

The sewage question : with remarks on a little suspected, frequent, and not easily detected source of typhoid and other zymotics / by Andrew Fergus.

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THE
SEWAGE QUESTION,

WITH
REMARKS ON A LITTLE SUSPECTED,
FREQUENT, AND NOT EASILY DETECTED SOURCE
OF TYPHOID AND OTHER ZYMOTICS

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1872

THE

SWAYNE QUESTION

REMARKS OF A LITTLE PRACTICAL
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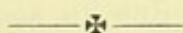
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STATE OF NEW YORK AND OF THE
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PREFACE.



I HAVE to apologise to my readers for presenting them with two papers, in the second of which so much of the first is reproduced.* My reason for giving the Leeds paper entire is to show that the evil effects of sewer gas were well known, and that attempts had been made to draw attention to the subject before the illness of the Prince of Wales. I had done the same at Newcastle the previous year—but on both occasions, engineers and others in favour of sewage irrigation, were in the ascendant, and insisted that when we have tubular drains we have little to fear. As far back as the month of October, 1868, I directed attention to the subject at the Meeting of the Glasgow Medico-Chirurgical Society, but the Profession, with a unanimity rarely exhibited by it, condemned the views brought forward on that occasion.

One speaker remarked that “Dr. Fergus’s whole argument virtually resolved into a strenuous denunciation of the modern water closet system.” Again, the same speaker says, “It was in places where there were no sewers that they were to look for the noxious gases so much spoken of.” The next gentleman

* In reading the Second Paper, pages 7 and 8 may be passed over.

said, "He also believed that the quantity of noxious emanations from the sewers must be very trifling indeed;" also, that "Dr. Fergus was rash in his assertion that these emanations were the cause of gastric and other fevers." A third speaker said, "He would not join with Dr. Fergus in believing that the production of sewer gases was the cause of fever;" and the last speaker, the Medical Officer of Health, said, "With regard to fevers, he (Dr. G.) considered it well established, that enteric fever in certain cases is due to sewer gases, but so far as Glasgow is concerned, this evil was not of any very great amount."—(*Glasgow Medical Journal*, Nov., 1868.) Seeing that the Medical Officer had for more than five years held his office, and was, moreover, chairman of the meeting referred to, and therefore, in a very responsible position when the discussion took place—I was surprised that he should know so little about the evil effects of sewer gas. If it were not too serious a matter it would be amusing to contrast the above opinion of the Medical Officer, with the same gentleman's recent memorandum to the Police Board, (see *Herald* of Jan. 20th), in which he says, "That even the best constructed sewers may become, under circumstances of very frequent occurrence, magazines of offensive and deleterious gases." No one agreed with me when I described modern sewers and cesspools as gigantic laboratories for the production of sewer gas—the Medical Officer *now* admits they may be so—but uses the word magazines, *i. e.* storehouses. The term "laboratories" seems to me better, as indicating that the gases are there produced.

It may be useful to contrast the Medical Officer's opinion in 1868, with what it was in 1872. In the former year he seems to have had no idea of the decomposition going on in the sewers, as he then speaks of the modern water-closet as a "great luxury," as it gets "instantly rid of the foul matter."

—Page 127. However, to do that gentleman justice, we shall quote his opinions in parallel columns.

1868.

"It was *accurately* stated that the evils inseparable from the W. C. system were likely to be less felt in Glasgow than in many other places, *owing to the considerable fall of the greater number of the sewers*, and the almost unlimited supply of water by which the matter was diluted."

GLASGOW MEDICAL JOURNAL,
November, 1868.

1872.

"It has been conclusively shown, that houses presumed to be beyond suspicion of any possible danger to health from this cause—houses in which the most skilful engineers and architects had, as they believed, exhausted the resources of modern sanitary science—have, nevertheless, been exposed in a high degree to the diseases arising from air in contact with the products of decomposition in the sewers. And this for a very obvious reason. *Such houses are usually built on high levels, where the drains have a very rapid fall.*"

The italics (which are our own) show that in 1868 the rapid fall in the sewers preserved Glasgow from sewer gas,—in 1872, the same rapid fall renders houses in high levels "exposed in a high degree to disease."

The Medical Officer kindly offers to give every assistance to overcome inertia on this matter—but whence came the inertia—or why complain of it, when, after five years' service, he himself tells us in 1868 that Glasgow has little to fear from sewer gas? How have the sewers become so bad since then—what are the grounds of the Medical Officer's sudden change of opinion—and what confidence can the public, or public authorities have in his leading?

There is matter of congratulation that the Medical Officer is now alive to this "ever-abiding source of danger;" but it is a pity that so many years have elapsed meanwhile, and so many

valuable lives sacrificed. After carefully reading and re-reading his very well written memorandum, (albeit of opinions held by others long ago), I do not see one word to tell us how these noxious gases are produced, and, if we are ignorant of this, all our remedial measures must be entirely empirical, in fact, groping in the dark; and under the influence of panic and ignorance works will be ordered to be executed, which a fuller and truer knowledge of the subject would have shown to be inadequate to meet the danger.

I should like to know how much the facilities for sewer gas getting into houses have been extended by the enforced introduction of water-closets and sinks, and whether this was done by the order or with the sanction of the Sanitary Office, acting under the instruction of the Medical Officers.

In 1868 I condemned the introduction of water-closets into workmen's houses, and I observe that Dr. Littlejohn, Medical Officer of Health for Edinburgh, is of the same opinion. He says, "That if they took a range of houses where this had been done, in the course of one year there were double the number of deaths from typhoid and scarlet fever; and any epidemic fever occurring in these houses was intensified, and assumed a character of malignant mortality."—(*Edinburgh Daily Review*, January 18.)

As to remedial measures, I would suggest the following:—

1st. That all soil pipes should be carried up to the roofs of the houses, and left quite open to the external air, and, if possible, the soil pipe should also be used to carry off the rain water from the roof. Landlords would be more than compensated for this expenditure, by the increased duration of the soil pipes.

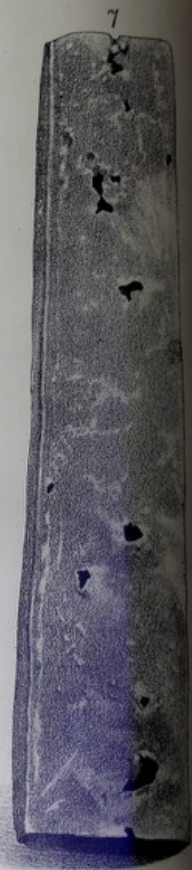
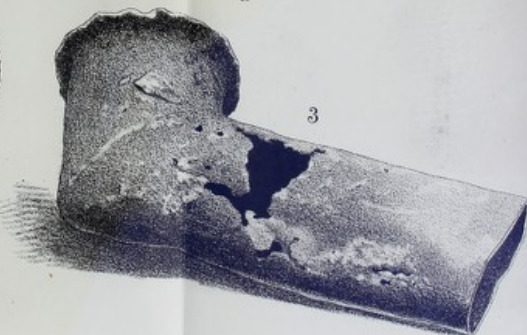
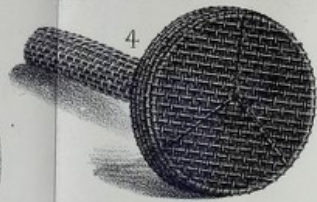
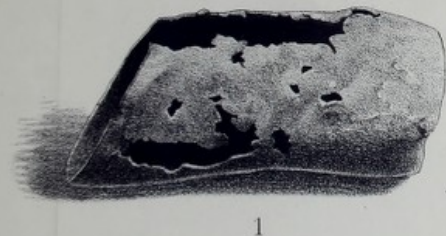
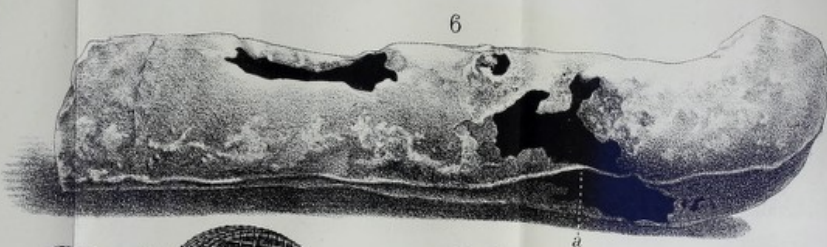
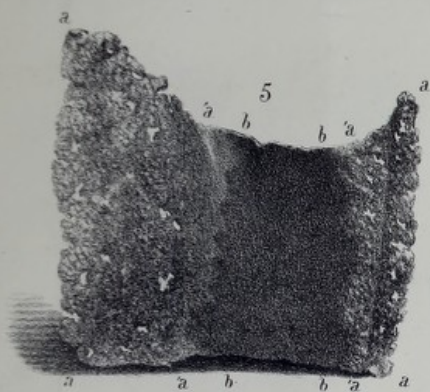
2nd. Water for domestic use should be taken from the main.

3rd. Where cisterns are still in use, a charcoal cage, to be refilled from time to time, should be placed in the overflow pipe; or, better still, the overflow pipe should not be connected with the sewers, but should pass directly to the back of the house, and any overflow would be at once detected.

4th. All over the city, and especially at the highest levels, the sewers should be connected with the furnaces of some of our large public works. More than three years ago I proposed that this should be done, so that all the foul air from the sewers should be burned.

But all these would be mere palliatives—I hold that the only true sanitary solution of the question is—that provision be made to keep all excreta and organic refuse out of the sewers and water courses.

PLATE OF DECAYED SOIL PIPES &c
REFERRED TO IN DR FERGUS' PAPER.



SANITARY ASPECT OF THE SEWAGE QUESTION;

WITH REMARKS ON

A LITTLE-NOTICED CAUSE OF TYPHOID FEVER, AND OTHER ZYMOTICS.

By ANDREW FERGUS, M.D., ETC., GLASGOW.

(Read before the Medico-Chirurgical Society of Edinburgh, and reprinted
from the Edinburgh Medical Journal for February 1872.)

I BEGAN the study of this question long ago, with a mind thoroughly unprejudiced on the subject. The longer I study the matter, and the more I read, I become more and more convinced that our present system of water-carriage is a mistake, and was begun in ignorance of the results that would flow from it. It is, moreover, very wasteful, and highly deleterious to public health. I hold with Lord Palmerston that "dirt is merely useful matter in a wrong place," and that, if we would only observe the economy of nature, we would find there is no loss, no such thing as waste; but that, on the contrary, what is superfluous in one order of organized nature is food for another.

Thus, we see that the secretions given off by animals involuntarily are utilized; as, for example, the carbonic acid given out so abundantly by animals is absorbed by plants. Some secretions, however, are left under our own control, and in the disposal of these we experience great difficulty, simply, as I believe, because we do not adopt the method pointed out to us by nature. Earth being the original parent, everything taken from it should be restored to it again—the true rotation is, from earth to plants, from plants to animals, and from animals back to the earth again. We have

DESCRIPTION OF PLATE.

FIG. 1.—Pipe removed from a house where there was typhoid. Two months before it was taken out, the water-closet had been renewed, but the plumber had failed to detect the state of this pipe.—P. 7.

FIG. 2.—A piece of lead soil-pipe slightly corroded, which entered an iron pipe below a water-closet. The iron pipe much perforated, allowing an escape of sewer-gas, which produced fatal diphtheria.

FIG. 3.—Perforated soil-pipe from house where party died of phthisis.—P. 6.

FIG. 4.—Wire cage, filled with seaweed or other charcoal, to put into the overflow pipe of cistern.—P. 8.

FIG. 5.—Soil-pipe laid open, in which, so numerous were the perforations, that very little of the lead required to be cut. The sides *a a*, *a a*, are irregular owing to these perforations, and they may also be seen over the whitish part. The spaces between *a a* and *a a* are the parts of the soil-pipe covered with the whitish deposit spoken of in the paper. The part within the *b*'s is the lower segment of the pipe over which the sewage flowed. It is quite sound—not in the least decayed or worn.—P. 5.

FIG. 6.—Pipe from Edinburgh. It will be noticed that the solder has not decayed, *a*.—P. 7.

FIG. 7.—Main descending soil-pipe, showing the perforations.

not followed this rotation of nature, and hence all our difficulties have arisen.

Those excretions which have a high commercial value, and would materially assist in enriching our land, we have passed into our rivers and streams, rendering these in many places nothing better than cesspools.

I adduce in proof of this, the condition of three rivers—the Thames, the Tyne, and the Clyde. On both banks of the Tyne there are a vast number of chemical works; I am told that 45 per cent. of all the alkali made in Britain is manufactured there, and that the manufacturers are in the habit of passing the refuse matter into the river in a much more acid state than elsewhere; yet, three years ago, I saw salmon passing quite freely to the upper reaches of the river.

In 1847, an Act was passed compelling all the privies, etc., of London to be drained into the river, and we all know how soon it became foul. On the Clyde we have plenty of chemical works, but in Glasgow alone about 32,500 water-closets; and I think it is a fair inference to deduce, that these are the chief causes of the pollution of the river. Salmon passed freely up until the rapid introduction of water-closets.

All organic matter, *i. e.*, matter capable of putrefaction, is injurious. I shall only give one instance of this sort of nuisance, *viz.*, pot ale from distilleries. Mr Smith tells me that from one of these distilleries there are 500,000 gallons per week, each tun of which contains organic matter to the value of 3s. 6d. a tun. Now, if a law was passed, excluding all organic matter or refuse from the sewers, it would compel the proprietor of this distillery to make a large revenue from what he now wastes, and by which he creates a nuisance.

The question arises, Is the condition of rivers, when loaded with organic refuse in a state of putrefaction, injurious to health? Bad as they are, and utterly shocking in an æsthetic point of view in summer, I really do not think that they are so. The question has been often discussed, but I have never yet heard anything going to prove that rivers in this state were hurtful to health, neither do we find that the diseases which proceed from excremental pollution prevail in the neighbourhood of rivers which are thus befouled. I should like this to be distinctly and clearly borne in mind by those gentlemen who take an interest in sanitary matters, because if they look merely to the purification of rivers, the result will be unsatisfactory, inasmuch as though the rivers *were* rendered quite pure, there would be no gain as regards the health of the community. I hold, that if we wish to purify our rivers, diminish the death-rate, and improve the health of the water-closet towns, we must stop the decomposition of excreta and other organic matters in the sewers, from which gases capable of producing disease arise.

Fresh excreta are not injurious to health, it is only when they decompose that they are so; and the most favourable circumstances

to facilitate this are, that they should be placed in narrow passages, with a limited supply of air and water.

In a word, our cesspools and sewers are ingeniously-contrived chemical laboratories for the production of sewer-gas.

I wish I could bring to the surface, and exhibit to you in all their hideousness, the sewers of any large city. We should find them of great variety, viz., old water-courses arched over; and the sewers, some circular, some oval, and, I fear, still some square. At the bottom of most of them we should find a thick, blackish, tenacious mud, and flowing over it a dirty, sluggish stream, slowly, silently, yet continually giving out sewer-gas. Sinking the sewers to their unsightly bed, let us look at the manner in which they are connected with our houses by water-closets more or less out of repair, and more or less imperfect, some of them being merely pipes, with no pretence of a pan, passing directly into the sewers, and thus becoming a source of danger. Another source is by means of fixed basins or sinks, some of them in our bedrooms, and within a few feet of our beds.¹

I may be told, perhaps, to trap and ventilate the sewers, but, of course, if we trap in one place we but leave more to escape in another; in fact, this would only be to exclude a poisonous gas from our own houses that might find its way into our neighbour's, who, perhaps, might not be so well protected. Ventilation is not easy, and is very costly. Mr Bazalgette estimates that the ventilation of the sewers in London would cost £460,000, with an additional annual expense of £201,480 for fuel, exclusive of labour; flushing with water would cost £381,250.²

Supposing that we have trapped our sewers, and carried a ventilating pipe to the roof, we have not destroyed the poison, but merely diluted it. Instead of passing into our houses, it passes over them, and must have an injurious and lowering influence on the health of the surrounding inhabitants, the air being thus more or less contaminated.³

¹ When talking over this subject with the late Sir James Simpson, he told me of a row of houses which, by way of being *improved* (?), had sinks placed in them. Typhoid fever had up to that time been unknown in these houses, but very soon afterwards it broke out, and passed through the whole range.

² More than three years ago, I made a proposal to ventilate the sewers of Glasgow, by having them connected with the furnaces of some of the numerous public works in that city, which could have been done with very little cost.

³ To show how slight a contamination of air will produce disease, allow me to mention a case which came under my own observation a few weeks ago. A youth was fishing for, and caught two trout; fourteen days afterwards (period of incubation) symptoms of typhoid fever appeared. His father, a most observant and intelligent medical man, remembered that a sewer, entering the stream near where his son had been fishing, had been opened for repair at the time; therefore, although the sewerage was not strong enough to kill the trout, the atmosphere was so tainted that its inhalation produced typhoid fever. I made particular inquiry into this case, and found that the youth had not drunk any of the water of the stream; neither, so far as was known, had he been in any other way exposed to the result of excremental pollution.

This sewage gas is always being formed, is generally lighter than air, and frequently hotter. It follows that it must often be in a state of tension, that it will ascend, and, if possible, escape at the highest point. When it does so into the streets, if the outside temperature is very low, we shall see the watery vapour condensed like steam.

Many people rush quickly past these sewer gratings in a cold winter day to avoid the pestilential vapour, and greatly pitying the poor people who are obliged to live in such a neighbourhood; never suspecting that the very same vapour may be entering their own houses, although invisibly, owing to the higher temperature within.

It may be asked, How can this gas get into our houses if the water-closets are in perfect working order, and the drains in good condition and well trapped? I answer, that it is not easy to trap the drains thoroughly. People imagine that if they have a few inches of water in a bent tube, dignified by the term "syphon trap," that no air can pass into their houses from the sewers; and certainly there will not, so long as the pressure is equal on both sides of the water in the bent tube. But if rain rapidly fills the drain with water, or if the drains open into a tidal river, at the time of high water there is a great pressure on the air in the sewer, and it forces its way into our houses through any trap that has yet been invented. The gas being in a state of tension will escape as the barometer falls. In familiar illustration of this, we sometimes hear people predicting rain from perceiving a disagreeable odour; and correctly so—the falling atmospheric pressure being the precursor of rain as well as the liberator of the sewer-gas.

This contamination of air in sewers will vary in different localities and at different seasons of the year. Generally the amount of oxygen is diminished; and we find as impurities in air from sewers—carbonic acid, light carburetted hydrogen, sulphuretted hydrogen, and foetid organic matter, which last is probably the principal cause of the extreme unhealthiness of sewer air. At the Sewage Conference at Leamington, one of the most philosophical physicians (Dr Benjamin Richardson) gave a list of fifteen diseases that may all pass from, or be conveyed by, sewage.¹

When we look back to the epidemics of the middle ages and some centuries ago, we readily acknowledge that, if they were not directly caused, they were enormously aggravated, by the habits of the people. If any of these epidemics reappear, why should we not attribute it to the same cause? We are given to congratulating ourselves on having, by our improved sanitary arrangements, got quit of the plague, sweating sickness, etc., etc.; but if some

¹ Dr Richardson's Table of Diseases from Organic Poisons:—"The diseases which may be produced by the organic poisons are as follows:—Smallpox, measles, scarlet fever, diphtheria, typhus fever, typhoid fever, erysipelas, hospital fever, puerperal fever, cholera, yellow fever, ague, glanders, boil and carbuncle, infectious ophthalmia. This is a long list of diseases, amounting to fifteen in number, mainly traceable to the poisons which, as I have said, may pass from the sewage."

bypast and long latent epidemic reappears, why should we not look to the same cause as before as its probable generator? or why should we not inquire if some of our present and most fatal epidemics may not be produced by, or owe their intensity to, a similar origin?¹

Mr Simon very pertinently asks why diphtheria, which scarcely had a place in history till it overran Europe in the sixteenth century, and which since then has scarcely been spoken of, should recently have become an important disease in England?²

The answer to Mr Simon's question is simply this:—We have been careless in the disposal of our excretions, and have been drinking water or breathing air contaminated with excretal matter in a state of decomposition. For details proving this, as regards outbreaks of diphtheria, I refer to the Second Report of the Medical Officer of the Privy Council—see pages 167, 168, 171, 172; and in the Eighth Report, page 251. Typhoid fever, killing in England 15,000 to 18,000 people annually, is another disease resulting from excremental pollution.

All modern investigators agree in this; and there is seldom a week but in one or other of the medical journals we do not find an account of some outbreak of zymotic disease from excremental pollution.

In the last Report of the Medical Officer to the Privy Council, published a few months ago, I find a table of the places visited by the Inspectors owing to increased death-rates. The total number of places so visited is 66; but 6 of these being double entries, reduces the number to 60; and in 50 of these the increased death-rate was traced to excremental pollution, producing typhoid fever in 49 and scarlet fever in 16 of these infected places.

In most of these cases the water was befouled; but as this is so well known as a cause of disease, and has been so amply proved, I shall not dwell upon it, but rather enter somewhat more in detail on another source of typhoid and other zymotic diseases which is not so well known, and cannot so easily be guarded against.

About fifteen years ago I first detected perforated soil-pipes. At first I merely looked upon them as a nuisance, because offensive, and did not connect them with disease; neither did I then know how these perforations were produced.

In the first pipes I inspected, as the perforations were on the upper side, I imagined that pieces of lime might have dropped down on the pipes and eaten their way through. This opinion I abandoned, as I found the perforations were from within. I also found that they were generally on the upper surface of the pipe, and that,

¹ It may be mentioned here that cholera did not prevail in this country till after the adoption of water-closets; neither had diphtheria been epidemic for 200 years till we adopted this system.

² I append a table, from which you will perceive that there are no deaths till 1851; in that year there were only 40, and till 1857 the numbers varied from that to 310. It then suddenly increased—reaching its maximum, 9587, in 1859. The total deaths till 1868 are 54,872.

therefore, the destruction could not be caused by fluid conveyed through it. I also observed that the pipe usually affected in this manner was the cross one, leading from the closet to the main descending soil-pipe; and that if there was a bend or arch in the pipe, the upper surface of the bend or arch would become perforated. Another element to be taken into consideration is, that these perforations are most frequently found in the upper flats of houses, and, occasionally, in the sides of the descending soil-pipes.

The question now arises, How is this destruction of good well-made lead pipes effected?

If we remember the position of this destructive action in the pipes, and take into consideration the results of chemical analysis,¹ as well as the increased rapidity with which this action takes place in pipes that are not ventilated, I think we are justified in coming to the conclusion that these results are owing to the action of sewer-gas. If you will carefully notice the specimens you will perceive that the destructive action is from within, and that in some places the pipes are more or less corroded even where the action has not gone the length of complete perforation (fig. 5).

Of course, my own discovery of such pipes in houses has only been where I have been attending professionally, and where the diseases were of such a type as are known to be produced by breathing the results of the decomposition of excreta. The diseases I have observed as resulting from this state of pipes are typhoid fever, diphtheria, scarlet fever, diarrhoea, etc.; and in one or two cases I have had to order the removal of families who were suffering from ill-health from this poison, without exhibiting symptoms of any well-defined disease. As the investigation of the causation of disease is carried out, I believe that the list already given of those diseases produced or conveyed by sewage will be increased. In two cases of phthisis in people long past middle life, I could not attribute the disease to any other cause. The family history was good, the mode of living correct, and the general health satisfactory up to the time of the soil-pipes becoming corroded (fig. 3).

About three years ago I was asked to visit the child of the superintendent of a large public institution. I at once suspected typhoid fever, which proved to be the case. I was, moreover, told that it

¹ By Mr Stamford's kind permission, I am enabled to give the analysis of the inner coating of these pipes:—

Carbonate of lead, . . .	2.70	86.00	91.00	92.90
Carbonate of lime, . . .	80.63	2.50	2.10	2.90
Water,	0.45	1.20	1.00	0.50
Lead insoluble as oxide, .	—	3.50	1.50	1.45
Silica,	1.35	2.80	1.00	1.60
Organic matter,	14.87	4.00	3.40	0.65
	100.00	100.00	100.00	100.00

The analysis No. 1 indicates that probably chloride of lime had recently been used to destroy the effluvia from the already perforated pipes.

had twice already been in this gentleman's family; and that the year before the whole family had suffered from diphtheria. On making inquiry as to the state of the drainage, water-supply, etc., I was told that the water was Loch Katrine, and so beyond suspicion. The master of works for the institution was a most intelligent man, who had paid special attention to the drainage. He had soil-pipes with extra depth of traps, indeed the deepest I have seen, and it was difficult to account for the manner of infection, the pipes being pronounced free from any defect; but, in a short time, another child was seized, as well as several of the officials of the institution. In passing a particular spot in the superintendent's house, however, I perceived a faint odour of sewer-gas; and, on mentioning this to him, he most promptly had the pipes uncovered, and perforations were at once discovered in the vertical soil-pipe.¹ This led to a complete overhaul of all the pipes in the house, and the removal of those that were defective; and since then I have not heard of a single case of typhoid or diphtheria in the establishment. Plumbers do not readily detect this defective state of pipes, as they look for a liquid leakage. Some time ago, in visiting a case of typhoid, I asked the mother of my patient as to the state of the closet and pipes. She replied, "Oh, Doctor, you are wrong this time; all these things were renewed only two months ago." Of course I was extinguished; but still ventured to inquire what might be the cause of a very perceptible, and by no means agreeable, odour. A dead rat was suggested as its possible origin. However, as it was no matter to trifle with, I requested that the plumber might be sent for, and also that he should be told that the soil-pipe close to the cross-pipe was eaten away (fig. 6).

At my next visit, the lady told me that the plumber had been very much astonished to find the pipe exactly in the state I had predicted. I now exhibit the pipe. I have been told that this state of pipes must be peculiar to Glasgow, and must be produced by some chemicals getting into the sewers; but I have made many inquiries, and find the same thing existing in every water-closet town in reference to which I have had information. This, the worst specimen on the table, is from Edinburgh, where there are few chemical works (fig. 6). Lead has generally been used as the material for soil-pipes, and as we have seen how capable it is of corrosion, it becomes a very important sanitary question to inquire how long a good lead soil-pipe will hold out. I have been studying this question for several years, and it is now about five since I first exhibited pipes in public, yet I would not wish to dogmatize on the subject, but rather give approximations, and would remark that the time will vary under the various circumstances according to the strength and rapidity of flow of the sewage, as well as the original thickness of the pipe. But after allowing for this, we must broadly distinguish between soil-pipes which are ventilated and those which

¹ I would by no means be understood to say that smell, merely as such, produces disease; it is simply a quality of what in this case does so.

are not. By the former I mean when the pipe is carried up to the roof of the house and open to the external air; by the latter I mean when the pipes are closed up. Of these last mentioned, the duration may be stated to be about twelve years, the extremes of variation being from a minimum of eight to a maximum of twenty years.

In ventilated pipes the duration may be stated to be nearly double, running from twenty-one to twenty-three years, the extremes of variation being from eighteen to thirty or even more years. The practical sanitary conclusion which it concerns us all to keep in mind is, that any house, no matter how carefully and well built, may become unhealthy from this source, and that when cases of typhoid fever, diphtheria, etc., occur, the pipes should be thoroughly inspected—especially their upper surface—and the whole of the soil-pipe uncovered.

I must strongly insist on this, as in many cases the plumbers have declared the pipes to be all right, which turned out to be very defective when uncovered. For some years back, I have insisted on a careful examination of the soil-pipes wherever I have cases of typhoid or diphtheria, and in every case where I could get this carefully carried out, I have detected these perforated pipes.¹

What first led me to connect this state of soil-pipes with disease was the fact that, as regards water-supply, Glasgow should not be exposed to diseases resulting from excremental pollution; and if we have these diseases, we must attribute them to some other source.

Another way in which sewer-gas may act injuriously, is by its passing up the waste-pipe of the cistern, and becoming absorbed by the water. In houses that have been shut up for a few months, this should be guarded against by running off all the water, and clearing out the mud at the bottom of the cistern, before the houses are re-inhabited. I also propose to insert into the waste-pipe a long wire cage with a circular head, and to keep this filled with seaweed or other charcoal, which should be replenished from time to time (fig. 4). Of course it would be much better if all water used for cooking or drinking were drawn direct from the main.

It would prolong the duration of the pipe, and be an important sanitary improvement, if the soil-pipes were in every case carried up to the roof, and left quite open to the air. The expense of this would be more than compensated to the landlords by the greatly-increased duration of the lead pipes.

Another group of diseases arising from excremental pollution are the diarrhoeal, including cholera. I need not, I think, insist that this last disease is the direct consequence of taking into our system the results of excremental pollution. Instead of going into any proof of my own as to this, I shall quote from the admirable and vigorous language of Mr Simon. In the Eighth Report, page 39,

¹ Except in one case, where the patient had only returned a few days previously from the country, and where I found, from making inquiry, that the water in the country house was impure.

he thus writes:—"When cholera is epidemic in any place, persons who are suffering from the epidemic influence, though perhaps with only the slightest degree of diarrhoea, may, if they migrate, be the means of conveying to other places an infection of indefinite severity; but the quality of infectiveness belongs particularly, if not exclusively, to the matters which the patient discharges by purging and vomiting from his intestinal canal; that these matters are comparatively non-infective at the moment when they are discharged, but subsequently, while undergoing decomposition, acquire their maximum of infective power; that choleraic discharges, if cast away without previous disinfection, impart their own infective quality to the excremental matters with which they mingle in drains or cesspools, or wherever else they flow or soak, and to the effluvia which these matters evolve; that if the cholera contagium, by leakage or soakage from drains or cesspools, or otherwise, get access, even in small quantity, to wells or other sources of drinking water, it infects in the most dangerous manner very large volumes of the fluid; that in the above described ways, even a single patient with slight choleraic diarrhoea may exert a powerful infective influence on masses of population, among whom, perhaps, his presence is unsuspected; that things such as bedding and clothing, which have been imbued with choleraic discharges, and not afterwards fully disinfected, may long retain their infectious properties, and be the means of exciting choleraic outbreaks wherever they are sent for washing or other purposes."

Again, in Report Ninth, pages 33 and 34, Mr Simon thus powerfully writes:—"It cannot be too distinctly understood, that the person who contracts cholera in this country is, *ipso facto*, demonstrated with almost absolute certainty to have been exposed to excremental pollution; that what gave him cholera was (mediately or immediately) cholera-contagium—discharged from another's bowels; that, in short, the diffusion of cholera among us depends entirely upon the numberless filthy facilities which are let exist, and specially in our larger towns, for the fouling of earth, and air, and water, and thus secondarily for the infection of man, with whatever contagium may be contained in the miscellaneous outflowings of the population. Excrement-sodden earth, excrement-reeking air, excrement-tainted water—these are for us the causes of cholera. That they respectively act only in so far as the excrement is cholera-excrement, and that cholera-excrement again only acts in so far as it contains certain microscopical fungi, may be the truest of all propositions; but whatever be their abstract truth, their separate application is impossible. Nowhere out of Laputa could there be serious thought of differentiating excremental performances into groups of diarrhoeal and healthy, or of using the highest powers of the microscope to identify the cylindro-tæmium for extermination. It is excrement indiscriminately, which must be kept from fouling us with its decay.

"The local conditions of safety are, above all, these two—(1)

that, by appropriate structural works, all the excremental produce of the population shall be so promptly and so thoroughly removed, that the inhabited place, in its air and soil, shall be absolutely without fæcal impurities; and (2) that the water-supply of the population shall be derived from such sources, and conveyed in such channels, that its contamination by excrement is impossible."

"It is to be hoped that, as the education of the country advances, this sort of thing will come to an end; that so much preventable death will not be always accepted as a fate; that for a population to be thus poisoned by its own excrement, will some day be deemed ignominious and intolerable."

As regards diarrhœa, Dr Greenhow reports, and Mr Simon endorses his opinion, that the deaths from this cause vary from 4 in every 100,000 of the population, to 663 in the same number. He calculates that if the diarrhœal death-rate could be restricted in the whole of England to ten times the minimum death-rate of 4, there would be a saving of 20,000 lives annually, and there would be a great reduction in the deaths from typhoid fever also. Both Mr Simon and Dr Greenhow are of opinion, that the excess of mortality from these diseases has in all places been coincident with one or other of two definite local circumstances: (a) the tainting of the atmosphere with the products of organic decomposition, especially of human excrement; or (b) the habitual drinking of impure water.

Before turning our attention to remedial measures, allow me to remark, that water-carriage was adopted in ignorance of the results that would flow from it. It was known that water and air oxidize excreta, and it was supposed that we had nothing more to do than merely to pass these matters into streams to be rid of them. The result has amply proved that no river in the kingdom can oxidize the excreta of the towns on its banks. We have had our rivers rendered gigantic cesspools; and though many schemes have been proposed for the treatment of sewage, most of them have failed when brought to the touchstone of scientific research.

The plan of sewage irrigation has many advocates, and therefore I shall offer a few remarks upon it. No doubt it would in some degree utilize the sewage, but it would not in the least improve the sanitary condition of water-closet towns. Its advocates assert that it will carry the excreta *fresh* to the soil, in refutation of which I shall simply advert to the case of Croydon.

I do so, *first*, Because it is a very perfect specimen of sewage works carefully carried out under the most favourable circumstances; *second*, Because the advocates of sewage irrigation insist that the excreta ought to be carried *fresh* to the soil; and, *third*, Because the engineer tells us that the time from the closet, through the drains, through the straining-beds, and out again into the river, varies from a minimum of four to a maximum of six hours.

If this is correct, it follows that at Croydon there should be no gas, it being a well-known fact that excreta take at least twenty-

four hours to decompose and give off gas.¹ At Croydon, then, there should be no need of sewer ventilation, yet Dr Carpenter, who highly approves of the system pursued there, tells us that from some mal-arrangement of the pipes in his house, sewage-gas passed into it, with a force resembling the escape of steam, and produced typhoid. As recently as the 6th of this month (January), I see there is a letter from him in the *British Medical Journal*, giving an account of an admirable method adopted in Croydon to destroy sewer-gas by charcoal. From this it is evident, 1st, that the excreta are *not* passed on fresh to the land; 2d, that it must take much longer than the theoretical time to pass from the closet, through the pipes, and over the meadows. I suppose the mistake may have in part originated in supposing that sewage matter will flow as rapidly through pipes as pure water; but if we have sewer-gases at Croydon, with its recently and admirably constructed sewers, and their favourable fall, what would we have if we attempted sewage irrigation in towns less favourably situated, where the drains are not nearly so well constructed, far more numerous and complicated, and where we might find it necessary to pump the sewage? Another objection to sewage irrigation is, that if the sewage is pumped, in all probability the liquid will be pumped up and the gas left. This was confirmed by the results of drainage works in twenty-five towns in England. In nine of them there was a reduction of more than 50 per cent. in the cases of typhoid; in ten, a reduction of from one-half to one-third per cent.; while in four, there was either a slight decrease or an absolute increase. In these four, the sewage was pumped. It was quite expected that as drainage works were carried out there would be a diminution in zymotics, but experience proves that it has also a favourable influence as regards phthisis. In fifteen towns there was a reduction of deaths from this source of from 49 to 11 per cent. No large city has yet adopted the process of irrigation for the whole of its sewage, and in places where it has been adopted the Birmingham Report complains that it is very difficult to get an account of the financial results.—(Birmingham Report, p. 69.)

The latest estimate allows one acre for every 20 to 30 of the population, and at such a rate you can easily calculate how many acres a city like this would require. To meet this difficulty, intermittent downward filtration has been proposed; but as by it the greater part of the manurial value is lost, I shall not enter upon it.

The most fatal objection to irrigation, and indeed every other scheme for the treatment of sewage, is that they do not meet the sanitary difficulty. Before the sewage is taken to the land or submitted to any of the numberless patent schemes, the whole mis-

¹ I wish it to be understood, that I do not speak as to the present state of Croydon; I am dealing with a much larger subject, and merely quote Croydon as an illustration in point. I make this remark, because when I used it on a former occasion I was misunderstood, and told that because Croydon is healthy now, I had no right to refer to it.

chief has been done, while experience has also amply proved, in regard to water-carriage, that no river in the kingdom can oxidize the excreta from the towns on its banks. Our engineers stick to water-carriage, however, with a tenacity which is most surprising,—simply, I suppose, because they are engineers, and do not know, or will not study, the other aspect of the question; yet, Mr Hawksley (Birmingham Report) says, that while the art of removing excremental refuse in water has been brought to perfection, the problem of the re-purification of the polluted waters remains unsolved. This being the case, it seems rather wonderful that engineers do not think it worth while to try other methods. The views I bring before you to-night I have long held. This paper was proposed to be read before the Prince of Wales's illness, and would have been read last month had there been an open night. I may mention that I brought the same views before the public five years ago at a Glasgow Sewage Association; three years ago I did the same at the Medico-Chirurgical and Philosophical Societies of Glasgow; and I also read papers on the subject at the Social Science meetings of Newcastle and Leeds; but in no place did I make many converts as to the evils arising from sewer-gas.

The illness of the Prince has recently galvanized many people into the greatest excitement on the subject, but I fear the effervescence may as speedily subside, and nothing be done—that we shall still go on acting contrary to nature's laws, and have the results I have been trying to point out.

In London alone, according to Mr Krepp, thirty millions of money have been spent on water-carriage—we all know with what disappointing results in a sanitary point of view.

These matters, which pollute our rivers, poison our air, and produce disease to so lamentable an extent, are of great value. I believe that £80,000 is a very moderate estimate of the value of the excreta of this city, yet we throw them away, and then ransack the whole earth for bone-dust and guano.

Sanitary science should not rest content till it has made towns as healthy as rural districts—this, at least, should be the result aimed at; and this we shall never be able to do until there is a change in the mode by which excreta are disposed of.

If cholera were epidemic in any place, I have no doubt that every intelligent officer of health would direct that the stools of all patients should be disinfected. Very probably, however, before this was carried out, the mischief would be done by the cholera contagium getting into the sewers or wells.

Why, then, not provide for such an emergency beforehand, by reserving the sewers for the rainfall, and making provision that all excreta shall not be allowed to decompose, but be disinfected,—the progress of what we may term antiseptic chemistry rendering this less and less difficult? I sum up as follows:—

1st, That no excreta shall be allowed to pass into our sewers, water-courses, or rivers.

2d, That all refuse from manufactories containing organic nitrogen and carbon—*i.e.*, putrescible matter—shall also be kept out of our sewers, water-courses, and rivers.

3d, That all excreta shall be submitted to chemical or other action, by which they shall be rendered non-putrescible.

As regards the second point, we would require imperial legislation to prevent organic refuse from being passed into the sewers, etc.; but I think the first and third might be carried out under the powers in the Police and Public Health Acts; and I am quite sure that the gain would, in a short time, exceed the expenditure. I am often told it would be very difficult to carry out these views, but everything really worth having is attended with difficulty, and I cannot but affirm that if a tithe of the time, skill, and ingenuity, and one-thousandth part of the money, had been devoted to investigations in this direction, which have been spent on water-carriage, the problem would have been solved long ago.

I have already said that the numberless patents which have been taken out do not meet the whole case: they either fail in the sanitary—*i.e.*, do not prevent decomposition in the sewers; or in the economic—*i.e.*, do not retain or recover all the fertilizing matters.

I shall therefore enter into no detail as regards them, but bring under your notice some plans which fulfil the requirements I have specified.

1st, Mr Moule's earth-closet is known to most of you, and has done well in private houses, asylums, and small villages in this country; and in India has been a very decided success. The great objection to its use in towns is the bulk of the material required. This objection is removed by employing, as Mr Stanford proposes, seaweed charcoal instead of earth. As a very small quantity of charcoal is sufficient, by an improved closet, it is expected that even less than weight for weight of excreta will be found sufficient. I have repeatedly seen Mr Stanford's process in operation, and am convinced it is in every way well worthy of trial; as it satisfies, in all respects, whatever the most ardent sanitarian could desire. The product from the closet is a black mass, somewhat like cinders, free from smell, and without the least appearance of faecal matter. Mr Stanford considers that eight cwts. per head per annum is sufficient, and that this need only be removed once a year; and the reservoir of char at the top of the house need only be replenished once a year. The closets are arranged to be quite automatic, and require no attendance from within. Mr Stanford values the char after use at 8s. a head per annum, and proposes to burn it in revolving retorts, and to collect in suitable condensers the gas liquor, tar, and gas. The charcoal increases at each reburning, and therefore the plan is self-supporting, unless, indeed, the increased value of the char should render it advisable to sell it.

Mr Stanford's proposal has been so well thought of that a company has been formed to work it, and the large shipbuilders on the Clyde have agreed to adopt it; and I am also told that already

arrangements have been entered into to provide closets for works employing 12,000 men.

Captain Liernur proposed some time ago what he terms a pneumatic system of collecting the excreta, and applying it direct to the soil. The great objections to his scheme were that it would require a special plough—that we would require to be always ploughing, or the matter would accumulate, and that if frost came we would be necessitated to cease putting it into the ground.

When a community has been accustomed to water-closets, it is very difficult to get any alteration made, and therefore some schemes have been devised to retain the water-closet, but to prevent the matters from them getting into the sewers.

Mr Strang proposes an upward system of filtration. His apparatus consists of a large box, divided by a perforated bottom, the upper division being filled with cinders, ashes, or charcoal. The lower division receives the contents of the closets; as it fills the water rises through the perforated bottom, passes upwards, and flows off at the top much purified. From time to time the contents of the lower division are removed, and are of considerable value.

Mr Hoey has devised an apparatus which is intended to leave us with all the comfort and convenience of the water-closet, and yet at once to get quit of all the nuisance and dangers of that system.

It is not easy to describe mechanism without drawings, but I shall try and give some explanation of Mr Hoey's plan.

First, The water-closets are left just as they are at present.

Second, The flush-pipe is not attached to the general cistern, but to one holding only one-fifth of a gallon of water, which takes two minutes to fill. When the bar of the water-closet is raised, the supply to this small cistern is cut off, so that it is almost impossible to waste water—it could only be wasted by some one raising the bar every two minutes.

Third, A vessel like a bird-cage fountain is filled with sulphuric acid, and at each time the closet is used a portion of it is discharged with the water by means of a plunger dipping into the acid.

Fourth, The waste-pipe from the closet flows into a reservoir underground, from which the excreta are removed by pneumatic pressure without the slightest offence, and then taken to the country to be evaporated into portable manure.

Instead of the sulphuric acid, I would propose the use of common salt, to which my attention was directed by the researches of Dr Angus Smith. You will find salt very favourably spoken of in his work on Disinfectants, at page 78. At page 128, he tells us that it is seven times cheaper than chloride of lime, and fourteen times cheaper than carbolic acid; and at page 97 we read what was the effect of only two ounces on one cwt. of human excrement. The great advantages of salt are its cheapness, its thorough efficiency, as well as its being itself a valuable fertilizer of soil, and amply repaying the agriculturist for his outlay.

I would recommend the removal of the product of the closets by

pneumatic pressure, without in the least disturbing the inmates of the house. It would be conveyed to an establishment where it would be evaporated to dryness, and converted into a portable, and I have no doubt very valuable, manure.

The advantages of Mr Hoey's plan are obvious. Where water-closets are already in use, they leave our household arrangements as they at present are, and save an enormous waste of water.¹

Then, as the excreta cannot putrefy, it follows that there need be no fear of sewer-gas getting into our houses, or of faecal matter percolating through the soil into wells, etc. Either of these plans would at once deodorize and render innocuous the stools of patients suffering from infectious diseases; they are not expensive, and could be as easily worked as our present system; while the collected matter, after the evaporation of the water, would make a valuable manure.

All of these schemes show a profit on paper. I think, however, profit should not enter primarily into our calculations. We ought to take a broader view of the question, and ought to feel that this is a gigantic evil, and it must be got rid of. We must not go on living contrary to the laws of nature, lowering our health by breathing impure air, wasting our manure, swelling our death-rates, and robbing posterity.

I do not say which of these schemes is best, or that any of them is perfect; but they are all superior to our present system of water-carriage, and it would well become the authorities of any large community to have them tried, and to prove for themselves which is best.

In conclusion, let me emphatically say, that the only true sanitary solution of this question is that all excreta must be kept out of our water-courses and rivers—nay, I go further, and affirm that if it is true, as Dr Benjamin Richardson tells us, that fifteen organic poisons may pass from sewage—if it is true that diarrhoea, cholera, and enteric fever (the first and last killing 35,000 per annum), are traceable to the imbibition or inhaling of the results of decomposing excreta—if it is true that the same causes lower the health and swell the death-rate from other diseases—then I say, that the only satisfactory solution of our difficulty will be found by making pro-

¹ To test the powers of this limited supply of water to keep a closet clean, I had one fitted up in my own house, with a cistern only containing $\frac{1}{2}$ of a gallon of water.

It has now been in use for more than two years, and is quite as clean as others in the same house where the supply is unlimited.

If such a closet was generally adopted, there would be a saving of water of several gallons a head.

Mr Hoey tells me that the expense of altering a water-closet to suit his apparatus would be 13s., and that two guineas would be the amount required to put in a tank for six closets, making the expense for each about 7s.

As regards the utilization of the matter from such a closet, I may mention that Mr Chapman has bought the urine from the public urinals of Glasgow from the Police Board for £1000 a year; and he tells me that if the excreta are diluted with not more than four times their bulk of water, he can utilize them. He has already fitted up extensive works for the treatment of the urine.

vision that all excreta shall, within twenty-four hours of being voided, either be returned to the earth, or shall be subjected to chemical processes before decomposition takes place.

TABLE showing the NUMBER of DEATHS in ENGLAND from certain ZYMOTIC DISEASES, in each Year for which the Record has been made, from 1838 to 1868, which may be read along with Dr Richardson's List of the Organic Poisons (p. 4).

Years.	Scarlatina.	Diphtheria.	Measles.	Hooping-Cough.	Smallpox.	Fever.	Diarrhœa, Dysentery, & Cholera.	Total.
1838	5,802	...	6,514	9,107	16,268	18,775	3,440	59,906
1839	10,325	...	10,937	8,165	9,131	15,666	3,493	57,717
1840	19,816	...	9,326	6,132	10,434	17,177	4,799	67,684
1841	14,161	...	6,894	8,099	6,368	14,846	4,198	54,566
1842	12,807	...	8,742	8,091	2,715	16,201	7,622	56,178
1847	14,697	...	8,690	9,260	4,227	30,994	15,630	83,498
1848	20,502	...	6,867	6,862	6,903	22,037	15,604	78,775
1849	13,111	...	5,464	9,615	4,645	18,347	74,155	125,337
1850	13,370	...	7,080	7,770	4,666	15,375	14,400	62,661
1851	13,594	40	9,370	7,905	6,997	17,930	18,045	73,881
1852	18,813	74	5,846	8,022	7,320	18,641	21,754	80,470
1853	15,653	46	4,895	11,200	3,151	18,554	20,502	74,001
1854	18,325	203	9,277	9,770	2,808	18,893	42,092	101,368
1855	17,128	186	7,354	10,185	2,525	16,470	15,044	68,892
1856	13,931	229	7,124	9,225	2,277	16,182	15,912	64,880
1857	13,919	310	5,969	10,138	3,936	19,016	24,037	77,325
1858	25,481	4,836	9,271	11,648	6,460	17,883	16,004	91,583
1859	19,907	9,587	9,548	8,976	3,848	15,877	20,597	88,340
1860	9,681	5,212	9,557	8,555	2,749	13,012	11,185	59,951
1861	9,077	4,517	9,055	12,309	1,320	15,440	20,999	72,717
1862	14,834	4,903	9,800	12,272	1,628	18,721	12,667	74,825
1863	30,475	6,507	11,349	11,275	5,964	18,017	16,801	100,388
1864	29,700	5,464	8,323	8,570	7,684	20,106	18,366	98,213
1865	17,700	4,145	8,562	8,647	6,411	23,034	25,894	94,393
1866	11,685	3,000	10,940	15,764	3,029	21,104	32,644	98,166
1867	12,300	2,600	6,588	11,873	2,513	16,862	21,735	74,471
1868	21,912	3,013	11,630	9,223	2,052	19,701	32,427	99,958
Totals	438,706	54,872	224,972	258,656	138,029	404,861	539,046	2,190,144

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EXCREMENTAL POLLUTION,

A CAUSE OF DISEASE;

WITH

HINTS AS TO REMEDIAL MEASURES.

BY

ANDREW FERGUS, M.D.

(A paper read at the Social Science Congress, Leeds, October, 1871.)

LONDON.

—
1872.

EXPERIMENTAL POLLUTION

A DANGER OF DISEASE;

AND

POINTS US TO REMEDIAL MEASURES

ANDREW W. FERGUSON, M.D.

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1872

EXCREMENTAL POLLUTION.

SANITARY science should never rest content till our towns have become as healthy as our rural districts; this at least should ever be the result aimed at. The question as to the causes of the unhealthiness of our towns is a very large one, and I intend merely to touch upon one of them, namely, how much of this unhealthiness is due to the way in which the excreta of the inhabitants are disposed of, also whether there can be any sanitary improvement in our modes of dealing with them.

We all know that some of our excretions are at our own disposal, and that some are not. If we trace the latter we shall find that they are at once utilized, and that thus the balance of nature is kept up. The carbonic acid continually given off by living beings is returned to the vegetable world whence it was originally derived, and in this way the correct rotation of nature is kept up. Certain of our other excretions are left to our own control, it is in the disposal of these we act contrary to nature, and have the most dire results. I believe that had the rotation of nature been followed in regard to them, and had these excretions been returned to the earth in a fresh state, or had they been prevented from decomposing, we should have had a very marked diminution in the mortality of our cities, and even an improved state of health in our villages and private houses.

I do not enter into minute details, but shall take a few leading diseases to illustrate the mischief that arises from excremental pollution. Dr. Benjamin Richardson, at the Sewage Conference at Leamington, gives a list of fifteen diseases that may be conveyed by sewage.* When we look back to the epidemics which prevailed some centuries ago, we readily acknowledge that if they were not directly occasioned by the habits of the people they were much aggravated by them. If any of these re-appear there is no reason why it should not be attributed to the same cause. We congratulate ourselves on having, by our improved sanitary arrangements, got rid of such diseases as the plague, the sweating sickness, &c., but in the event of any long-latent epidemic reappearing, we shall do well

* DISEASES FROM THE ORGANIC POISONS.—The diseases which may be produced by the organic poisons are as follows:—Small-pox, measles, scarlet fever, diphtheria, typhus fever, typhoid fever, erysipelas, hospital fever, puerperal fever, cholera, yellow fever, ague, glanders, boil and carbuncle, infectious ophthalmia. This is a long list of diseases, amounting to fifteen in number, mainly traceable to the poisons which, as I have said, may pass from the sewage.

to inquire whether our own habits are not in a great measure the responsible cause. Mr. Simon very pertinently asks why diphtheria, which scarcely had any place in history till it overrun Europe in the 16th century, and which, since that time, has again been but rarely mentioned, should for the last ten years have become an important disease in England.*

The answer is simply this—we have been careless as to the disposal of our excretions, and have been drinking water, or breathing air, contaminated by excretal matter, often in a state of decomposition. For details in proof of this, as regards diphtheria, I refer to the second report of the Medical Officer of the Privy Council, pages 167, 168, 171, 172; also to the eighth report, page 251.

Typhoid fever, killing from 15,000 to 18,000 every year, is another disease resulting from excremental pollution. I think I need not quote authorities to prove this, but I may refer you to the researches of all modern investigators of this disease, and especially to the reports of Mr. Simon, yearly prepared for the Privy Council. The origin of typhoid fever, from excremental pollution, is clearly proved in almost every volume of these valuable reports, either in the reports themselves, or in the appendices written by the various official inspectors.

In the last report, published a few weeks ago, I find that these inspectors had visited sixty-six places, but six must be deducted as double entries. In fifty, out of the sixty remaining cases, the occasion of the increased death-rate, which gave rise to the official inspection, was excremental pollution; in forty-nine of these the result was typhoid, and in sixteen scarlet fever, in the affected towns or districts. In most of these cases the water was befouled by excremental pollution, but as this as a source of disease is so well known, and has over and over again been so amply proved, I shall take it as granted, and dwell somewhat more in detail on another most fruitful source of typhoid fever, which is not so well known, and cannot be so easily guarded against.

A number of years ago I was able to trace several cases of typhoid fever to corroded soil pipes. At first I was very much puzzled as to the cause of this corrosion, but continued observation solved the difficulty.

I found that the perforations of the pipe were generally on its upper side, and therefore they could not be caused by the fluid passing through it. I also observed that the pipe most frequently affected was that leading from the closet to the main descending soil pipe, and that, wherever there was a bend in the tube, the upper surface became perforated. I have also sometimes found these perforations in the sides of the pipe as well.

The question here arises, how is this destruction of good, well made lead pipes effected? If we consider what part of the pipe it is that is destroyed, and also consider the result of chemical

* Eighth Report, 1865, p. 37.

analysis,* as well as the increased rapidity with which the destructive action takes place in pipes that are not ventilated, I think we are justified in coming to the conclusion that the destructive element is sewer gas.

If you will look carefully at the specimens, you will observe that the destructive action is from the inside. You will perceive that in some places the pipes are more or less eaten into, even where the action has not gone the length of complete perforation.

Of course, the discovery of these pipes in houses has only been in cases where I have been called professionally, and where the diseases were of such a type as we know can be produced by the inhalation of the results of decomposing excreta. (I may mention that as soon as the pipes have been removed, disease has ceased; notably so in an institution where, nearly three years ago, an outbreak of typhoid fever disappeared, and has not returned since the soil pipes were removed.)

The diseases I have observed, resulting from this condition of pipes, are typhoid fever, diphtheria, &c., &c., but in one or two cases I have had to remove families, all of whom were suffering from ill health from this poison, without exhibiting symptoms of any well defined disease.

In towns where w.c.'s have been extensively introduced, lead is generally used as the material of soil pipes, and as I now show you that these are liable to become imperfect, it is a very important sanitary question to inquire how long lead will last, in other words, what is the duration of a good lead soil pipe.

I have been attending to this matter for several years, and it is now more than four since I first publicly exhibited pipes like these; still I would not wish to speak dogmatically on the subject, as I think it requires further investigation. If I am correct in supposing that the destruction of the pipes is the result of gases, then the rapidity of the process will vary in different localities, as the sewage may be stronger or weaker, or passing more or less quickly into a state of decomposition. My researches, so far as they have yet proceeded, indicate, (1st) that where there is no ventilation, by the main descending soil pipe being closed at the top, not allowing the gases to escape, a lead pipe may in ten years become a source of disease, and possibly even earlier, if the sewers are faulty, promoting rapid decomposition of the excreta. If the sewers are good, well made, with a rapid flow of sewage, a non-ventilated pipe may last fifteen years.

When there is ventilation, the soil pipe being open at the top, and

* Analysis of whitish-brown powder from the interior of the perforated pipes.

Carbonate of lead...	...	...	86.00	...	91.00	...	92.00
Carbonate of lime...	...	...	2.50	...	2.10	...	2.90
Water	...	...	1.20	...	1.00	...	0.50
Lead insoluble as oxide	...	...	3.50	...	1.50	...	1.45
Silica	...	...	2.80	...	1.00	...	1.60
Organic matter	...	...	4.00	...	3.40	...	0.65

also acting as the rain water pipe, lead will last for twenty, thirty, or even more years. The practical conclusion to be drawn from this, in water-closet towns, is that where there is no ventilation you are not safe unless your soil pipes and connexions are renewed every ten to fifteen years, or every twenty to twenty-five where ventilation exists. Allow me to remark that we cannot trust the plumber to find out this condition of the pipes; they will probably only look for liquid leakage, and if they do not find it, they pronounce the pipes to be all right, and say that the smell we complain of must be caused by gas, dead rats, &c., &c.

In the most recent cases of disease (typhoid) from this cause which has come under my own notice, when I inquired as to the state of the drains, the lady of the house assured me that all was right as the w.c. had been renewed two months ago. Next day, however, perceiving an unpleasant smell, I requested that the plumber should examine the pipe from the closet to the soil pipe, as I was sure it must be perforated. I now exhibit the result. A year ago I was told that this state of pipes must be peculiar to Glasgow, and was in all probability occasioned by the refuse of chemical works passed into the sewers. Since then I have inquired into the state of several w.c. towns, and find in them all the same condition of pipes. I show you a specimen from Edinburgh where there are no chemical works. Should the cholera contagium get into the drains, we should have fearful havoc, wherever this defective state of soil pipes existed.*

Another group of diseases arising from excremental pollution, are the diarrhœal, including cholera. I need not, I think, insist that this last disease is the direct consequence of taking into our system the results of excremental pollution. Instead of going into any proof of my own as to this, I shall quote from the admirable and vigorous language of Mr. Simon. In the eighth report, p. 39, he thus writes—

“When cholera is epidemic in any place, persons who are suffering from the epidemic influence, though, perhaps, with only the slightest degree of diarrhœa, may, if they migrate, be the means of conveying to other places an infection of indefinite severity; that the quality of infectiveness belongs particularly, if not exclusively, to the matters which the patient discharges, by purging and vomiting, from his intestinal canal; that these matters are comparatively non-infective at the moment when they are discharged, but subsequently, while undergoing decomposition, acquire their maximum of infective power; that choleric discharges, if cast away without previous disinfection,

* As the investigation of the causation of disease is carried out, I believe that the list already given of those diseases produced or conveyed by sewage will be increased. In two cases of phthisis, in people long past middle life, I could not attribute the disease to any other cause. The family history was good, the mode of living correct, and the general health satisfactory, up to the time of the soil pipes becoming corroded.

impart their own infective quality to the excremental matters with which they mingle, in drains or cesspools, or wherever else they flow or soak, and to the effluvia which those matters evolve; that if the cholera contagium, by leakage or soakage from drains or cesspools, or otherwise, gets access, even in small quantity, to wells, or other sources of drinking water, it infects in the most dangerous manner very large volumes of the fluid; that in the above-described ways, even a single patient with slight choleraic diarrhœa may exert a powerful infective influence on masses of population among whom, perhaps, his presence is unsuspected; that things, such as bedding and clothing, which have been imbued with choleraic discharges, and not afterwards fully disinfected, may long retain their infectious properties, and be the means of exciting choleraic outbreaks wherever they are sent for washing or other purposes."

Again, in ninth report, pp. 33 and 34, Mr. Simon thus powerfully writes:—"It cannot be too distinctly understood that the person who contracts cholera in this country is *ipso facto* demonstrated with almost absolute certainty to have been exposed to excremental pollution; that what gave him cholera was (mediately or immediately) cholera-contagium discharged from another's bowels; that, in short, the diffusion of cholera among us depends entirely upon the numberless filthy facilities which are let exist, and specially in our larger towns, for the fouling of earth, and air, and water, and thus secondarily for the infection of man, with whatever contagium may be contained in the miscellaneous outflowings of the population. Excrement-sodden earth, excrement-reeking air, excrement-tainted water; these are, for us, the causes of cholera. That they respectively act only in so far as the excrement is cholera-excrement, and that cholera-excrement again only acts in so far as it contains certain microscopical fungi, may be the truest of all propositions; but whatever be their abstract truth, their separate application is impossible. Nowhere out of Laputa could there be serious thought of differentiating excremental performances into groups of diarrhœal and healthy, or of using the highest powers of the microscope to identify the cylindro-tænum for extermination. It is excrement indiscriminately which must be kept from fouling us with its decay.

"The local conditions of safety are above all these two. (1.) That by appropriate structural works, all the excremental produce of the population shall be so promptly and so thoroughly removed, that the inhabited place in its air and soil shall be absolutely without fœcal impurities, and (2.) that the water supply of the population shall be derived from such sources, and conveyed in such channels, that its contamination by excrement is impossible."
 "It is to be hoped that, as the education of the country advances, this sort of thing will come to an end, that so much preventable death will not be always accepted as a fate; that for a population to be thus poisoned by its own excrement will some day be deemed ignominious and intolerable."

As regards diarrhœa, Dr. Greenhow reports, and Mr. Simon en-

dorses his opinion, that the deaths from this cause vary from four in every 100,000 of the population to 663 in the same number of the population.

He calculates that if the diarrhoeal death-rate could be restricted in the whole of England to ten times the minimum death-rate, (namely, four) there would be a saving of 20,000 lives annually, and there would be a great reduction in the deaths from typhoid fever also. Both Mr. Simon and Dr. Greenhow are of opinion that the excess of mortality from these diseases has in all places been coincident with one or other of two definite local circumstances, (*a*) the tainting of the atmosphere with the products of organic decomposition, especially of human excrement—or, (*b*) the habitual drinking of impure water.

Before turning our attention to remedial measures, allow me to remark that water carriage was adopted in ignorance of the results that would flow from it. It was known that water oxidizes excreta, and it was supposed that we had nothing more to do than merely to pass these matters into streams to be rid of them—the result has simply proved that no river in the kingdom can oxidize the excreta of the towns on its banks. We have had our rivers rendered gigantic cesspools, and though many schemes have been proposed for the treatment of sewage, most of them have failed when brought to the touchstone of scientific research.

It is singular that so few plans have been devised to keep excreta out of the sewers, *i.e.* to have no sewage at all.

The plan of sewage irrigation has many advocates, and therefore I shall offer a few remarks upon it—for though it would in some degree utilize the sewage, it would not in the least improve the sanitary condition of w.c. towns. Its advocates assert that it will carry the excreta fresh to the soil, in refutation of which I shall simply advert to the case of Croydon.

I do so, (1st.) Because it is a very perfect specimen of sewage works carefully carried out under the most favourable circumstances. (2nd.) Because the advocates of sewage irrigation insist that the excreta ought to be carried fresh to the soil. (3rd.) Because the engineer tells us that the time from the closet, through the drains, through the draining beds—out again into the river—varies from a minimum of four to a maximum of six hours. If this is correct, it follows that at Croydon there should be no gas, it being a well-known fact that excreta takes at least twenty-four hours to decompose and give off gas.*

At Croydon, then, there should be no need of ventilation in the sewers, yet Dr. Carpenter, who highly approves of the system pursued there, tells us that from some mal-arrangement of the pipes in

* I wish it to be understood that I do not speak as to the present state of Croydon—I am dealing with a much larger subject—and merely quote Croydon as an illustration in point. I make this remark because when I used it on a former occasion I was misunderstood, and told that because Croydon is healthy now I had no right to refer to it.

his house, sewage gas passed into his house with a force resembling the escape of steam, and produced typhoid fever.

From this it is evident (1st) that the excreta are not passed on fresh to the land; (2nd) that it must take much longer than the theoretical time to pass from the closet through the pipes and over the meadows. I suppose the mistake may have in part originated in supposing that sewage matter will flow as rapidly through pipes as pure water, but if you have sewer gases at Croydon, with its recently and admirably constructed sewers, and their favourable fall, what will you have if you attempt sewage irrigation in towns, less favourably situated, where the drains are not nearly so well constructed, far more numerous and complicated, and where you might find it necessary to pump the sewage.

The most favourable circumstances for the decomposition of excreta are narrow spaces, with a limited supply of air and water; and if we would bring to the surface the whole network of the sewers of a large town we should find a very perfect laboratory for the production of sewer gas. These sewers often include old, irregular water-courses arched over, drains of larger and smaller dimensions, some round, some egg-shaped, and some square, I have no doubt still exist. At the bottom of most of these is a bed of black, thick, tenacious mud, and flowing over it a sluggish stream of various degrees of impurity, but slowly, silently, and continually giving off deadly gases. Sinking the sewers to their native and unsightly bed, let us look at the manner in which they are connected with our houses, by water-closets more or less perfect, and more or less out of repair, some of them being merely a tube passing into the drains without any pretence of a pan. We have also sinks and fixed basins in rooms, sometimes within a few feet of the bed. We are told to trap and ventilate the sewers, but by doing so in one place we only leave more gas to escape in another, indeed, it is but excluding a poisonous gas from our own house, which will find its way into our neighbour's, who may possibly not be so well protected from it. Sewer ventilation is not easy, and is very costly. Mr. Bazalgette estimates that to ventilate the sewers of London will cost 460,000*l.*, and for fuel per annum 201,480*l.*, exclusive of labour. Flushing with water would cost 381,250*l.*

Supposing that you have trapped your sewers, and carried a ventilating pipe to the roof, you have not destroyed the poison, but merely diluted it, and the contaminated atmosphere cannot but exercise an injurious effect more or less on the surrounding inhabitants. To show how slight a contamination of air will produce disease, allow me to mention a case that came under my own observation a few weeks ago. In a healthy rural district a youth was fishing for trout, and caught two. Exactly fourteen days afterwards (period of incubation) he was attacked by typhoid fever. His father, a highly intelligent and observant medical man, then recollected that close to the spot where his son had been fishing a sewer entered the stream, therefore, although the sewage was not strong

enough to kill the trout, the air was so tainted that its inhalation produced typhoid fever. I am myself a believer in the germ theory of disease, but without asking you to go this length with me, I ask you if I have not proved that certain diseases are produced by taking into our systems the result of the decomposition of excreta, and that several diseases may be produced by sewage. In these circumstances what ought we to do? If we had an epidemic of cholera, I have no doubt that every intelligent officer of health would at once direct that the stools of all patients should be disinfected, but probably before this order could be carried out the mischief would have been done. Let us educate the people to this beforehand, and we shall at the same time get quit of the risk of causing or conveying other diseases.

I hold that the only true sanitary solution of our difficulty is to provide that there shall be no decomposition of excreta, that the sewers shall be for the rains, and that all excreta shall be disinfected, the progress of our knowledge of what we call antiseptic chemistry rendering this less and less difficult.

We may, then, sum up as follows:—

(1.) No excreta shall be allowed to get into our sewers, water-courses, or rivers.

(2.) That all such excreta be submitted to chemical or other action, by which they shall be rendered non-putrescible.

(3.) That all refuse from manufactories containing organic nitrogen and carbon (putrescible matter) shall be kept out of our sewers, water-courses, and rivers.

As regards this last particular we would require an Act of Parliament to prevent manufacturers passing organic refuse into the sewers. A profitable return might probably be the result. Mr. Smith tells me, that from one work 500,000 gallons a week are passed into the sewers, each ton of which is worth 3s. 6d. As regards the 1st and 2nd particulars I may remark that my own individual opinion inclines in favour of the dry system, but provision must be made for those towns in which water-closets are already established, and where the inhabitants would be unwilling to part with them. I would propose that they should adopt the apparatus of Mr. Hoey, a model of which is here exhibited.

The principle of it is that the flush pipe shall be fed from a limited cistern containing one-fifth of a gallon, and that when the pan is discharged, a quantity of sulphuric acid, common salt, or some other antiseptic shall be discharged with it.

The whole matter must be passed into a tank or reservoir underground, from which it will be removed by atmospheric pressure.

The advantages of the system are obvious; (1st.) It leaves the w.c.'s as they are, and saves an enormous amount of water. (2nd.) As the added antiseptic will prevent the fæcal matter from putrefying, there need be no fear of sewer gas getting into our houses, or fæcal percolation through the soil into our wells, and we would cease to suffer from the diseases produced by these causes. (3rd.) It is not expensive, and can be as easily worked as the ordinary water-

closet. (4th.) The collected matter, after the evaporation of the water, would be a valuable manure.

As an experiment I had a closet of this description fitted up in my own house about two years ago—I find that it works admirably, being quite as clean and well flushed as two other closets in the same house where the supply of water is unlimited.

Of the dry systems, you are all acquainted with Mr. Moule's earth-closet. A grand improvement on it is Mr. Stanford's carbon-closet, but as a paper is to be read on it I shall reserve my remarks, merely observing that in every respect it meets the requirements of sanitary science.

As I have already exceeded the time allowed for voluntary papers, I must not enter on the consideration of the other diseases produced or conveyed by sewage. I merely append a table of deaths from zymotic diseases, most of which may pass from sewage.

TABLE showing the NUMBER of DEATHS in England from certain ZYMOTIC DISEASES in each year for which the record has been made from 1838 to 1868.

Years.	Scarlatina.	Diph- theria.	Measles.	Hooping Cough.	Small-pox.	Fever.	Diarrhoea, Dysentery & Cholera.	Total.
1838	5,802	—	6,514	9,107	16,268	18,775	3,440	59,906
1839	10,325	—	10,937	8,165	9,131	15,666	3,493	57,717
1840	19,816	—	9,326	6,132	10,434	17,177	4,799	67,684
1841	14,161	—	6,894	8,099	6,368	14,846	4,198	54,566
1842	12,807	—	8,742	8,091	2,715	16,201	7,622	56,178
1847	14,697	—	8,690	9,260	4,227	30,994	15,630	83,498
1848	20,502	—	6,867	6,862	6,903	22,037	15,604	78,775
1849	13,111	—	5,464	9,615	4,645	18,347	74,155	125,337
1850	13,370	—	7,080	7,770	4,666	15,375	14,400	62,661
1851	13,594	40	9,370	7,905	6,997	17,930	18,045	73,881
1852	18,813	74	5,846	8,022	7,320	18,641	21,754	80,470
1853	15,653	46	4,895	11,200	3,151	18,554	20,502	74,001
1854	18,325	203	9,277	9,770	2,808	18,893	42,092	101,368
1855	17,128	186	7,354	10,185	2,525	16,470	15,044	68,892
1856	13,931	229	7,124	9,225	2,277	16,182	15,912	64,880
1857	13,919	310	5,969	10,138	3,936	19,016	24,037	77,325
1858	25,481	4,836	9,271	11,648	6,460	17,883	16,004	91,583
1859	19,907	9,587	9,548	8,976	3,848	15,877	20,597	88,340
1860	9,681	5,212	9,557	8,555	2,749	13,012	11,185	59,951
1861	9,077	4,517	9,055	12,309	1,320	15,440	20,999	72,717
1862	14,834	4,903	9,800	12,272	1,628	18,721	12,667	74,825
1863	30,475	6,507	11,349	11,275	5,964	18,017	16,801	100,388
1864	29,700	5,464	8,323	8,570	7,684	20,106	18,366	98,213
1865	17,700	4,145	8,562	8,647	6,411	23,034	25,894	94,393
1866	11,685	3,000	10,940	15,764	3,029	21,104	32,644	98,166
1867	12,300	2,600	6,588	11,873	2,513	16,862	21,735	74,471
1868	21,912	3,013	11,630	9,223	2,052	19,701	32,427	99,958

