to expect the authorities of a town to be very active or zealous in the application of the measures contemplated by the Public Health Act, when they foresee the possibility or almost the certainty of protracted litigation, entailing endless trouble and expense, to say nothing of the production of a nuisance and cause of disease in many instances to a portion of their own population.

Anxious, if possible, to find a remedy for these evils in an agricultural application of the refuse, which, whilst relieving town populations, should avoid the waste of a valuable material, we yet felt that the realization of the former object should not be at all contingent upon the success of the latter; and that whilst steadily keeping in view the ulterior purpose, and endeavouring as far as in us lay to smooth the way for a reproductive employment of so much confessedly valuable matter, our paramount duty was to make inquiry into the mode of dealing with sewage with a view to the removal of existing difficulties, and thus to fulfil the chief obligation laid upon us by the terms of our Commission.

With this view of the matter it became necessary, as we have already intimated, that the Commission, or some part of it, should personally examine the different localities where attempts had been made to obviate the injurious influences of sewage by special treatment before throwing it into the watercourses, or to accomplish that object still more perfectly by employing the liquid as manure.

The following is a list of the localities visited and inspected by the Committee; it is separated into two classes according to the nature of the operation carried on:—

Localities where Sewage is applied to Land in a Liquid Form.

Rugby.	Edinburgh.	Mansfield.
Watford.	Rusholme.	Milan.

Localities where Works for the Purification of Sewage are in operation.

Croydon.	Leicester.	Tottenham.	Cheltenham.
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In addition to the above it was thought desirable that the Committee should examine the various farms where liquid manure on a large scale, produced on the farm itself, is employed. It is true that liquified farm manure is not sewage, but it is of the same nature; and making allowance for the quantity to be applied, its application is attended with much the same engineering conditions, and its agricultural effects are the same in kind if not in degree.

Apart, then, from the circumstances in which the application of town sewage and of the liquid manure of a farm would present differences, it is obvious that a great amount of useful information bearing upon the question was likely to be obtained by a careful inspection of those farms where works have been established for the distribution of liquid manure.

The following is a list of such farms visited by the Committee:—

Cashiobury	-	-	Earl of Essex.
Tiptree	-	-	Mr. Mechi.
Bulmersh Court	-	-	Mr. Wheble.
Myer Mill	-	-	Mr. Kennedy.
Cumming Park	-	-	Mr. Telfer.
Farm at Luining	-	-	Marquis of Breadalbane.
Farm near Glasgow	-	-	Mr. Harvey.

It is not our purpose on the present occasion to enter upon a detailed account of the processes carried on in either class of works above mentioned. Most of them have been before described, more particularly in the accurate report made by Mr. Austin at the commencement of last year to the General Board of Health, to which we beg to refer. Having personally satisfied ourselves of the actual state of these works, it may suffice, without entering on details already before the public, to present a general statement of the information we have obtained, and of the facts which appear to us to be sufficiently established.

And, first, with respect to the application of liquid manure, whether that of town sewage or the produce of a farm.

There are two forms of application of liquid manure in use in this country. The first is that of flooding land with the liquid from open cuttings arranged at certain distances from each other, so that in reaching the lower cutting which conveys it away, it shall have passed over and saturated the whole surface soil. This, which is really sewage *irrigation*, is seen on a large scale in the Craigentenny meadows close by Edinburgh.

In the second form of application, the liquid is forced by pumps through an underground system of iron pipes, extending through the fields to be manured. At convenient distances in each field is placed an upright pipe in connexion with those underground, so that by attaching to this a length of flexible tube, the manure can be led to any part of the field. The manure is delivered from this tube through a jet, which has various shapes, according to the mode in which the distribution is to take place. The liquid is in some cases projected into the air, and falls on the land like a shower of rain. In others it is allowed to flow through a comparatively large opening at the feet of the man who holds the hose, and who thus gradually distributes it over the whole surface of the field.

The cases in which this form of liquid application of town refuse is best seen are those of Rugby and Watford.

Application of Sewage by Irrigation.

The Edinburgh meadows afford the largest instance in Great Britain of the application of sewage by gravitation. The operation has been carried on over some of these mea-

dows for more than sixty years. They comprise in all about three hundred and twenty-five imperial acres, and receive the sewage of about one-half the city of Edinburgh, that is, of something like eighty thousand people.

The crops, almost entirely grass, are of the richest description, as may be judged from the fact that they are sold by auction every year at an average of from 20*l.* to 30*l.* per imperial acre.

Of the value of sewage application in this case no doubt can be raised. The works were undertaken in the first instance solely with the view of profit, and they have answered so well that the meadows, some portions of which were formerly barren sea sand, are now a very valuable property.

There is one circumstance, however, in the case of the Edinburgh meadows which is invariably brought forward as an objection by the opponents of sewage manure, namely, that they give rise to constant complaints, not only from persons living in the immediate neighbourhood, but from the inhabitants of some parts of Edinburgh itself at a distance of two miles. There can be no doubt that in their actual condition they would be a source of nuisance, especially in hot weather, but we feel satisfied from inspection that this evil is not a necessary concomitant of sewage application, even in the large quantities employed at Edinburgh, but that it arises from the existence of open ditches which convey the sewage, and on whose banks solid offensive matter is deposited and exposed to the air. The absorption of the offensive gases of sewage by the soil and by vegetation is so rapid that there is no perceptible smell five minutes after the application, and it is therefore plain that if closed drains or pipes were substituted for open ditches, the inhabitants of Edinburgh would cease to have cause to complain of this employment of the sewage.

Another point deserves notice in regard to these meadows. It is sometimes urged that although it may be economically practicable to apply sewage to land where it can be done by simple gravitation, it is another matter where the circumstances are such as to require the use of steam power.

Of the Craigentenny meadows some fifty acres are irrigated with sewage which is pumped up by a steam engine, and although the profit derived from this portion is less than where no pumping expense is entailed, the proprietor

expresses no kind of regret at the results of the outlay and working expenses which have been incurred.

In times of heavy rain the quantity of sewage liquid which comes down at Craigentenny is so great that it is found impossible to deal with it otherwise than by allowing some portion of it to escape into the sea; but with this exception and that of the open ditches, it may be safely asserted that the method pursued at Edinburgh deals with sewage, considered as a thing to be got rid of, with great success.

Upon examining the liquid which escaped from the banks on the seashore after percolating through a soil little better than sand, it was found that this liquid was practically inoffensive, and might with propriety have been thrown into any ordinary watercourse.

This practical illustration of the sufficiency of the soil to remove the offensive character of liquids which percolate it, is quite in consonance with all the facts that have come under our observation, and we feel satisfied that wherever sewage can be so disposed of, there is no fear of its re-appearing in an objectionable condition.

The case of Mansfield, as well as that of Milan, which were visited by a part of the Committee, and to which special reference is made in Appendix, No. 1, are, as it were, varieties of what we have before called sewage irrigation, being in fact irrigation with water which has received a certain amount of sewage, and which therefore possesses a greater fertilizing power than ordinary water. We do not point to them as having any very direct bearing upon the general question of the disposal of sewage, but they sufficiently prove the value, in an agricultural sense, of sewage, especially in the case of Milan, where, although the water used for irrigation receives little or nothing of the solid excrement of the population, and is so dilute that it is hardly to be distinguished by the senses from ordinary stream water, it confers upon the land to which it is applied an increased value of from 4*l.* to 5*l.* per statute acre per annum, above that obtained for land irrigated by streams containing no sewage.

Another and very important conclusion to be derived from an examination of these two last-named places is, that whatever evils may result to health from the neighbourhood of large surfaces of water as used in irrigation, such evils are not sensibly increased by the presence of sewage, where that sewage forms a comparatively insignificant pro-

portion of the whole body of liquid. This will be best understood by referring to Appendix, No. 1.

Application of Sewage by Hose and Jet.

This form of applying town sewage to land usually presupposes the employment of steam or other mechanical power, and, unless the sewage is allowed to run to waste, necessitates the use of large reservoirs in which the liquid may collect during the night and at other times when its distribution is impracticable. It is therefore obviously attended with far greater expense, both in the original outlay of works, and in the daily expenses of distribution, than the more primitive and simple system of application employed at Edinburgh. It appears to the Commission that where land is to be had of suitable quality, and requiring only a moderate amount of power to force the liquid on to it, even this more expensive method of applying sewage by pumping may be economically practised, especially if more ample means for distributing the liquid be employed than the hose admits of. The errors which appear to the Commission to have interfered with the success of the attempts hitherto made in this direction are principally, first, that of laying down pipes over too large an area of land in relation to the quantity of liquid to be disposed of; and, secondly, of applying the sewage to crops which are unfitted to receive it.

The first of these mistakes is admitted at once by those who have incurred the outlay, and have thereby entailed a heavy annual charge on their operations. For instance, at Rugby, the area over which cast-iron pipes have been laid amounts to about 470 acres; the sewage is derived from a population of 7,000 persons, so that supposing it to be fairly distributed over the whole area, each acre would receive annually the excrementitious matter of no more than 15 persons, a quantity far too small to produce remunerative results.

Again, as a source of moisture to vegetation, which in times of drought constitutes a very important element in the value of liquid manure, the large area over which it is generally distributed is fatal to success.

Thus at Rugby the daily quantity of sewage amounts to 160,000 gallons, or about 800 tons. The area of land that can conveniently be watered in the day does not exceed 10 acres.

Each of these 10 acres therefore would receive 16,000 gallons, or a quantity equal to something less than an inch of rain-fall.

That this quantity of water would be highly beneficial to vegetation in times of drought is obvious enough; but inasmuch as at the rate of 10 acres a day it would require 47 days to get through the whole area, it is plain that as regards the great bulk of the land the favourable opportunity for the application would be lost; whilst supposing the drought to be prolonged, the fields first watered would be parched up again long before it would be possible to give them another watering.

It seems, then, to the Commission that the distribution of sewage over too large an area of land is an error, both as limiting the quantity of fertilizing matter applied, and the benefit which the land receives in time of drought.

This error is also met with, though to a less extent, in the case of the sewage of Watford, which, resulting from a population of about 6,000, is distributed over an area of about 200 acres, or at the rate of 30 persons to each acre of land.

The second error to which we have alluded is the application of sewage to crops, for which it is not well suited; thus, in addition to natural and artificial grasses, it has been and is applied to turnips, and green crops generally, and to wheat and other corn crops.

Now it is not at all intended to assert, that liquid manure does no good to these crops; on the contrary, it is at once admitted that it may be applied to them with great advantage, and in many cases it would be of immense benefit to the farmer to have the opportunity of so applying manure, especially in the case of turnips and mangold wurzel; but it must be borne in mind that the problem to be solved with respect to town sewage is not a simple one — it is, in fact, one of considerable difficulty, namely, how to dispose regularly, day by day, of a constant and large quantity of liquid which will not admit of accumulation. The growth of corn and even of green crops does not allow of a daily regular application of liquid, and however beneficially it might be applied to them at times, for a large number of days in the year its use is inadmissible. It follows, therefore, that a very considerable proportion of the sewage must under any circumstances be applied to permanent grass land. Moreover, as the cost of laying

down pipes entails a large annual expense in reduction of profits, and as this annual expense is directly as the amount of land treated, it follows that the application of sewage to those crops which cannot *regularly* receive it, is a mistake. Indeed, if this view needs further confirmation, it will be found in the fact that even where all the appliances of pipes and hose and pumping power exist, and the rent charge due to the outlay upon them is inevitable, we yet find that the application of liquid manure to other crops than grass is gradually diminishing.

Another cause tending to destroy the chances of profit which the application of sewage as at present practised offers, is the very small amount of engineering skill which has been sometimes brought to bear upon the laying out of such works. The Commissioners have met with instances where, by faulty arrangements, it had become necessary to pump the liquid before it could be applied to land, over which it might otherwise readily have been distributed by gravitation alone, and in which the machinery and pipes have been so ill adapted as to be a constant source of trouble and interruption.

The Commission, however, believe that on the whole there can be no doubt that the sewage of a town, in a liquid state, can be more profitably disposed of by direct application to land than by any other means, provided that, relatively to the population producing it, the area to which it is applied be small, that its use be limited to grass, that all natural levels be taken advantage of, and that the works be characterized by skill and a judicious economy.

The application of the sewage in the liquid state is obviously more easy in small than in very large towns, on account of the difficulty of finding suitable land for receiving it. This is peculiarly the case with respect to the metropolis, which we therefore propose to treat by a precipitating process.

It remains that we should advert to the influence of such a use of sewage in the liquid state on the public health. We have already stated, in speaking of Edinburgh, that the danger to health resulting from the method there pursued is, in our opinion, only or chiefly referable to the collection of noxious matter in the open ditches, and that otherwise the application would be un-

objectionable. The same is true in great measure of the other methods described.

With proper precautions, then, we believe that the direct application of sewage to land is not objectionable on the score of nuisance or of danger to health.

A still greater immunity from evil of this nature would be obtained by the use of some deodorizing material with the liquid manure. Such substances are even now available, and their efficiency will no doubt be increased by fresh discoveries. We reserve, however, what we have to say on this subject to our subsequent report.

The application of the liquid manure of a farm is only so far important to our present purpose as it furnishes evidence of a parallel nature to that of the use of sewage. Any very close comparison of the two must be made with caution. The use of liquid manure on a farm is not encumbered with the inconvenience which constitutes the chief difficulty of sewage application, namely, the enormous bulk of water in which the manure is conveyed, and the absolute necessity of its daily application. A farmer may apply the manure of his farm in a liquid state every day or once a week, as he likes. The use of sewage manure must be constant. We, therefore, under-rate the difficulties of applying sewage to agriculture by comparing them with those of liquified farm manure. In one particular, however, the sewage has the advantage. The application of liquid manure, the produce of the farm itself, by a system of underground pipes, does not increase the quantity of fertilizing matter at the disposal of the farmer—it merely alters the conditions under which that matter would be employed. On the other hand, in the case of sewage application the fertilizing material imported is extraneous to the farm, and so far a clear gain to it. If, then, it were conceded, that the laying down of pipes and the pumping of farm liquid on to the land is economically bad, the decision would not rule the case of sewage, which stands on far different merits.

Precipitation of the Solid Matter of Sewage.

Of the different processes that have been proposed for the precipitation of sewage that by lime is the simplest. It is also the only one that has hitherto been put into

practical operation to any considerable extent, and we may therefore be allowed, without disparagement to other methods, to select it as a type for illustration of the whole.

The use of lime to separate the solid matters of sewage is founded on the following circumstances:—Sewage of itself, from the slimy glutinous character of the matter floating in it, and from the specific weight of that matter being so nearly the same with water, will only separate very imperfectly, and after a length of time, into a clear liquid and a solid deposit.

The addition of lime, however, by the chemical changes which it induces, but which we need not here describe, causes a separation of the solid suspended matter in a state of floculence, in the same way that white of egg clears coffee or isinglass fines beer.

The result is that the sewage rapidly changes its character, separating readily into a deposit, which falls to the bottom, and a clear liquid. This is essentially the process that is carried on at Leicester, Tottenham, and some other places, the two named being the most important. The clear liquid after the subsidence of the solid matter is considered comparatively pure and unobjectionable, and is allowed to flow into the rivers. The solid is drained as far as possible, and finally dried, and then offered for sale as manure.

We may at once state our belief that, as far as present knowledge goes, this very simple process offers as much prospect of commercial advantage in respect to the manufacture of a solid manure from sewage as any patent process that has been proposed.

But with reference to the prospect of obtaining any very large profit from the treatment of sewage, we see no reason to dissent from the view that has been individually held and promulgated by several of our members, that neither the lime process nor any other existing method of precipitating sewage is likely to be commercially advantageous to those who engage in it. We consider that this is, however, not the light in which the matter should be viewed. The great problem is to get rid of sewage, advantageously to agriculture if it may be; if not, at the least expense to the community at large.

Throughout the discussions that have hitherto occurred upon this question, the real issue has been left comparatively in abeyance. The primary consideration is not whether

the sewage can be made serviceable to agriculture, but whether or not there exists any method which, consistently with a fair expenditure of money, falling on those who ought in justice to bear it, will practically rid us of the nuisance and danger attendant upon town sewage.

The object must be accomplished, and the question is simply how its accomplishment can most satisfactorily be attained. All other considerations are secondary to this. The process of precipitation by lime as carried out at Tottenham, and on a larger scale at Leicester, is satisfactory up to a certain point. The solid matter of the sewage is effectually separated and a clear and comparatively innocuous liquid is run off. We shall presently consider the objections that have been urged against this liquid, but we wish now to point out that any nuisance which is chargeable to works such as those at Leicester and Tottenham is due, not to the act of precipitation, but to the process employed for drying the solid matter into a condition fit for sale. At both the establishments in question the sewage is received and treated in closed or covered tanks, and as the lime considerably diminishes the smell of the sewage, the whole operation can be carried on and the clear liquid run off without offence. But the solid deposit which settles down in the form of a thick sludge must be removed, and must in some way be dried. This part of the operation is very difficult; it requires much space, and the value of the product is too small to allow of the drying being entirely effected by artificial heat. Consequently, both at Tottenham and Leicester we found great pits and mounds of this sludge undergoing a gradual process of draining and drying in the open air, and it is to these accumulations of the precipitated matter of the sewage, exposed to the sun and other agencies, that the offensive smells which sometimes, but not always, are perceptible from the works, must be attributed.

As an inexpensive means of avoiding nuisance, we may here advert to the simple process adopted by the Local Board of Health at Cheltenham, for separating and disposing of the solid matters of sewage in conjunction with the use of lime, which has been attended with considerable success. This method seems likely to be made available in many other places with advantage. The chief portion of the solid matter is separated in tanks by deposition and a coarse filtration or straining

process; the liquid flowing off is then treated with lime, in order to diminish the smell and to precipitate the finer particles in suspension in the water before it is allowed to flow into the stream. The deposit or sludge first obtained is mixed with the ashes and scavengers' refuse of the town, and thus a solid manure is formed which has been eagerly bought by the farmers of the neighbourhood at 2s. 6d. per cubic yard. A charge of 3s. 6d. per cubic yard would pay all working expenses and interest on the outlay, and it is thought that this price might be obtained for it.

With regard to the liquid which results from the operation of liming sewage; its frequent examination by different chemists has proved, what would in fact have been anticipated, that it contains a considerable quantity of dissolved matter of a vegetable and animal origin which the lime is incapable of separating; a certain amount of smell also remains, although by no means the same in kind or degree as in the sewage itself.

In the report of Dr. Hoffman and Mr. Witt, addressed to the referees on metropolitan drainage, the subject of these precipitating processes has been discussed at some length. These gentlemen have arrived at the conclusion that, inasmuch as a quantity of "putrescible" matter is left in the liquid resulting from liming the sewage, and that this liquid, when kept during warm weather, is liable to become a second time offensive to the senses and consequently dangerous to health, such process is not admissible in the case of the metropolis. But we submit that the question is not whether, in the abstract, sewage after treatment with lime contains vegetable and animal matters in solution, and is liable to further putrefaction, but whether such treatment so far destroys the noxious character of sewage that practically it may be thrown into rivers without danger.

Without going so far as to say that the precipitation by lime is a perfect process, or that it can in all cases be adopted, we feel satisfied that it does, to a great extent, fulfil the purpose for which it is employed, so far, at least, as the purification of rivers is concerned.

By far the largest amount of nuisance and danger arising from the pollution of rivers by sewage, is due to the solid suspended matters, which give off noxious effluvia throughout the period of their decomposition. This is especially the case in our tidal rivers, where these deposits form shoals and cover the banks, and at

low water offer a vast surface of offensive matter for the contamination of the air. The lime process does effectually remove this solid suspended matter, and in so far accomplishes a great and manifest good. It also destroys the immediate influence of the noxious gases in sewage; and although it may in the abstract be open to the objection of still leaving matter capable of further putrefaction in the liquid, we are of opinion that wherever this liquid is thrown into a body of water considerably larger than itself, no evil results will practically be experienced.

Our conclusion then is that in the absence of the means for the direct application of sewage to land, the methods of precipitation at command do actually offer remedial measures of a very satisfactory character. It remains to consider whether these remedial measures are within the fair limits to which a town population may be taxed for the suppression of the sewage nuisance.

We have already stated our belief that, unless some new process of greater efficiency should be discovered, the formation of a solid manure from sewage will not be remunerative; that is to say, that the amount realized by the sale of the manure will fall short of the cost of its production. Neither is this to be considered as a condition dependent on want of appreciation of the manure, which time and better information on the part of the consumer will remove; on the contrary, the tendency has been hitherto to put the price above the value which a sound acquaintance with the nature of manures would attach to it. It is even questionable whether, in some instances, any money at all would be given for this deposit, and in considering the practicability of carrying into effect plans for the precipitation of sewage we must be prepared for this eventuality.

It will, therefore, be placing the matter in a necessary, although the least favourable light, if we consider that the manure when made possesses only so much value as to induce farmers to cart it away without paying for it. It may be desirable, however, that we should here advert to a plan by which the expenses attendant on these precipitating processes would be very materially reduced, and the necessity for works for this purpose in the vicinity of towns, and the possible nuisance, or fear of nuisance, to which they might give rise, would be entirely obviated. This plan is to limit the process to the precipitation of sewage, and after allowing the clear liquid to run off, to

pump the sludge, or mixture of deposited matter and water, directly on to the fields through pipes.*

It has already been stated that the chief source of nuisance, or liability to nuisance, in such works consists in the necessity for drying the sludge, and a very large portion of the original outlay for works, of the area required for such works, and of the daily expenses, is involved in this part of the operation. By the plan above mentioned all these difficulties would be materially reduced; the works would be confined to the precipitating tanks and the engine for pumping, and neither the sewage nor the deposit would see the light of day before the one was discharged in a comparatively innocuous state into the rivers, and the other was deposited on the fields.

It has been calculated that the quantity of sludge to be pumped would not exceed five per cent. of the whole sewage; so that the cost of applying it would be small in comparison with that of distributing the whole sewage on the land.

We have already stated that the processes for separating the solid matter do not realize the agricultural value of the sewage. It has long been understood that at least four-fifths of the substances valuable in relation to vegetation pass away with the water. The solid matter, therefore, which in this plan would be pumped on the land, would not fertilize so large an area as the whole sewage; but in relation to the necessary disposal of sewage, which it is our duty to keep steadily in view, this circumstance would offer some advantages, inasmuch as it would in many cases be much easier for town authorities to find the smaller area of land upon which it might be applied, than that extensive space which the whole sewage would require. Other modifications in carrying out this system will readily present themselves. The quantity of this thick liquid being comparatively small, it might not be necessary to lay pipes over the whole of the land, but a main pipe being led to a reservoir on a central part of the farm, the proprietor would be able to distribute it by water carts, to mix it with other manures on his premises,

* The method in question, which occurred to the visiting Committee in the course of their inspections, it was subsequently found had already been proposed to the referees on Metropolitan Drainage by Mr. Gibbs, C.E.

or to perform to a certain extent those processes of partial drainage and drying which now are effected at the sewage works. We feel confident, that many farmers who would object to deal with sewage in the liquid state, would willingly receive large quantities of this sewage mud, as it entails fewer difficulties of application.

The adoption of this method would remove one of the principal objections which might be urged against the application of precipitating processes to the case of London, and we have accordingly suggested it in the plan referred to.

The two methods for the disposal of sewage, that is to say, by direct application to land, or by precipitating processes, have been, perhaps, sufficiently considered. It is almost unnecessary to add that they can be worked conjointly, and in some cases such a plan would be attended with advantage. Thus, for instance, where opportunities occurred for the disposal of a part of the sewage for direct application, but the whole could not immediately be so got rid of, the remainder might be treated by methods of precipitation.

The erection of works for the latter purpose would obviate the present nuisance, and give time for that change of opinion which will ultimately cause the sewage to be sought after by agriculturists.

Moreover, in many cases the previous separation of the solid matter may increase the facilities for liquid application, allowing of the use of large quantities by open irrigation on a limited area without the risk of nuisance.

It remains now only to revert to one point in relation to the character of the liquid after these precipitations of sewage have been effected.

It has been already mentioned, that objections have been taken to the lime and other similar processes, on the score that the liquid is liable to become again putrid. We have stated that we believe this circumstance to be practically unimportant, but as it is a wise policy in all cases to avoid even the occasion of offence, it is very desirable that even this objection should be overcome. If, after the separation of the solid matters by lime or other precipitants, any further treatment of the clear liquid would place it in a condition in which ulterior change, involving the production of offensive and noxious smells, would be impossible, the

problem, both in a theoretical and practical sense, would be most completely solved.

We are of opinion that the accomplishment of this object is quite within the means of chemical science, and we feel ourselves justified in expressing this conviction from the results of experiments which have already been made in presence of some members of the Commission, although our investigation of this point is not yet complete.

From the whole of our inquiry we have arrived at the following conclusions :

1st. That the increasing pollution of the rivers and streams of the country is an evil of national importance, which urgently demands the application of remedial measures ; that the discharge of sewage and of the noxious refuse of factories into them is a source of nuisance and danger to health ; that it acts injuriously not only on the locality where it occurs, but also on the population of the districts through which the polluted rivers flow ; that it poisons the water, which in many cases forms the sole supply of the population for all purposes, including drinking ; that it destroys the fish, and generally that it impairs the value and the natural advantages derived from rivers and streams of water.

2d. That this evil has largely increased with the growing cleanliness and internal improvements of towns as regards water supply and drainage ; that its increase will continue to be in direct proportion to such improvements ; and that as these improvements are yet very partial, the nuisance of sewage, already very sensibly felt, is extremely slight as compared to what it will become when sewage and drainage works have been carried into full effect.

3d. That in many towns measures for improved water supply and drainage are retarded, from the difficulties of disposing of the increased sewage which results from them ; that the law which regulates the rights of outfall is in an anomalous and undefined condition ; that judicial decisions of a conflicting character have been arrived at in different instances, and that consequently the authorities of towns have constantly before them the fear of harassing litigation.

4th. That the methods which have been adopted with the view of dealing with sewage are of two kinds ; the

one being the application of the whole sewage to land; and the other, that of treating it by chemical processes, to separate its most offensive portions; that the direct application of sewage to land favourably situated, if judiciously carried out, and confined to a suitable area exclusively grass, is profitable to persons so employing it; that where the conditions are unfavourable, a small payment on the part of the local authorities will restore the balance.

5th. That this method of sewage application, conducted with moderate care, is not productive of nuisance or injury to health.

6th. That when circumstances prevent the disposal of sewage by direct application to land, the processes of precipitation will greatly ameliorate, and practically obviate the evils of sewage outfalls, especially where there are large rivers for the discharge of the liquid; that such methods of treating sewage do not retain more than a comparatively small portion of the fertilizing matter, and that although in some cases the sale of the manure may repay the cost of production, they are not likely to be successful as private speculations.

7th. That considered merely as the means of mitigating a nuisance, these precipitating processes are satisfactory; that the cost of them in any case is such as town populations may reasonably be called upon to meet; that the necessary works need not, if properly conducted, be a source of nuisance; and that, by modifications of the existing methods, even the slightest risk of nuisance may be entirely obviated.

8th. That the employment of the one or other method of disposing of sewage, or of both conjoined, must depend upon locality, levels, markets, and a variety of other circumstances, and that the case of each town must be considered upon its own peculiarities.

9th. That there is good ground for believing that the methods yet proposed for dealing with sewage are not the best that can be devised, and that further investigation will probably result in the discovery of processes more thoroughly equal to the suppression of the nuisance, and at the same time calculated to give more valuable products.

10th. That the magnitude of a town presents no real difficulty to the effectual treatment of its sewage, provided it be considered as a collection of smaller towns.

As, however, the conditions under which the evil may be best removed will differ greatly in different localities, we think it would be desirable, before any legislation takes place on this subject, that investigation should be made into the state of the outfalls of different classes of towns, and of the condition of rivers in populous districts, with the view to advise as to the general legislative measures that might safely be adopted.

(Signed)

ESSEX.

HENRY KER SEYMER.

ROBERT RAWLINSON.

J. THOMAS WAY.

J. B. LAWES.

T. SOUTHWOOD SMITH.

JOHN SIMON.

HENRY AUSTIN.

13, Great George Street, Westminster,
26th March 1858.

OUTLINE OF A PLAN FOR DEALING WITH THE SEWAGE OF THE METROPOLIS.

THE question of works of actual drainage being beyond the scope of the Sewage Commission, it is not intended to offer any opinion whatever as to the plan of main sewers which it may be most desirable to adopt for the improvement of the drainage of the metropolis; but on turning attention to the best means of disposing of the sewage, it becomes absolutely necessary to consider the position of the outfalls.

The plans of main drainage at present proposed with the view of obviating the pollution of the Thames, have for their chief feature the adoption of distant outfalls for direct discharge of the sewage. The proposal of such distant outfalls, involving enormous expense, is based on the supposition that the sewage cannot so be dealt with close at hand as to remove its offensive and noxious properties. The investigations of the Sewage Commission have led to a contrary conviction, and it is felt that a very important part of the trust confided in them would be neglected if they hesitated to express it. It is believed that whatever difficulties may at first sight seem to attach to the purification of the sewage of London, they are such as will disappear under a proper application of the methods of treatment at disposal; and that the removal from the Thames of its chief source of pollution may be accomplished more effectually and economically by the plan about to be submitted than by those hitherto contemplated.

Perfect purity of the water of a large tidal river, such as the Thames, passing through a densely populated district before reaching the metropolis, crowded with vessels, and subject to so many other sources of pollution, could not be expected even if the entire sewage of the metropolis itself were removed; but it is certain that whatever plan of intercepting drainage may be adopted for the removal of the sewage, improvement of the river to the extent which is practicable will only be very partially accomplished unless means are adopted, 1st, for prevent-

ing the formation of the mud banks along its shores ; and, 2ndly, for preventing the direct discharge of the immense quantities of foul deposit brought down from the sewers in times of considerable rain.

With reference to the first point, Mr. Goldsworthy Gurney has drawn attention to the fact that to whatever distant point the sewage may be conducted for discharge within the tidal influence, the solid matters (by far the most offensive portion) will again work up the river,* and deposit on the sides wherever the opportunity is left ; but independently of this danger it is much to be feared that the solid matter brought down

* Mr. Gurney, in his recent report to the First Commissioner of Works, "On the state of the Thames in the neighbourhood of the Houses of Parliament," after describing the conditions of the river, and various experiments tried by himself, says :—

"All facts connected with tidal rivers show the greater power of the upcast over the down in convection of deposit. The former estuaries of the Thames, Battersea, Chelsea, and Bermondsey, were formed by alluvial matters first brought down from the hills by the freshet, and deposited in the slacks and eddies low down the river. They could not be deposited on the estuaries directly from the freshet, because the freshet never flowed over them. The alluvial matters deposited low down the river were brought back again by the upcast tide and precipitated on these estuaries at high water.

"The greater power of the upcast over the down, in the convection of insoluble deposit in tidal rivers, is strikingly shown in the following case which I will mention, because in almost every condition it is parallel to the Thames, and may be examined at any time without inconvenience. In early life I lived on the banks of a tidal river (the Camel in Cornwall). Like the Thames, the tide in this river runs up and down in about the same time, and at about the same rate. The freshet gives an extra downcast over the flow. This river empties itself into the Atlantic about 14 miles below my residence. Along the north coast of Cornwall there is a quantity of sand deposited from the sea, composed of broken *shells*, torn from the rocks. Its specific gravity is 2.437 ; it is greater than that of sewage, and sinks at the rate of three feet per minute. This sand is brought up from the *mouth of the river* by the upcast tide, against the freshet, and precipitated along its sides, 14 miles from the sea, beyond the reach or influence of the breakers. There is no mistake in this matter ; no doubt as to the source or origin of the sand. I often watched the convolutions in the tide, turning the sand up and down as it came along in the water, on the flow, and noticed their absence on the ebb : I analyzed the sand for agricultural purposes. It is now carried away by carts for manure. I particularly noticed that the quantity of sand carried away out of the retrogrades by carts one day, was deposited again from the tides the next. If it was *not carried away* by the carts, the quantity *did not increase*.

"The quantity of sewage retained in the Thames seems also a ruling quantity. The river is never choked up, nor is it ever clean. The quantity of sewage discharged into the river, like the sand in the

the river from the populous districts above,* and added from other sources, will very seriously tend to its continually increasing pollution, if the mud be still permitted to deposit along the banks, under the most favourable conditions for decomposition.

The importance of the second point, that is to say, the increased discharge of solid matter during rain, is well known to those who are aware of the immense accumulation of deposit in the sewers during dry weather. It is strikingly illustrated in the experiments recorded by Dr. Hoffman and Mr. Witt, by which it appears that a heavy fall of rain brought down more than 20 times the amount of solid matter discharged upon ordinary days of dry weather.†

The plan about to be proposed for dealing with the sewage, especially provides against these chief sources of pollution of the Thames, the discharge and deposit of solid organic matter.

The main difficulty in the way of deodorizing the sewage of London has been the insurmountable objection to the construction, within or near to the metropolis itself, of any usual form of reservoir and deodorizing works on the great scale required. The chief feature of the proposed plan would be the construction of these works in such a manner as to form the foundation for a complete embankment of the river, so that, while avoiding the possibility of any nuisance or other source of inconvenience from such works, the very means adopted for dealing with the sewage of the metropolis would be the means also of realizing the other great improvements for which an em-

Camel, is always in excess; yet the *quantity retained is nearly constant*, governed by the size of the slack and retrogrades. These cases are parallel: the explanation of the one is the explanation of the other.

"I think it right to observe here, that it is evident *sewage*, like the above sand, if thrown into the Thames, no matter how far down, will be brought *back again* by the upcast; and if the retrogrades are not destroyed, it will be retained in the river in quantities sufficient to be offensive to the Houses of Parliament; but if the retrogrades are destroyed, it will not be so retained. In the Thames, and all tidal rivers, where there is no room on the sides, for *slacks or retrogrades* to form, *there is no deposit*."

* It has been already stated that the population of the valley of the Thames above Hampton, the highest source of water supply of the metropolis, amounts in all to upwards of 700,000. In very few of the towns have drainage works yet been carried out.

† At the time mentioned, the morning of June 20, 1857, upwards of an inch of rain fell in the locality, chiefly between midnight and 4 a.m. The sample was taken at 2.15 a.m.

bankment of the river has been so long desired. In connection with such embankment it has already frequently been proposed to construct main sewers to carry the sewage of the metropolis down the river; but the enormous interference with wharf property by an *uninterrupted* line of embankment, and the impossibility of passing the various dock entrances, render this course impracticable.

The proposition now submitted is, as shown in the accompanying plan, to construct such embankments, detached from the shore, in the form of advanced terraces,* continuous on the surface, but affording at convenient distances entrances to the inner basins, on the principle recommended by the Commissioners of Metropolis Improvement, in their report of 1844. In the interior of these lengths of embankment a series of separate reservoirs would be formed, into which the whole of the sewers of the metropolis now discharging directly into the Thames would have their outfall. The solid matters would there be separated and precipitated, and the liquid treated with some deodorizing agent before discharge.

Intercepting sewers would cut off the whole of the high level drainage of the metropolis, now such a source of mischief to the low districts, and conduct it by gravitation to the reservoirs. Steam engines on land would raise the sewage of the low levels to the same height. The reservoirs would each be subdivided, and the compartments would be used alternately, so that the sewage would remain at rest a sufficient length of time to deposit its suspended matter, the liquid being regularly discharged, except in times of flood, during ebb tide, and below low-water level.

Engine power would be provided capable of raising into these terrace reservoirs, from the low level districts, the maximum flow of sewage together with rainfall at the rate of one inch in depth in 24 hours, but the capacity of the reservoirs would be sufficient to receive even a larger amount by gravitation from the high level urban

* This statement has reference only to those portions of the embankment between Southwark and Vauxhall Bridges, where the sewage of the central districts of the Metropolis would be treated. The several other detached embankments required for the sewage of the districts, both above and below, from Brentford to Woolwich, would be filled in solid, and would form valuable local improvements. It should be stated also that although it is proposed to make the embankment complete, past the Houses of Parliament, the reservoirs in this part of the river would extend only between Hungerford and Queenhithe.

districts, and to retain it long enough to ensure the separation of the immense quantities of offensive solid matter brought down from the sewers during heavy rains. It is rarely on more than two or three days in a year that a fall of rain exceeds the depth of an inch, and the excess which would be directly discharged from the sewers on such occasions would cause no appreciable pollution of the river.

The solid matters precipitated in the reservoirs would be pumped away in the form of sludge through pipes in connection with the whole of the reservoirs, and carried out to sea, if no opportunity should arise for the beneficial employment of this material. That this comparatively small proportion of the whole sewage of the metropolis may be profitably employed, however, upon extensive tracts of barren land especially fitted to receive manure in so convenient a form, there can be little doubt; for the heavy expenses of the precipitating and deodorizing works, and of transmission of the manure to the land, which, if such expense fell on the consumer, as before pointed out, would in all ordinary cases prevent any profitable return, would here have been already incurred on behalf of the public. The value of this sludge manure would be very great, and there would remain only to be deducted from that value the cost of arrangements on the land itself for distribution of the manure.

The objections which may possibly be raised against this scheme are, 1st, that the liquid discharged into the river will not be absolutely pure; and, 2ndly, that the precipitating reservoirs may themselves become a nuisance.

On the first point it need only again be observed, that those who under any circumstances expect absolute purity of the Thames will certainly be disappointed; but that its comparative purity, that is, purity to the extent of freeing it from the offensive and injurious properties of the sewage of the metropolis, will be secured.

With reference to the second point, it may be admitted that deodorizing establishments on a large scale and of the ordinary class, would at times generate a certain amount of nuisance, but the constructions here proposed are not of the nature of deodorizing establishments as usually understood or as usually conducted. It has already been stated that the nuisance of deodorizing works arises mainly from the exposure of the deposited matter, and from the processes necessary for its manufacture into

a portable manure. Nothing of this sort would here take place. The reservoirs would be, in fact, detached lengths of large sewers, in which deposit would take place as in the tidal sewers now of Southwark and Westminster; but they would differ from these latter in being altogether free from the objections which attach to them. The sewage in these new sewers or reservoirs would be always deodorized; they would have no external openings in the shape of gullies for the emission of foul air, nor would offensive smells escape from them under any circumstances, and they would be at a distance from habitations, instead of being in the midst of and in immediate connection with them.

By dividing the metropolis into several large towns, as it were, with their separate outfalls, as here proposed, instead of attempting to deal with it as one unmanageable whole, much of the difficulty and expense of the undertaking is at once removed. The work becomes far less formidable in dimensions; the serious difficulty of construction, and the danger to buildings, consequent upon many miles of large sewer being laid in most treacherous ground, and below low-water mark,* would be avoided; and a great extent of interruption of the traffic, and of alteration and reversal of the existing drainage of the low-level districts, would be rendered unnecessary.

Lastly, while it is believed that this plan would effectually secure the purity of the river and the improvement of the metropolitan drainage without entailing any difficulties or inconveniences of its own, it would afford the means of realizing the greatest improvements in other respects of which the metropolis is susceptible.

It is true that the consideration of such improvements is wholly beyond the province of the Sewage Commis-

* In justification of this apprehension, it is only necessary to refer to the difficulties which have already been experienced in getting in sewers merely at the level of low water, in the quicksands which prevail to so great an extent in the Surrey and Westminster districts. The original contract for the Victoria Street sewer in Westminster was under 14,000*l.*; it has already cost between 60,000*l.* and 70,000*l.*, and the accounts are not yet closed. It has been the cause of serious damage to various buildings, and it remains to this day a crippled and imperfect work. The referees state, with respect to their own plan, that, "Considering the magnitude and extent of the main sewers, we doubt the possibility of carrying them into effect without in some parts affecting the stability of contiguous buildings."

sion, but it may be permitted them, in the interests of the public, simply to refer to the great collateral advantages which would naturally follow from the adoption of the means proposed for dealing with the sewage of the metropolis, which it is their especial duty to consider.

The improvement of the navigation and the means afforded for exercise and recreation by these river terraces to that large neighbouring population at a distance from either of the parks, and the general effect of these works in the adornment of the river, will be readily appreciated. At the same time, the northern line of terrace from Queenhithe to Westminster would supply a new East and West thoroughfare, direct and of ample width, so long desired for the relief of Cheapside, Ludgate Hill, Fleet Street, and the Strand. Connections between the existing thoroughfares and this new line would be conveniently formed at the places shown on the plan, and for the accommodation of the central and northern parts of the city a short new street might be formed as indicated, rising from Earl Street to St. Paul's Cathedral.*

The southern line of embankment would also, at a small additional cost compared with so great a result, afford the opportunity for a metropolitan railway connection of great public convenience, giving a west-end station to the South-Eastern lines, and a city station to the South-Western lines.†

These improvements may appear to be on too gigantic a scale to allow of any hope of their realization. A liberal estimate, however, shows that, exclusive of the purchase of properties for the new lines of streets, and the working

* With the exception of the houses in St. Paul's Churchyard, the property through which this line would pass is not of a valuable character. While most convenient for the traffic, it would secure a very fine architectural effect by opening out a general view of the Cathedral from the low ground.

† It may be well to explain, with respect to this proposition, that it is found to be perfectly practicable for the line to pass beneath the approaches to London and Southwark Bridges, clear of the bridges themselves. It need occupy only part of the ground floor of the large warehouses contiguous to London Bridge, so that the destruction of property at that end would be comparatively very small. At the Vauxhall end the property through which the junction would pass is of the poorest description. The South-Eastern lines would obtain a station at the foot of Westminster Bridge; the South-Western lines at the foot of Southwark Bridge.

expenses of dealing with the sewage, they may be executed for three and a quarter millions sterling; and that the total cost for the whole scheme, including working expenses, and making no allowance for any return, would fall far below the amount estimated as required for the works hitherto contemplated simply for conveying the sewage of the metropolis to Sea Reach.

APPENDIX.

APPENDIX No. 1.

Sewage Commission.

REPORT OF THE DEPUTATION APPOINTED TO VISIT THE CITY OF MILAN.

A PERUSAL of the treatises on the works of irrigation of Lombardy having led to the opinion that the effects of irrigation with the waters which convey from the city of Milan the refuse of the population, as compared with irrigation with plain water, would in all probability offer some useful information, both in a sanitary and agricultural point of view, which, from the fact of the long experience there obtained on the subject, might be of service in the consideration of the best means to be adopted for the disposal of the refuse of the towns of this country, the meeting of the Commission held on the 23rd day of October last, was pleased to appoint us a deputation to proceed to Milan, in order to obtain all the information in our power which would bear upon the immediate objects of the Commission.

We beg to present the following report of our investigations :—

“Although the works which have been executed for that vast system of irrigation, upon which the agricultural wealth of the whole of the lower parts of Lombardy and Piedmont so much depends, are full of interest, we considered it right to confine our observations strictly to those points of more immediate importance to the Sewage Commission, and to which the attention of the several writers upon these works had only been very partially given. Our enquiries, therefore, were not of a lengthened character. We left London on the 5th ultimo, and returned on the 4th of the present month.

“We found that letters had already been addressed in our favour by the Austrian Government at Vienna to the Civil Governor at Milan, who directed that every information at the command of the officers of the Government should be placed at our disposal without reserve, and we experienced at all hands the utmost attention and civility; but the works in question not being under the charge of the Government, and there not being

any representative of the English Government at Milan, we found considerable difficulty, as strangers, in the outset of our enquiries, which threw us somewhat on our own resources. But our own personal examinations, and the evidence which we were subsequently enabled to obtain from various parties best qualified to furnish the information, have, we believe, secured the desired particulars.

"The works of irrigation surround the city of Milan in all directions, and although the rice cultivation is not permitted to approach within a distance of four miles, there appears to be in practice no restriction with regard to water meadows in general, which in many parts abound close upon the walls of the city. Irrigation with the water charged with the liquid refuse of the population is conducted only in a southerly direction.

"The drainage of Milan is of a very defective character, but it is complete of its kind. The main sewer, the Sevese, encircles the oldest part of the city, and receives about four-fifths of its entire liquid refuse.

"The Naviglio Interno—an open navigable canal, which forms nearly a circle within the walls, divides the city into two parts, and connects the Martesana Canal on the north with the Grand Canal and the Canal of Pavia on the south—drains the remaining one-fifth of the city. Every house in the main body of the city has a drain connected with a public sewer, which receives all the rain and waste water of the premises; but the faecal matter of the population, except from those houses which drain directly into the Canal, is retained in cesspools.

"The water-supply of Milan is wholly derived from private wells, and is consequently of a very limited character; but various accessions of water enter the main sewer, chiefly from the Naviglio Interno, on the north, from which point, branching off in opposite directions, this stream perpetually flows throughout the entire course of the sewer, thus considerably diluting the liquid refuse of the city. This stream is not capable of being employed in cleansing the general system of sewers of the city, as writers on the subject have supposed. Looking at the levels of the surface, this great advantage might probably have been obtained had the works been laid out with any system, but, as in most towns which have been the growth of centuries, these sewers have been executed piecemeal, without reference to any general plan; and their varying levels and defective character demand periodical cleansing by manual labour, and the deposits thus driven forward into the main sewer are carried away by the stream. The proportion of solid matter, however, which finds its way into the sewers must be unusually small, for besides that the faecal matter is retained, the streets of Milan are kept scrupulously clean. Independently of the regular cleansing operations of the authorities, manure is so highly prized in the neighbourhood that men are to be seen all day long collecting, on their own account, the fresh horse dung from the streets.

"The contents of the sewers flow from the city by an open channel on the south, where another body of water from the Naviglio Interno immediately joins it, forming altogether a stream of about twenty-seven million gallons per day, called the River Vettabbia.

"The cesspools are water-tight receptacles, without any overflow or other outlet, and are said to be capable of containing usually about 36 cubic mètres. The cost of construction is said to vary from about 17*l.* to 24*l.* They are emptied about twice a year, sometimes much oftener, late at night, during the eight colder months, by the neighbouring farmers and market gardeners, who pay a small sum to the householder for this manure, and find it worth while to cart it to an average distance of about a mile from the outside of the city, where it is discharged direct from the cart on to the land. About three hundred of these men receive from the municipal authorities licences for this service, for which a small sum is also paid. This manure is removed chiefly to the north of the city. There are within the city boundary 5,460 houses, and from seven or eight to even forty and fifty cartloads of matter are said to be removed at each emptying of a cesspool, of which there would be between forty and fifty emptied each night. The carts are filled by means of open buckets, and the nuisance of the system may be imagined. Latterly a company has been established for the employment of a pneumatic cart, as in Paris.

"The farmer pays for this cesspool matter in proportion to its solidity, but as there is no soakage or overflow from the cesspool, its contents appear to be at all times, more fluid than is found to be the case here.

"There are very few water-closets in the city; where they do exist, the householder has to pay for the emptying of his cesspool, instead of receiving anything for its contents. It is forbidden to discharge urine into the drains, but there being so direct an interest against the discharge of any fluid into the cesspools, it may readily be supposed that no more than is unavoidable finds its way into those receptacles, and that as the streets themselves abound with urinals, the chief portion of this valuable part of the refuse of the town does find its way to the sewers.

"The river Vettabbia which conveys this liquid refuse of the city is made to ramify and serve for the irrigation of about 4,000 acres of land, after which it falls into the river Lambro, about 10 miles below the city. The daily quantity of water flowing from the city equals about 160 gallons per head. The depth of water conveyed on to the land, calculated over the whole area, is about eight feet per acre per annum, conveying to each acre the liquid refuse of about 40 persons; but it must be observed that much of the water is used over and over again, successively, on lands at lower levels.

"It has been stated how little solid matter is conveyed in this stream. Nowhere in appearance is it as muddy as the Thames

between the bridges, and yet much of the land irrigated by it becomes so rich that the surface is pared off every few years, not, as erroneously stated by some writers on the subject, in order to preserve the level of the lands for irrigation, but to obtain the vegetable matter which becomes in time too luxuriant in growth as material for manure for other lands for which it is highly prized.

" We examined the country throughout the whole course of the Vettabbia ; took samples of the water, and of the produce, and notes of the detail of the system of irrigation employed. We had the advantage, besides, of minutely inspecting the whole arrangements of a considerable farm, situate between three and four miles from Milan, where the waters of the Vettabbia are employed to great advantage, and of receiving the fullest information from one of the most intelligent proprietors, Dr. Chiappa, a retired physician of Milan, who was born on the estate, and has been engaged in farming operations all his life.

" The expense of forming a meadow for irrigation appears to vary from about 8*l.* or 10*l.* to upwards of 40*l.* an acre, according to the original character of the surface. The water is turned on for from 6 to 10 hours once a week, throughout the summer months, but a certain portion of the meadows are irrigated constantly throughout the winter, and are then called " marcite." In the winter irrigation, the great object is to maintain a constant flow of a film of water over the whole surface of the land. It is never stopped, except for the short period necessary for cutting the crop. The consumption of water will be obviously, therefore, enormously great in this operation, and the proportion of the meadows which can be so treated is correspondingly small.

" On the modern system ' a Milanese oncia ' of water is required for the irrigation of twenty ' pertiche ' of marcite meadow, being nearly a quarter of a million gallons per day per acre ; but, as before stated, the same water is used many times successively on lower lands.

" Dr. Chiappa farms about 580 acres of land, of which about 80 are termed " marcite," irrigated with the waters of the Vettabbia. The produce of these 80 acres supports 100 cows, stall fed. Six crops of grass are cut during the year of the following proportionate weight :

In February, 800 kilogrammes per Pertica.

" April,	800	"	"
" June,	600	"	"
" August,	600	"	"
" October,	400	"	"
" December,	400	"	"

or about 22 tons of grass per acre per annum.

" Hay is made in June and August, and sometimes in October, when the season permits. The cattle are fed upon hay for about 40 days in the year. At all other times they have the fresh

grass, and nothing else. The effect of climate and of higher temperature than in this country, must of course be taken into consideration in judging of the produce of these meadows.

"No manure whatever is used on this land. The manure of the cattle fed with its produce is used elsewhere. On all the lands irrigated with plain water, a large quantity of manure is at all times used. To obtain the same produce from such lands as is here obtained from irrigation with the waters of the Vettabbia, it is calculated would require five cubic mètres of good decomposed manure per Pertica, of the value of four Austrian liras per mètre, or about 4*l.* 8*s.* per acre per annum.

"It will be observed that the waters of the Vettabbia in passing successively over the lands throughout their course decrease in fertilizing power in proportion to the distance they have travelled from the city; but looking at the position of the land in question, the above amount might probably be taken to represent the average value of the liquid refuse of the city.

"The effect of irrigation generally on the health of the population has been a vexed question in Lombardy and Piedmont for between two and three centuries.

"We sought information on this subject from the persons most likely to have made themselves acquainted with the facts—the physicians of the great hospital of the city, and of the most extensive practice amongst the poorer classes of the people.—We found, as might have been expected, that the population who lived in the midst of and close upon irrigated lands are subject to the same diseases as are common wherever extensive tracts of vegetation are alternately covered with water, and then exposed when comparatively dry to the action of the atmosphere under a hot sun. But what we were not prepared to expect is the very small distance to which, in these districts, the injurious influence appears to extend. It is stated as the result of general experience that dwellings situated not closer than about a quarter of a mile to the ordinary irrigations are safe from their malarious influence, and that although, as has been already stated, those irrigations have been brought close to the walls of Milan, and in some instances carried even within the walls, ague is never endemic in the city, nor is any other form of marsh-disease known spontaneously to arise within it. Although the land is not artificially drained, the subsoil is generally of a porous character, and hence a freedom from stagnation of water, which may in some measure account for the limited space to which the noxious effects are restricted, and for the comparative immunity from disease under so extensive a system of irrigation and with so high a temperature.

"There is a general agreement that where the water is mostly stagnant, as in the rice fields, the injury to health is far greater than in ordinary irrigation, and, indeed, the unhealthiness of the rice cultivation is so decided that it is strictly forbidden by law from being carried on within the distance of four miles from

the capital. It is, however, permitted within the distance of about the third of a mile from villages and small towns.

"Whatever may be the influence of irrigation in producing intermittent and remittent fevers and other forms of marsh-disease, it does not appear particularly to predispose the population to typhus or to epidemic disease in general. Its influence appears to be strictly endemic. In the farm we have described as irrigated entirely with the waters of the Vettabbia, though there have been three visitations of epidemic cholera in Milan and the neighbourhood, no case of the disease occurred during either of these attacks.

"Typhoid fevers are not uncommon in Milan and the suburban districts, and they present precisely the same characters as those which are prevalent in London; but they are not, as in London, concentrated in particular localities. When they prevail they are said to be distributed indifferently over all parts of the city. There appear to be no 'fever nests' in Milan.

"We could obtain no evidence of the production of disease by the existing mode of dealing with the solid portion of the excrementitious matter of the city. The tenor of such evidence as we could obtain on the spot is to show that no injurious effects of any kind result from it. It is admitted that the common mode of disposing of the faecal matter is a nuisance, but that it is a source of disease is denied on all hands. But it does not appear that public attention has yet been directed to this subject.*

"It must be added, however, that the cesspool matter is only allowed to be removed during the cold months, that it is nowhere accumulated, but employed at once over a considerable district of market gardens, and being of a liquid character, it is readily absorbed by the soil.

"We may state further upon this branch of our inquiry, that while we found in Milan some striking evidence of the conditions under which irrigation with water containing no sewage may be so conducted as to produce, with certainty, a marked injurious effect† upon the health of the neighbouring population, we also saw the conditions under which entire immunity from disease may be secured; and a knowledge of these facts may have an important bearing on the labors of the Commission: but we could trace no evidence whatever of the slightest increased injurious tendency of the irrigations conducted with the waters of the Vettabbia beyond those of other districts around where plain water is employed.

"We gather, therefore, the following facts as the result of our visit:—

"1. That this example of the application of sewage to agriculture, notwithstanding that the sewage is conveyed in so ex-

* See Appendix, No. 2. † See the evidence of Dr. Capelli as to the Lazzaretto.

tremely diluted a state, is the most extensive and the most important of any which has come under notice.

" 2. That the experience of the irrigations around Milan add a striking additional proof to those already obtained of the great value to agriculture of a command of pure water alone, and of the immense increase of that value obtained by the addition of sewage combined with the higher temperature derived by the liquid in its passage through a town.

" 3. That no nuisance whatever is perceptible from this liquid application of the sewage, and that although this entire freedom from offensiveness is no doubt due to the absence of the solid matter and to the great state of dilution in which the liquid portion of the sewage of the town is conveyed, we believe that similar immunity may be obtained in this country by some deodorizing process, whereby the solid matter will also be separated from the liquid, and both rendered inoffensive.

" 4. That the solid matter could then be frequently applied in the neighbourhood of a town, as at Milan, without any of the offensiveness there experienced.

" 5. That the liquid could also be applied with all the advantages accruing from its use at Milan, without any of the risk of injury to health there incurred from the use of such large bodies of water.

" 6. That this risk of injury to the health of the population living immediately in the midst of the irrigations of Lombardy, is such only as arises elsewhere from similar use of large bodies of water, a difficulty which we should never have to contend with in dealing with the sewage of towns of this country. That no increased disease whatever is traceable from the application to the land of the waters of the Vettabbia in which the sewage of the town is conveyed, notwithstanding the much higher temperature of the climate and the greater evaporation than is experienced in this country.

" 7. Finally. That the evidence obtained at Milan of the great agricultural results which have been for long periods of years realized by the application of sewage with so little arrangement or expense for the purpose, and which might be equally well adopted here without any offensiveness or risk of injury to health, strongly confirms our conviction of the folly and extravagance of the adoption of expensive arrangements for throwing so valuable a material away.

" There may be many facts as to climate, soil, modes of agriculture, and other questions of considerable interest in connection with these works, to which we have not yet had an opportunity of directing our attention, but with the view to future reference we have collected some of the more important treatises which have been published on the subject.

" We have to express our obligations to the Governor of Milan, Baron de Burgen, for the courtesy and assistance afforded to us ;

to Signor Bosco, Engineer-in-Chief of the Public Works of Lombardy ; Signor Valsuani, Engineer-in-Chief of the City ; and especially to Signore Milortiz, Pirovano, Cesa Bianchi, Gallizia, Hajeck, and Drs. Vaga, Bianchi, Capelli, and Chiappa, for the personal trouble which they took to provide us with the fullest information."

T. SOUTHWOOD SMITH.
J. THOMAS WAY.
HENRY AUSTIN.

December 1857.

APPENDIX No. 2.

WE give the following evidence as showing the state of opinion and feeling in Milan on some points of our inquiry. We do not regard the general want of recognition of injury to the Public Health from the system of disposing of the excrementitious matter of that city, as satisfactory evidence that no injurious effects are occasioned by it. The public attention there does not appear to have been awakened to the danger of the long retention of such matter within and around dwellings. If the statement of Dr. Bianchi as to the infant mortality and the low average age at death at Milan be correct, that city cannot be regarded as a healthy one. However, we have recently received returns from which the mortality of Milan and its several districts can be determined.

The evidence of Dr. Capelli affords a striking illustration of the injurious effects which may arise from irrigation carried on in particular localities and without due precaution. The Lazzaretto seemed to present conditions which would, probably, render those effects particularly apparent, and we therefore made a special examination of the locality, and of the health of the inhabitants.

The Lazzaretto is a square piece of land of about 34 acres, for the most part constantly under irrigation ; it is entirely closed in on its four sides by habitations, and thus forms a complete reservoir of malaria.

STATEMENT of DR. ANDREA VAGA, PHYSICIAN and DIRECTOR of the "OSPITALE MAGGIORE," MILAN.

THE Ospitale Maggiore of Milan is capable of containing upwards of 3,000 patients. It is often full, especially in winter. There are at present in the different wards 2,850 patients.

The sick are received into this hospital from all quarters of the city, as well as from all districts in the neighbourhood.

We have the means of verifying the particular localities from which the sick are sent to the hospital.

This hospital, therefore, affords the full means of judging of the state of the public health, particularly of the poorer part of the population, both with relation to the prevalent diseases and the particular localities in which they prevail.

Typhus and typhoid (*gastro-enterite*) fevers are of common occurrence in Milan. They occasionally break out in good families, and in the better parts of the city, but they more often occur among the poor because the poor are more crowded.

There is no special hospital in Milan for fever patients. The disease is never so prevalent as to require it. There are no localities in Milan which can be said to be the special seats of fever. There are no parts of the city which can be called "*fever nests*." The disease, when it occurs, breaks out in all parts of the city indifferently.

Fever does not specially prevail near the canals. The Sevese and the Vettabbia are no exceptions. There is no special disease and no unusual prevalence of disease in the closest neighbourhood of the Vettabbia and the Sevese in any part of their course through the city, but there are occasionally cases of ague along the course of the canal.

Does not think the mode of removing the cesspool matter from the houses has any injurious effect upon the inhabitants of the houses or the neighbourhood, nor upon the men employed in this service. It is disagreeable work but not unhealthy. Now and then, indeed, it occurs that men who imprudently go into the cesspools are asfixiated, and die on the spot.

Does not think the distribution of the cesspool matter on the lands cultivated as market gardens has any injurious effect on the population of the immediate neighbourhood. Has never observed fever or any other special disease to be produced by it.

It is in accordance with the whole of his observations and experience that the application of the cesspool matter to the market gardens in the neighbourhood of Milan is practised without any appreciable injury to the public health.

If any special injurious consequences were produced by this practice, he could not but be made acquainted with the fact, from his position as the head of the hospital which receives the sick indifferently from every part of the city and neighbourhood.

Intermittent fever is not endemic in the city of Milan. Does not believe it is ever produced by causes existing in the city itself. Occasionally cases of it occur there, but they are cases that come either from the country, or from the suburbs near the irrigations. Has no doubt that ague and other diseases that arise from marsh miasma are peculiarly prevalent in the immediate neighbourhood of the (*marcite*) meadows and other irrigated lands, but in the latter in by far much less proportion.

(Signed) ANDREA VAGA, M.D.

Milan, November 21st, 1857.

APPENDIX No. 3.

GIUSEPPE BIANCHI, M.D., PHYSICIAN of the COMUNE DEI CORPO SANTO DI MILANO SECONDARIO DI PORTA TANAGLIA.

1. YOU are physician of the suburb situated out of the Porta Tanaglia, called Borgo degli Ortolani?—Yes.

2. That is the suburb of the market gardens?—It is.

3. How long have you practised in this quarter?—Twenty-one years.

4. Your practice lies among the poor as well as among the wealthier classes of this quarter?—Yes.

5. You are well acquainted with the condition of the people of this quarter, and with their state of health?—Quite well acquainted.

6. Is not this the principal quarter in which the people live who remove the cesspool matter from the cesspools of Milan?—Yes, it is the principal one.

7. Does this afford a fair specimen of the condition and health of the inhabitants in the other quarters in which this occupation is carried on?—Yes, quite.

8. Is not the cesspool matter removed from the houses in covered carts?—Not always exactly so, and that from carelessness.

9. Are not these carts when full taken to the yards belonging to the men who remove the cesspool matter?—They are; but many times they are taken directly to the fields.

10. How long do the carts while full remain in the yards?—A few hours, very seldom a few days, and the latter against the strict regulations of the Board of Health.

11. Is any disagreeable smell given off from the carts while they remain in the yards?—Not so much as can be thought, as the smell comes out very strongly when the matter is moved.

12. Are the yards in which these carts are kept surrounded by dwellings?—Yes, they are.

13. Are the inhabitants of this suburb in general poor people?—Yes, generally speaking.

14. Do they generally earn enough by their employments to obtain sufficient food and clothing?—Yes, because greens and other vegetables are rather dear.

15. Are you acquainted with anything in the occupations of these people, or in their social circumstances, calculated to affect their health injuriously?—I am completely unacquainted with any.

16. What are the diseases most prevalent amongst them?—There are truly no prevalent peculiar maladies, so that I can say confidently that there is no difference with the town in general in this respect.

17. Are epidemic diseases, such as typhus, typhoid, scarlet, miliary fevers, small-pox, cholera, peculiarly prevalent in this suburb?—Generally speaking all those diseases are not in any way prevalent here; and if the cholera was in that quarter rather strong that cannot be derived from the management and removal of the cesspool matter; first, because in 1836, when the cholera was prevalent (July and August), there was no removal of the matter, as that is quite prohibited in summer; and, secondly, I observed a great number of cases of cholera in houses of which the inhabitants do not occupy themselves with the cesspool matter; and on the contrary, I saw many houses being free from cholera, notwithstanding that the only occupation there was the management of that stuff.

18. Are such diseases peculiarly prevalent among the inhabitants who live immediately around the yards in question?—Not at all.

19. Can you state the infant mortality in this suburb?—In the first two years the mortality of infants is a little more than the third part of the total mortality of the suburb. Carrying on the amount till the seventh year, the mortality is two-fifth parts of that of the total one.

20. Can you state the average age at death?—The average mortality would be twenty-eight years, which number, I think, will not surprise you, taking into account the considerable mortality of infants.

21. Can you tell whether the general mortality is greater in this suburb than in other quarters of Milan? If so, how much greater?—It is less by one per cent. as compared with the general mortality of Milan. It is two and a half per cent.

22. Are there any houses close to the fields or market gardens where the cesspool matter is distributed?—Yes, but not in great numbers, as the matter is rather distributed in the market gardens and fields, which extend for a mile and a half. But wherever the market gardens are near the houses the matter is spread over them as much as is necessary.

23. What is the state of the health of the people who live in this immediate neighbourhood?—As good as that of the inhabitants of the suburb itself. There is no difference.

24. Have you observed any injurious effects upon the health of these inhabitants generally distinctly traceable to the application to the land of cesspool matter?—No, never. Decidedly the cesspool matter is unpleasant to the nose, but quite uninjurious for the health.

25. Have you observed any injurious effects on the health of the women and children in particular?—Not at all; but I think I ought to say that, if the mortality of children is so great (as above mentioned), it does not at all depend on the effect of the cesspool matter, but on the extreme carelessness of their parents, who do nothing at all when they are ill, and they call the doctor only to obtain the certificate of death. The strong mortality of the children is the cause of the high average of death.

26. Does the retention of the carts in the yards cause any degree of discomfort to the inhabitants, and has it ever been complained of as a nuisance?—Disagreeable it is, of course, but it has never caused nuisances of any kind, nor has it ever been complained of.

27. Does the distribution of the cesspool matter in the fields and gardens cause any discomfort in the neighbourhood, and is that ever complained of as a nuisance?—My answer is the same as that to the last question.

(Signed) GIUSEPPE BIANCHI, M.D.

Milan, November 22nd, 1857.

APPENDIX No. 4.

LAZZARETTO MILANO.

ANTONIO CAPELLI, M.D., Milan, November 20th, 1857.

YOU have practised as a physician in Milan many years?—Upwards of twenty.

You are well acquainted with the Lazzaretto?—Yes; I lived close to it several years, and had constant opportunities of making myself acquainted with the condition of the inhabitants.

Since your removal from the immediate neighbourhood you have still had opportunities of observing the state of health of the place?—I am frequently called there in cases of sickness, in consultation.

How long is it since the Lazzaretto has been used as a place for performing quarantine?—Not since the great plague in 1630. When cholera was epidemic in Milan, it was in contemplation to use it as a hospital for cholera patients, but the design was not carried into effect.

How many acres of ground are enclosed within the walls of the Lazzaretto?—Two hundred and twelve pertiche (about 34 acres).

What is the amount of the population?—Six hundred and fifty souls.

What are the occupations of the residents?—They are of all kinds, mechanics, carpenters, blacksmiths, butchers, shoemakers, lucifer-match makers, candle-wick makers, &c., &c. There are also a great number of washerwomen who live and carry on their work here.

They are in general poor people?—Some of them are very poor, but there are many in comfortable circumstances.

Are they an industrious people?—They are, and commonly they are fully employed, three-fourths of them at least.

Do they generally earn enough by their industry to obtain sufficient food and clothing?—The greater part of them quite sufficient.

What is the condition of their houses?—Commonly each house consists of two rooms, one on the ground floor and the other immediately above. Originally each compartment consisted of a single room only; but this being of unusual height it was divided into two by carrying a floor across from wall to wall.

Have you observed anything in the condition of the residents of this locality, in relation to their food, clothing, or occupation, calculated particularly to injure their health?—No, not anything.

Have you observed anything in the state of their houses calculated to injure their health?—Yes; the universal want of cesspools,* the general want of light, particularly in the upper room, and the dampness of the ground floor. These circumstances I regard as unfavourable to health.

In the absence of the cesspool to what have the inhabitants recourse?—To the open air. This is universal among men, women, and children. What is from necessity retained for a time within the house is thrown, on the first opportunity, into the pure running stream† in the foss that surrounds the building.

The ground within the walls of the Lazzaretto is now converted into irrigated meadows (Marcite)?—It is.

How long has it been so used?—Twenty years.

Is the irrigation within the walls of this building carried on in the same way as irrigation generally?—It is precisely the same. In the principle of construction, in the disposition of the ground, in the quantities of water used, in the season of using it, and in the times of applying it, there is no difference whatever.

Is not the house refuse of the inhabitants mixed with the water of irrigation?—Not any of it; it is not possible so to use it.

Then what becomes of the house refuse?—It is partly given to the air, as I have already stated, being deposited before and about the houses, and what remains is thrown into the surrounding foss.

Is not the refuse water of the washing which is so extensively carried on here used in irrigation?—Yes, the refuse of the washings, the soap, and the lixivium are mixed with the water of irrigation.

Then the only difference between the water used in irrigation within the walls of the Lazzaretto, and that used in irrigation generally, is, that in the former case the washing refuse is mixed with the irrigating water?—That is the only difference.

So that the ground within the Lazzaretto, as now treated, is in point of fact a winter meadow (Marcita)?—Just so.

Have you observed any influence on the health of the inhabitants from this use of the ground?—A most decided one.

In what respect has it acted injuriously on the health?—First, in producing every kind of ague; secondly, in producing the other forms of disease due to marsh miasma, such as neuralgia,

* Dr. Capelli regards the cesspool as a safer receptacle for cesspool matter than the open ground.

† With this exception, this stream receives no sewage matter.

rheumatism, chest inflammations (pleuritis), &c. ; thirdly, in some-times producing pernicious remittent fever, which often kills in a few days.

Are such diseases frequent among these people?—Very frequent indeed.

Is the health of infants and children more especially affected?—Yes, most especially, as is shown in the unusual prevalence among them of scrofula and rachitis.

When epidemic diseases prevail in Milan, such as typhus, scarlet fever, measles, miliary fever, small-pox, &c., are the inhabitants of the Lazzaretto more subject to these diseases than others of their class?—I have not observed much difference ; but the inhabitants of this place form a very inconsiderable portion of the population. The injury to the health in their case has reference to endemic rather than to epidemic disease.

That is, to those forms of disease which are recognized as the products of marsh miasma?—Just so.

You have stated that the condition of their houses has, in some degree, an unfavourable influence on the health of the inhabitants, from the want of the proper means of disposing of the house refuse, from want of light, and from dampness ; do you suppose that these circumstances act by increasing the susceptibility to malaria, or in what other way?—If these conditions were entirely absent, if the houses were of the best kind, the people would be affected in the same manner, though perhaps in a less degree. These unfavourable conditions do exert some influence in increasing their susceptibility generally ; but those who live in the best houses in this neighbourhood, and who are comparatively rich, are by no means exempt from the influence of the malaria ; on the contrary they feel it very sensibly.

Have you observed whether the ordinary organic diseases produced by marsh miasma, such as enlargement and hardening of the liver, enlargement of the spleen, and dropsy are common diseases among the residents in this place?—Certainly they are ; it must inevitably be so.

Then is it the result of your observation and experience that the diseases you have named are produced generally wherever irrigation is carried on close to human habitations?—Everywhere ; it is so inevitably.

It has been thought that a continual motion or flow of the water over irrigated land lessens the unhealthiness of irrigation ; have you made any observation with reference to this point?—The flow of the water in the Marcite, slow as it is, is yet in constant motion, and that circumstance appears to render the Marcite less pernicious than irrigated grounds where the water is always perfectly stagnant, as the rice fields.

Irrigation has been gradually brought nearer and nearer to the city, has it not?—It has.

Is no apprehension entertained of danger to the Public Health from this?—So much so that the authorities have entertained a

project, which they have submitted to the Emperor, to prevent any nearer approach of irrigation to the city, and gradually to remove to a further distance that which has been brought close up to the wall; that plan is not a new one. It engaged the attention of the authorities of the town so long ago as the year 1810, during the government of Napoleon, and had nearly become the law of the land, but was not completed. Since that time the conversion of land into meadows of irrigation, and particularly into winter meadows (Marcite), has been a steady and constant encroachment, but altogether unauthorized. The increase in the value of property by this mode of disposing of the land is so great, that it is difficult to resist the temptation.

Has the close approach of irrigation to the city as yet exerted any manifest injury on the Public Health within the city?—Not at all; it is only the immediate neighbourhood to which the irrigation has been brought that has sustained injury.

Then is it the result of your observation and experience that the injurious effects of irrigation are local, and restricted within a narrow compass?—It is strictly so; that is the universal experience.

Has experience yet shown within what distance safety is secured?—Not with any great exactness; but all our experience goes to show that a population residing at a distance of a quarter of a mile, would be unaffected.

Are not persons coming from a healthy district, that is, from one in which there is no marsh miasma, particularly susceptible to the influence of the malaria arising from irrigation?—They are peculiarly so.

Have any facts come under your own observation illustrating this?—Yes. I may mention one striking example of it. A friend of mine having been transferred from Verona to Milan came to reside with his family at the Veterinary Institution, which is situated about the third of a mile from the Porta Orientale. Both he and all the members of his family felt so much the influence of the malaria arising from the neighbouring irrigations, that they all in succession became attacked by intermittent neuralgia, rheumatism, dyspepsia, &c.; and it is remarkable that whatever kind of sickness occurred in this family during their residence in this place, even such maladies as hæmorrhagies, pleuritis, &c., required quinine for their cure; and without quinine, or some medicine of this class, it was impossible to cure the malady. This family never became acclimated. They were obliged to give up their house and remove into the city.

Is the land within the Lazzaretto artificially drained?—No, there is no underground drainage, nor is such drainage in use in irrigation generally.

What amount of produce is obtained from the land within the walls of the Lazzaretto?—Six or seven crops; six usually, seven often, and sometimes eight. This is independent of the cattle fed upon it, and of the produce of the withy plantations.

Do you know the rental?—Twenty thousand francs, or twenty-four thousand swanzigers per annum.

Was this locality particularly affected by cholera?—Not particularly; there were sixteen cases during the last epidemic.

To whom does the Lazzaretto belong?—It is the property of the "Ospitale Maggiore."

Are the sick in the Lazzaretto in the habit of seeking relief at this hospital?—Some of them, being poor persons, go there when ill, but others prefer to remain at home, and are attended at their own houses by the doctor that belongs to that Corpo Santo.

(Signed)

A. CAPELLI, M.D.

To you know the rental?—Twenty thousand francs, or
 twenty-four thousand francs per annum.
 Was this rental particularly affected by cholera?—Not
 particularly; there were certain cases during the last epidemic.
 To whom does the property belong?—It is the property of
 the "Hospitals."
 Are the beds in the hospitals in the habit of seeking out as
 this hospital?—Some of them being poor persons go there when
 ill but others prefer to remain at home and are attended as
 their own houses by the doctor that belongs to that City House.

(Signed) A. CATTELL, M.D.

LONDON:
Printed by George H. Lane and William Hooton,
Printers to the Queen's most Excellent Majesty,
For Her Majesty's Stationery Office.

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Printed by GEORGE E. EYRE and WILLIAM SPOTTISWOODE,
Printers to the Queen's most Excellent Majesty.
For Her Majesty's Stationery Office.

SEWAGE OF THE METROPOLIS.

SEWAGE COMMISSION.
1857-8.

