Some points in the physiological and medical aspect of sewage irrigation / by Alfred Carpenter.

SOME POINTS

IN THE

PHYSIOLOGICAL AND MEDICAL ASPECT

OF

SEWAGE IRRIGATION.

THE SECOND EDITION OF

A PAPER

READ AT THE

SOCIAL SCIENCE CONGRESS, AT BRISTOL,

Oct. 2, 1869;

WITH NOTES UPON THE RECENT EVIDENCE ADDUCED AGAINST IRRIGATION IN THE HOUSES OF PARLIAMENT, &c.:

TO WHICH IS ALSO APPENDED,

A PAPER ON THE INFLUENCE OF SEWER GAS ON THE PUBLIC HEALTH.

BY

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LONDON:
ROBERT HARDWICKE, 192, PICCADILLY.

1870.

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PREFACE.

THE numerous applications which have reached the writer for further information upon the effects of Sewage Irrigation in the neighbourhood of Croydon, may be fairly urged as an excuse for presuming to republish the following Papers, with the various additions which time has shewn to be necessary, and likely to be useful.

A. C.

Croydon,
Oct., 1870.

INTRODUCTION.

The attention that Sewage Irrigation is now receiving in all parts of the United Kingdom, as well as in almost all civilized parts of the world, is a fair proof of the success which has attended the establishment of sewage farms, in those few places which were bold enough to make the experiment. It must be conceded that the evils which were prophesied as not only likely but certain to arise, have not yet made their appearance, and the general public is beginning to understand something of the matter, and to discredit the prophets of evil. It seems, however, that the nearer we approach to success, the more violent the enemies of the system become. This is really nothing more than might be expected, though it should be understood, that the promoters of sewage irrigation have never asserted that it is the only plan which ought to be adopted for the disposal of sewage matter, but that "when carried out in a scientific manner, it removes the difficulty which arises from the noxious plan of polluting the rivers of England, and that there are circumstances in which other systems may be applicable:" (*vide* "Proceedings of Sewage Congress at Leamington, 1866," page 248). The supporters also say, it is free from danger when used in a scientific manner. It does not, therefore, seem quite just that the promoters of other plans for the utilization of sewage, should be amongst its most ardent and unscrupulous opponents—that they should be the disseminators of reports calculated to raise the fears of the rate-paying and health-seeking public.

Wherever it is proposed to establish a sewage farm, they try to prevent the plan from being adopted by most unfair means. When we consider the matter, it seems, however, that sewage irrigation has to bear up against onslaughts, in a manner similar to that which every other truth has had to submit to. This opposition may therefore be fairly looked upon with some favour by those who believe irrigation to be right, because it is certain to lead to a correction of all those possible evils which may arise from imperfect knowledge, imperfect application, and want of experience. In those parts of the country in which land can be easily obtained for the purposes of sewage irrigation, there is but little chance of success for any other plan, if the promoters of other plans depend upon statements in their favour only. It therefore follows that the arguments against each competing scheme must be stated, and here it is that the opponents of sewage irrigation have the widest field; they let their imagination have full play, and depict all manner of evils as likely to arise. They assert the most extraordinary tales regarding the results of sewage application in those places at which it has been tried, and urge upon those having the power, the positive duty of staying the suicidal action of the promoters of irrigation. Publications are thrown broadcast over the town—the local press teems with the statements made by some unknown A.B.C., shewing the frightful state to which certain towns have been reduced in consequence of the adoption of sewage farming—other publications have contained the ideas and operations of theorists who have not been over an acre of sewage ground more than once or twice in their lives, and then they have gone over the ground prepared to see and to smell most undoubted evidences of mischief, and of course, like other dupes, have seen and smelt them. They have also taken the "post hoc" as the "ergo propter hoc," and accused the sewage farm of having caused nearly every case of illness and death which has occurred in the neighbourhood since its establishment; they have also extracted single lines

from statements made by medical men and others, without reference to the context of those statements, or to the cross examination of the witness, under which the statement has been shewn as not applying; they have made these accusations in general terms, without reference to the question of the value of the scheme, and the impossibility or the expense of carrying on any other for dealing with sewage in the particular neighbourhood in question.

It appears to the writer that a review may now be fairly taken of the present state of the evidence. The system of sewage irrigation has been in operation under his immediate cognisance for ten years. It has been carried on upon a considerable scale—it has been jealously watched by large numbers of people, and conducted close to considerable populations; the medical as well as the social aspect of the case can therefore be judged of by his own experience, as well as the judgment of a large town. The Local Board, of which the writer is a member, has consistently followed out the principle, and its individual members used to be subjected to most violent attacks and considerable obloquy in consequence of such perseverance; and nothing but a conviction of the innate firmness of the road upon which they were at first forced, by necessity, to travel, would have enabled them to triumph over local prejudices, and turn their opponents, living in the immediate neighbourhood, into their friends and supporters. This triumph has been achieved; but whilst local opposition has been overcome by success, the result of that success has been to make the sewage farm a target, at which the supporters of other systems have felt themselves obliged to shoot, so as to tarnish its fame and stay its progress elsewhere: hence, attacks upon the system, supported by reports of supposed failures in those places where, in reality, it has been successful; the supposition is usually based upon hearsay evidence, which is continually appearing in the public press. These attacks at first were unheeded, because the evidence was not sufficient to

convince the waverers, experience being required to support the practice, as well as the physiological opinions of the promoters. This state of things went on year after year, until, in 1865, an onslaught was made in the columns of the *Times* newspaper, in which it was stated that sewage irrigation was a failure at Croydon, and would have to be abandoned in consequence of the illness caused by it, in the neighbourhood of the irrigated meadows belonging to the Croydon Local Board of Health. The truth of the premises were at that time emphatically denied, and shewn by the writer to be, so far as Croydon was concerned, distinctly the contrary: that sewage irrigation had been carried on in this neighbourhood, in a perfectly safe manner, for several years. It was shewn that the illness which was imputed to the meadows, was caused by circumstances totally distinct and at a long distance away from the sewage farm, and by conditions which had been removed as soon as they were manifested sufficiently to the Local Board. A minority in the Board had, for some years, urged the danger which might arise from a want of ventilation in the sewers, and this illness, imputed by outsiders to the meadows, was at once traced to its proper cause. The minority in the Board became a majority upon this question, and the conditions which gave rise to the illness, were at once ordered to be removed all over the district.

The truth of the proposition, viz., that sewage irrigation could be carried on in a perfectly safe manner, was distinctly proved and placed before the public by the writer at the Sewage Congress, at Leamington, in 1866, and there affirmed by the assembled Congress, consisting of more than 300 earnest enquirers from all parts of the kingdom.

In 1867, another attack was made upon the Croydon system, in the *British Medical Journal;* and in opposition to that attack it was distinctly shewn by the writer, that there was abundant evidence to prove that fields may be, and ought to be so managed,

as to be perfectly free from danger of any kind to a near neighbourhood, as proved by local evidence at Beddington and Norwood.

Again, in 1868, most unfavourable strictures appeared in the *Medical Times and Gazette.* Those were replied to at the time, and it was shewn that whilst it was impossible to remove all causes of preventable disease from any given neighbourhood by sanitary operations, yet the result of irrigation upon the health of the inhabitants of Croydon had been undoubtedly good, and that notwithstanding the difficulties which had to be encountered in consequence of prejudice, of the state of the law, and of malicious acts of unknown persons, there was abundant evidence to shew that good, and not evil, had followed from the establishment of the farms.

Since that time, numerous attacks have been made at scientific societies and at public meetings in London, and various parts of the country, often when there was no one competent to give the statements a complete refutation. This year, the arena has been enlarged, and the whole question has been inquired into by committees of both houses of parliament. The evidence there afforded, by many of those intimately connected with the management of sewage farms, quite overthrew the astounding charges made by the opponents of the system, and led to the recognition of the principle by both houses of the legislature, and has established the active commencement of a new era (as far as the general face of the country is concerned) of sewage utilization.

It may not be out of place, therefore, to review the statements that have been made, and the evidence (as far as Croydon is concerned) adduced before those committees, so far as they bear upon the medical and social aspect of the question. Another year's experience has not led to any material alteration of the opinion expressed in a paper read at the Bristol Social Science Congress last year, and as the paper is out of print, it

is reproduced with such comments and additions as are deemed necessary, for the purpose of still further illustrating its meaning. Since the reading of that paper, the commissioners appointed to enquire into the best means of preventing the pollution of rivers, have issued their report, and it is some gratification to find that the commissioners state (at page 90), that "nowhere have they found instances of ill health that "were properly attributable to malaria or other causes, due to "irrigation." Again, at page 128, they state that "no locality "can be named in which typhus, enteric fever, dysentery, or "other zymotic disease, generally attributable to foul emanations, "has been traceable to irrigation with town sewage." They conclude by stating that "on every ground, therefore, irrigation "may be confidently recommended as a safe and trustworthy "remedy for the nuisance with which towns have to deal."

It appears, however, notwithstanding these conclusions, and as well as the overwhelming evidence which was afforded by the commissioners and others, before the committees previously alluded to, the opponents of irrigation continue their attacks with unabated zeal. Amongst the most ardent may be placed Dr. Letheby, who reiterated his charges in a paper read before the Metropolitan Association of Medical Officers of Health, and which paper has since been widely distributed, as if uncontradicted, though at the time it was read, the unphilosophical deductions then made, so far as they rested on evidence from Croydon, were exposed and commented on by the writer.

As it is very difficult to convey a correct idea of the position of the Croydon farms, with the situation of the houses in the neighbourhood, a reduced plan is appended of the farm at Beddington, from plans prepared by Mr. Latham: the farm has been (more or less) in operation for ten years. The Beddington farm, when first laid out, consisted of about 300 acres of land, and had to provide for the sewage of about 20,000 people: the 300 acres has decreased since that time to 285, in consequence of land being

taken from the Board's possession for building purposes and railway extension; yet in March last it provided for the sewage of upwards of 50,000 inhabitants. It will be seen, therefore, that it has been sewaged to the utmost extent, and placed in a very favourable position for producing illness, if such could easily arise. Until this year, rye-grass alone has been grown on a large scale. Since March last, the Local Board have become possessed of a much larger area in close proximity (altogether nearly 500 acres); and root-crops have, this year, been abundantly and successfully produced. It will be observed that the farm is situated directly to the west of the town of Croydon, and to the south-west of a very large part of the population of the parish; and it may be remarked that the wind is in that quarter for nearly half the year. The soil is loamy sand upon gravel, the bed of gravel being of some depth; in places it rests upon chalk, in others upon clay, the effluent water passing off into the river Wandle, at Hackbridge; the fall from sewer to outlet is about 40 feet.

The Norwood farm is a reverse of this,—it is to the north east of its principal population, and is a stiff clay. Five years since, 30 acres were provided for 2,500 people; now, it accommodates nearly 6,000: arrangements have been made to increase the area to 60 acres,—this extra land is just ready for use.

The reader will now be prepared to follow the remarks, and see the bearing of the position of the farm upon the public health, which may be considered—1st, as far as it has affected the town generally:—2ndly, the manner in which it has affected the health of those engaged upon it, and those living in the immediate neighbourhood:—and, 3rdly, the effect of the effluent water upon those using it for potable purposes.

These points will be referred to in detail as they arise. The dangers which were held up before the committees of both houses, were the certain production of—

Typhus, Typhoid or Enteric Fever, Dysentery, Epidemics or Entozoic Diseases, Cattle Plague, Foot and Mouth Disease, and numerous other diseases.

These will also be dealt with in rotation, in the notes appended to the paper forming the next chapter.

The time at the disposal of a reader at a congress is necessarily short, and some points are merely glanced at. It is thought best to let the paper stand, and add comments where required, so as to explain more fully the references made therein. Physiological and medical inferences have been drawn, without intending to give more than general directions for the practical management of a sewage farm, though many points of practical importance are mentioned, for the purpose of drawing the attention of those interested, to the results of experience in one of the oldest sewage farms in the kingdom. It is not intended to trench upon the domain of the engineer or the practical surveyor, who must know more of the points within their jurisdiction than the writer can possibly tell them; yet there are matters in connection with their work which theory may help to elucidate, and which fairly come within the province of the medical man to inquire into, and make suggestions for future guidance: so far, and so far only, the writer has presumed to go.

CHAPTER II.

I SHALL preface my observations with a description of the term "sewage irrigation," as I understand it, so that the term I make use of may not be misunderstood.

I assume that the sewage is the ordinary sewage of an English town; that it includes refuse proper to home manufactures only (*a*); that it is applied to the land consistently upon a regular plan; that the land has been artistically laid out for the purpose of irrigation, on a proper level, and so arranged that the carriers do not foul; that when the sewage arrives on the land it keeps moving and does not stagnate; that it runs over the land rather than into it; if it does, at most it does not penetrate more than a few inches into the soil (*b*). If there is no crop upon the land at the time of application, then the sewage applied to the land shall not be in excess of its storing power; that it is fresh sewage, and not already undergoing, or has not undergone putrefaction; and that the farm is managed by a skilful man.

(*a*) According to the evidence afforded by the report of the Commissioners upon Pollution of Rivers, it is seen that the refuse from print works and chemical manufactures, must be separately treated before admission into streams; that the ordinary pollution proceeding from tanneries, paper mills, woollen and silk works only, leave in their refuse such matter as adds to the pecuniary value of the sewage itself, and need not, therefore, under ordinary circumstances be excluded.

(*b*) There is at present much difference of opinion upon this point, some persons arguing that the sewage may penetrate as far and as deep as it possibly can, on a plan which may be called intermittent filtration, as described in report of Commissioners

I will also sum up the principal sanitary objections which have been made against sewage farms. They are:—

(1.) That sewage irrigation destroys vegetation, and turns the ground into a pestilential swamp, from which unhealthy miasms must arise, causing fever, ague, dysentery, and general unhealthiness to those living near to the land so used, even affecting populations miles away from it (*c*).

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on Pollution of Rivers, page 128: others thinking that it must not go far into the soil—not, in fact, out of reach of the roots of the crop, otherwise material is lost.

It is evident that those who support the latter idea, are the most practical and most useful to the community. If the sewage goes beyond the reach of the roots it is lost; if the interchange of elements by which it is resolved into the salts which indicate "previous sewage contamination" does not take place, putrefaction results at some time or other, gases may be given out which will be sources of evil every time the earth is disturbed, raising pestilential miasms, and being positively injurious to animal as well as to that vegetable life which is most useful to man. This is what happens in swamps. If the sewage penetrates beyond the reach of the rootlets of the crop, there will be an actual loss of useful material, and the financial result will not be so good as might be obtained; for it is evident that, if the organic matter that is in the sewage is at once taken up by the vegetable kingdom, there will be the same "quick returns" which is the essence of healthy business, and the principle of transfer will be more effectual the more immediately it is carried out, and larger returns will follow; less vital power being required to change the organic animal matter into vegetable produce, than is required when that matter has been already changed into organic and inorganic salts. The above conclusion must be necessarily correct, viz., to keep fertilizing matter near to the surface of the soil.

(*c*) These charges have been brought against all irrigation areas, without exception, by some enthusiastic opponents, whilst others have made the charges only against certain places which they acknowledge to have been badly managed, or over sewaged. Thus, the opposition is of three kinds,—one class, like Mr. A. Smee

(2.) That the wells in the neighbourhood would be contaminated with sewage elements by percolation, and thus also disease be engendered.

(3.) That the cattle fed upon such farms will be unhealthy, their flesh unwholesome, and their milk and butter unsafe for people to consume; and that the farms will be *foci* from which disease will be spread to any cattle in the neighbourhood.

These I believe to be the main points of objection to the establishment of sewage farms. The principles I have briefly enumerated as necessary for their successful management, will at once dispose of some of the objections made. A sewage farm must not be a swamp—it is no part of its plan to have anything stagnant upon it. A further definition of the "Theory of sewage irrigation," will show that if the theory I am about to propound be true, none of the objections made against it can hold good.

The theory may be stated in a few words, viz., that the sewage of a town may be so applied to land, that the rootlets of the growing crops shall at once seize upon the mischievous elements in the sewage, change their chemical forms, fix a portion of the elements in the plant, and render the rest comparatively harmless. This change will be

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and Mr. Hawkesley, would extinguish the system altogether; others, like Dr. Letheby, think that it cannot be carried on safely, but that in the abstract it is a beneficial operation; whilst a few, such as Mr. Harrison, are brought to bear witness against individual farms, but who are forced to confess that they believe irrigation to be the method by which sewage may be utilized with advantage and safety, upon a well managed farm, at a distance from dwellings. The first class of wholesale denouncers are not worth convincing; the second class are the most dangerous, but it is evident that their practical acquaintance with sewage farms is very limited; the second and the third class were shewn, on cross examination, to put the "post hoc" for the "ergo propter hoc" most regularly and pertinaciously: and all considered sewage farm and swamp as convertible terms, and by so doing proved their want of acquaintance with the first principle of sewage irrigation.

effected before decomposition shall have advanced far enough for the dangerous elements to escape into the atmosphere, and so carry with them the germs of disease (*d*). That if the application to the land be properly managed, the whole of the materials supplied shall be at least rendered innocuous, and the water perfectly freed from noxious organic matter. Is this definition of the theory correct? If it is so, the allegations made against sewage farms are groundless.

There are some points in the definition which require attention. The application of the sewage must not be in excess of the arresting power of the crop, and the storing power of the land, or one of the conditions is not complied with. It happens that this arresting power is a point not quite easy to determine; it may be frequently overstepped in consequence of unknown excess of sewage or deficient dilution, and a source of danger introduced which might at times seem to be uncontrollable. Nature, however, has placed two great safeguards against this chance of evil. The earth itself is a magazine in which a moderate excess of material may be stored with safety; and, secondly, should the excess pass beyond the storing power of the earth, then the nature of the crop, and the very act of growth of the plant, places a second safeguard in a production of ozone,

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(*d*) It is contended that the germs of disease are not the escaping gases, but some almost infinitesimal organic granules or microzymes which are wafted with the produced gas, and which alone will set up such diseases as diarrhœa, typhoid fever, or cholera. These germs will not increase and multiply in the moving and diluted sewage; they require a condition of things in which free oxygen is absent for their continuous development; the surface of a meadow or other field under irrigation, is the least likely place in the world for that rapid development to take place which alone will lead to the spread of epidemic disorders, for free oxygen abounds there; the germs are dwarfed and destroyed by it, even if they are not (as is probably the case) at once absorbed by the rootlets of the plant, and changed into comparatively harmless material, the germs being the natural food of plant-life, and by which plant-life is able to obtain some of its albuminous compounds.

which is discharged into the air among the crop, especially on those days when vegetation is most active and decomposition most rife, so that escaping elements of mischief, when moderate in amount, are at once oxidized and rendered comparatively innocuous. Thus it happens that only by a culpable negligence, can mischief arise from sewage irrigation areas.

It may at once be asked, how are these points proved? The answer is, that the work is seen in daily operation in the boudoir of almost every scientific lady in the kingdom, as well as in the drawing-room or the conservatory of every one studying the economy of nature. The action protecting a farm irrigated with sewage, is precisely the action which keeps the aquarium healthy and free from noxious miasm. It is well known that an aquarium may be kept for any length of time perfectly sweet and free from nuisance, if properly managed, but that if certain first principles be neglected, it becomes an intolerable pest. So it is with a sewage farm; like a railway or a steam-ship, it is dangerous if carelessly used, but that fact is not an argument against its employment—it is perfectly safe in the hands of those who understand it (*e*).

(*e*) It may be said that the very possibility of evil arising from sewage farms, is a good reason for their non-introduction into a particular district; that as mischief may arise if they are improperly managed, it will be best for the land-owner to resist their introduction at all. Such an argument is very short-sighted, and would assist, if carried into effect, in preventing that development of value which is sure to follow wherever a sewage farm is placed, and lead to unavailing regret at some future time. If land which is worth, in an agricultural point of view, say 30*s.* per annum per acre, can be raised to £25 per annum per acre by sewage irrigation, it will assist in raising the value of every acre of land within easy distance of the farm; and I can scarcely think that landowners will be for long so blind to their own interests, as to object to the introduction of such a system.

The rage for railways has passed away: their effect in increasing the value of land has been everywhere shewn. Now, any land-owner would hail with great satisfaction the chance of a railway station near to his property, whilst formerly it was looked upon as

The first great point to be attended to is, to establish a proper vegetable growth; the second is, to be careful that the *débris* of animal life shall not be in excess of the decomposing or fixing power of the vegetable. These are the most important points to be observed in commencing the cultivation of an aquarium,—these are the main points upon which the success of a sewage farm depends (*f*).

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an intolerable nuisance, like to that which sewage farms are now supposed to be. The time will come when every town will want its sewage farm, as well as its railway-station, and every land-owner wish to assist in promoting its formation near to his own border. The only objection which can be fairly made to their introduction is, that residential property of a superior character will be, to some extent, depreciated for residential purposes, in a manner similar to that with which the owner of a mansion would view the erection of a number of small villas close to his borders, or even a railway-yard, or of a manufactory of any kind close to his premises: his land then becomes too valuable to retain for purposes of pleasure. Surely, this is not an argument to be fairly used against the establishment of sewage farms. The other element, viz., that of possible danger, is no more to be entertained, than that a steam-engine should not be erected because it might blow up. The erection of a steam-engine in close proximity may damage residential property; but that ought not, nor could not prevent the erection.

(*f*) It becomes the duty of those having the management of sewage farms, to extract as much vegetable produce from it as shall represent the animal and vegetable material which has been placed upon it. It is calculated that the excreta of a man will grow vegetables sufficient for his own consumption, so that each acre of soil irrigated by the sewage of 100 persons, ought to grow sufficient garden produce for those 100 persons. Mr. Hope, our greatest practical sewage agriculturist, has shewn how many tons may be derived from each acre of land thus used, and which bears a regular proportion to the quantity of sewage applied. This balance must be preserved so as to prevent excess of fertilizing material in the land. It becomes necessary, therefore, that there shall be a regular and well-designed rotation of crops, so as to take out those elements which previous crops may have left in the soil, and it is best, when practicable, not to limit the farm to rye-grass. It has been remarked by the Royal Com-

If any one watches an aquarium in operation, he will notice the bubbles of air clinging to the growing vegetation in the water. At times these rise to the surface, or are absorbed by the water before they reach the top. These bubbles of air are well known to consist of oxygen set free by the plant in its act of growth. It is found that if this oxygen is collected, it gives distinct traces of ozone; it is therefore capable of oxidising very rapidly any noxious matter contained in the water, which would ordinarily interfere with animal life. The plant has decomposed the organic materials present in the water; has fixed the carbon, nitrogen, and some of the hydrogen; and has given off a large portion of the oxygen in a form most fitted to complete any work which has not been perfected by nature's scavengers, and which, if left to decompose, would render the water unsafe for the continuance of animal life.

The late Mr. Ward was one of the first who pointed out and utilised in a popular way, the property of vegetation in giving out oxygen, as exemplified in the Wardian cases. Its principle was also verified by the late Mr. R. Warrington, who shewed how perfectly the relations between the animal and the vegetable kingdoms were capable of being adjusted. The existence of ozone may have been also shown but not then proved.

In corroboration of the existence of this agent, many experiments have been made, and more distinct traces of ozone have been found over a running stream, which contains much vegetable growth, than over streams without

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missioners, that man is superior to sheep as a manure-producing animal; that the value of sheep for that purpose is about *5s.* per head; that one horse is equal to eight sheep; and looking at the powers of consumption possessed by man, and the little that is taken out of the food, it is evident by analogy that man must have a great agricultural value as a fertilizer. It becomes an important point, therefore, for the manager to keep an account of the weight and quality of the products of the farm, and compare that with the quantity of sewage which passes on to it. These items ought to be in correspondence; there will then be no difficulty in determining the sanitary state of the farm—it must be right if the production of matter has been equal to the supply.

such so-called water weeds. I have tested sewage streams, and have found ozone quite absent in the air about them. It has been absent over streams with sewage and weeds, though present in the air generally. It has been present over streams where the weeds have purified the waters, or into which sewage has not been allowed to pour; and when also it has been shown by independent tests that ozone was absent in the air at a neighbouring station, whilst there have been distinct traces over a running stream which contained much active vegetable growth; at the same time there was not a sign of it over an open sewer, in which the sewage travelled as rapidly as in the river where these experiments were made. Much difficulty has been experienced in carrying on the experiments, from various causes which need not be detailed here.

We may now see the reason for the providential spread of the American weed, the Anacharis Alsinastrum (*g*), which C. Kingsley calls the "magical weed," that has choked up our streams so wonderfully, has thriven on the mistakes of sanitarians, and, whilst engaged in the office of purifying our water-courses, has assisted in preventing damage to our atmosphere, and foreshadowed the establishment of sewage farms.

We learn from the aquarium that, if the consequences of animal life overpower the vegetable growth, and also, if the animal life does not remove the vegetable growth, both

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(*g*) This extraordinary weed was introduced into England from Canada scarcely twenty years ago. It has spread throughout the land; its beneficial effect as a sanitary agent was noticed by "Grindon, in *British Botany.*" It has saved many lives by purifying water-courses and water supplies, which would, if unpurified, have produced much evil, and sometimes caused death to some of those dependent upon such streams for potable water. Its growth is very rapid in dirty streams, provided the sewage is not in great excess, rapidly choking up the water-courses and canals, and interfering much with navigation. The "Cam" is said to have been so much blocked up by it, that a boat could scarcely get along; and thus it may have even helped Oxford to win the boat-race continuously for many years. Thus often do "great events from little causes spring."

are destroyed, the whole of the ozonised oxygen being first taken away. If the vegetable growth is not removed, it becomes more and more rank, and at length is financially worthless.

A similar result will follow upon every sewage farm, upon which ignorance or carelessness is allowed to work. If the levels of the carriers are not correct, if the sewage is irregularly or unequally distributed, if it is in excess of the growing power of the crop, the proper plants are killed, rank weeds spring up, and the financial as well as the sanitary state is unsatisfactory, and miasms will arise to the injury of the vegetable as well as animal life, and throw undeserved discredit upon sewage irrigation. But it is evident that if it is safe for a large aquarium to be kept in a lady's boudoir, it is clear that a similar adjustment of animal and vegetable relation, may be carried out on a larger scale out of doors, without the least risk to those near it. Indeed, a sewage farm is safer than an aquarium, because the land has a property which water at rest does not possess. It can hold a portion of the fertilizing elements contained in sewage, and store them up against the time when the plant is ready to appropriate them to its own use. This property is possessed by some soils much more than others. It cannot, however, be stored *ad libitum*—it must not be stored in excess. It is found, at present, the safest in practice to use up the materials as fast as possible, and avoid a danger which storage may cause, viz., unequal distribution. The danger from this cause is greater in some soils than in others, because they are less retentive. Thus, argillaceous soils will retain the fertilizing elements in larger quantities and for a longer period than sandy soils. It therefore follows, that on a more porous soil the plant must be always at work, whilst the store may be kept in clay soils, and used at convenience with greater safety (*h*). It is true that a

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(*h*) The opinion of most practical sewage agriculturists is, that if the sewage is able to penetrate for a few inches or so into a soil which contains clay, the crops do best. The reason for this result is probably found in the fact that, in clay soils, more of the mineral elements required for plant growth are to be found than in light lands. This excess of mineral matter will

process of filtration through a sandy soil, tends to change the sewage elements into nitrites and nitrates, but this is not the direction in which a sewage farm should work to be profitable. It is not the deodorising, disinfecting, or re-arranging property of earth which is required, so much as the selecting power of the plant roots. We have no occasion to solve the very important question mooted by Pettenkofer, and mentioned by Dr. Rumsey, in his able address last year, viz., "that the germs of disease deodorised, but not disinfected, might be developed into active and dangerous energy" (*i*). Such a contingency might happen with dried ordure, but the roots of the plant allow nothing

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allow, therefore, of a greater excess of the nitrogenous compounds which are so necessary to rapid vegetable growth, if the ground is so broken up that the roots corresponding to the tap-roots can penetrate sufficiently into the ground to fix the plant firmly in position : the rootlets, whose duty it is to provide pabulum, will keep near the surface and bend upwards, in their search for nutriment, ready to appropriate whatever reaches their minute and fibrillated extremities, and which may be observed actively at work whenever the ground is irrigated. These fibrillæ appear to have an elective affinity for certain elements in water: the weaker the combinations in which those elements exist, the easier it is for the plant to separate them, and turn them to proper account, and therefore it is that fresh sewage is most beneficial. The writer has watched these changes with much interest, and the actions going on seem to be somewhat analogous (though vital rather than chemical in character) to those which take place in certain dye-works, where the material seizes upon the saline matter which discharges the colour, and holds the salts in indissoluble union. The combination into which the plant enters with the organic matter and the inorganic salts required for perfect vegetation, is greatly more permanent than that which holds together the various elements in the sewage itself, which rapidly undergoes putrefactive action, if it is not taken possession of by the plant, or if not fixed until wanted by the argillaceous materials and ulmic compounds which exist in the soil itself.

(*i*) Pettenkofer, a German physiologist of some status as an authority, has discussed this point, and put forth the idea that ordure mixed with earth may be deprived of its noxious smell, but that the germs of disease may still retain their vitality. Thus, he

to escape them, and no germs of disease will pass by without being made to stand and deliver up all that in their structure which can be appropriated to vegetable life; which is *everything* likely to develope mischief, the very minuteness of the germs assisting to produce their own destruction, by allowing their absorption by the rootlets of the plant on easier terms and with less expenditure of vital power.

As it is necessary for the success of sewage irrigation to have sufficient area for its complete use, it becomes an important point to determine how much land is required for a given population, so that all the fertilizing elements may be taken out of the sewage water, and the latter made perfently safe to be returned to the nearest watercourse. This area must vary somewhat according to the density of the population, the character of the rainfall, and the still mooted question as to whether all the latter has to be provided for by the land or not. The experience of some years has now shown that one acre of land will amply provide for the sewage of one hundred persons. In small towns and thinly populated districts, the rainfall ought to be kept out of the sewers altogether, if the place has an ample water supply,

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asserts, that the excreta of cholera patients are not necessarily destroyed if they are mixed with earth, but may remain dormant, ready to develope into activity whenever they are placed in circumstances favourable to their reappearance. Supposing, therefore, that such earth containing ordure in excess should become mixed with water, and that water should carry away the germs of disease into a supply of water used for potable purposes, the disease would be reproduced by those germs, though they had been previously mixed with earth. If this account be correct, it would show that the earth-closet plan is not free from a danger which cannot properly belong to sewage irrigation; for there is no doubt but that the roots of the plant will infallibly abstract every organic particle of animal origin existing in the water which passes by the vegetable, and not a single germ capable of reproducing disease can reach the effluent stream, if the fields are properly managed, and care be taken to bring every portion of sewage into contact with growing crops, or with land ready for the growth of new crops, and which land has not been already saturated with sewage elements.

on the principle advocated by Mr. Menzies; but if the district is thickly peopled, 100 acres will be quite sufficient for both sewage and rainfall of an area occupied by 10,000 persons. This point has been fully proved in papers published by several writers, and after ten years' experience on the Croydon farms, we find that quantity fully equal to its work (*j*). A reference to the report of the Royal Commission on Water Supply, shows that the Wandle, at Mitcham, contrasts favourably with the Thames above Reading, although the former has received the effluent waters of the Croydon sewage farm, as well as actual sewage from several establishments between the place at which the water was taken and the head of the river in Croydon.

(*j*) The dilution to which the sewage is exposed, will have some effect upon the result of irrigation. The sewage must not be too concentrated—the quantity of water is of less moment than its density, as regards sewage compounds. The denser the sewage the more likely it is to do damage, for the plant may not be able to extract all the fertilizing materials before putrefactive changes take place. Mixture, therefore, with rainfall in crowded populations will do no harm, especially if the farm is provided with sewage by gravitation : a large quantity of useful material will be brought down by such rainfall, the animal *débris* will be washed into the sewers from the streets, and much useful carbon with it from the roofs of the houses. When the sewage has to be pumped, there is an important question to be considered in the matter as to expense ; but I consider that if it has not to be raised very high, it will be advantageons to pump both sewage and rainfall, if the population is densely crowded : in thinly populated districts, it cannot be doubted for a moment but that Mr. Menzies' plan is the proper one. All sewage farms will probably be all the better for 25 or 30 gallons per head per day of the population, rather than for a richer liquor ; and if the water supply is defective, or should only reach on the average 8 or 10 gallons a day, it will be absolutely necessary for success to admit the rainfall, otherwise the sewers must be daily flushed to prevent that deposit which is obstructive to sewage irrigation, because it abstracts some of the most valuable parts by chemical changes, which may be highly injurious to houses which are connected with the sewer so contaminated. A free supply of water and sewers free from deposit—and therefore sewers properly laid—are conditions absolutely necessary for the perfect success of a sewage farm.

Because there is a chance of evil from the over-charged soil of a badly-managed sewage farm, it has been argued that such farms must, from the very necessity of things, be nuisances to houses in close proximity to them (*k*). The soil must not be over-charged,—the farm must not be badly

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(*k*) It very often happens that the difficulties attending upon a proper management of the outfall, has led the sewer authority to make immense tanks for the purpose of arresting and extracting the solid matter in the sewage before it gets on the fields, or for otherwise dealing with the sewage. These tanks are great mistakes : they give rise to filthy miasms and dangerous odours, which are often imputed to the areas under irrigation, and produce evils which should be avoided. Nothing should intervene between the sewer and the soil, that can possibly lead to any detention of the sewage, and allow putrefaction to arise. The great value of the sewage is in its fresh application,—the only danger is in delay. It is now acknowledged by both authority and experience, that there is no danger to be apprehended at all from excreta less than 24 hours old. If, therefore, stagnation can be avoided; if settling tanks are not permitted; if the fall will allow of the rapid discharge of the sewage upon the land; the nearer that land is placed to the town, the better chance there is that all the conditions requisite for a successful sewage farm will be present. It only requires that the sewers are constructed so as to be perfectly self-cleansing, that the sewer authority has not pretended to sewer the place only by using cheap and nasty workmanship, with sediment always collecting and decomposing in them, because the pipes have been irregularly and badly laid.

Mr. B. Latham has designed a so-called sewage extractor, which admirably fulfils the purpose for which it is intended. It is a revolving straining wheel, acted upon by means of a turbine, and which is worked by the sewage itself, a small fall only being required for the purpose. This wheel removes all the objectionable and most of the useless matter from the sewage, and allows the liquid only to go upon the land. The refuse is mixed as it comes from the trough with deodorisers, and is daily removed from the outfall to the farm for immediate use as a solid manure, or is sold to market gardeners, who eagerly seek for it. Mr. Latham's ingenuity is here shewn in a most admirable manner. The machine is so satisfactory as to do away entirely with the necessity for settling tanks or any other kind of filter.

The settling tanks which were used for a long period by the Croydon Local Board, became gigantic evils, and produced much

managed; if it is, it will fail financially, bring its own downfall, and its promoters will be liable for damaging the neighbourhood. It has to be borne in mind that, for the farm to be successful, the flow of sewage must be fresh, that it should reach the soil a few hours at most after its discharge; the growing rootlets of the plant then take immediate possession of the changing elements in the sewage.

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of the odium which was unjustly fathered upon the sewage farm. Their removal has been aimed at by the writer for a long period, and it is confidently anticipated that the disagreeable results produced by the tanks will disappear, now that they have become things of the past. It was never found that any financial benefit resulted from the manure itself which was made there, but much loss was incurred by reason of the cost of disinfectants, which had to be always used when the temperature of the air was above 60°. Now, however, that the sewage so extracted is used fresh, it is said to be very valuable as a manure, and is realizing a larger price from the market gardeners, who use it in their fields, and who find it much more profitable than the comparatively useless material formerly carted away at irregular intervals from the filter works.

The foregoing observation will point out to the uninitiated, that it is in the soluble portion of sewage that the fertilizing principle resides, and that there is very little agricultural value in the solid matter unless it is perfectly fresh; and therefore it is to so-called water-closet towns that the system of sewage irrigation is most applicable, and in which it is most likely to be financially successful. Dr. Letheby stated at a meeting of the Metropolitan Association of Medical Officers of Health in December, 1867, that he considered "the present dilution of excreta as both wasteful "and mischievous, and creating a gigantic difficulty in regard to "its safe and useful application"; and recent events have shewn that the same opinion is still held. It is evident that Dr. Letheby's opinion is not corroborated by results. It is now generally believed and fully understood, that the true key to the safe and profitable disposal of sewage, is its immediate removal and rapid application to the land in a fresh state. This can only be done by much dilution, or by the general adoption by the local authority of the earth-closet system. Excessive dilution conveys it rapidly to the farm, and prevents evil arising in the neighbourhood of the meadows, the excreta being at once deodorized before putrefaction can take place. It is the use of putrefying sewage in

The appearance of a field of rye-grass, under irrigation with sewage, is a perfect picture of efficiency; the ground is covered with an inextricable tangle of rootlets, the extremities of which seem to meet the sewage, and acting upon it, both mechanically as well as chemically, as a filter, take out everything required for their own use, and as the water passes from the field, especially after a second application, to another portion of land, the quantity of organic material in the water is absolutely less in quantity than when it was supplied to the inhabitants as potable water—[*vide* Report of Commissioners on Water Supply.] (*l*)

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one case, and of fresh excreta in another, which leads to such various results and opinions. I take it as a *sine quâ non* of sanitary science, that sewage must be rapidly conveyed away, and applied fresh to vegetation, to render it profitable for irrigation, or safe for the inhabitants of the neighbourhood.

It is unfair to compare results obtained from the application of putrefying sewage, and the sanitary conditions of a farm to which putrefying sewage is applied, with any other particular system; and therefore any town in which there is not an abundant supply of water, and in which much of the human excreta is first deposited in cesspools or middens, and then sent into the sewers, is not a fair example from which the results of sewage irrigation are to be sought.

(*l*) The report states (Note 202) that the attention of the Commissioners was called to the condition of the Wandle, and they instructed Mr. Pole to examine the effluent waters after they had passed from the land. They abstract from Mr. Pole's report the following item, the whole report itself being in the appendix. Mr. Pole says, "When I saw the system at work on "May 11th, although the sewage was foul and dirty when it "went on the land, the water running off was quite bright and "clear, without any appearance of foul deposit in the channel. "I noticed several fine trout in the river near the point of dis- "charge, as well as in other places farther down. It is worthy "of remark, that the plan here adopted of allowing the sewage "to travel slowly over the land, in constant agitation, among "the blades and stalks of vegetation, appears to me peculiarly "favourable for the oxidation of the impurities by the action of "the atmosphere, which, I have no doubt, powerfully aids the "purifying action by vegetable absorption."

The opponents of sewage irrigation argue, that whilst the crop is growing, portions of the sewage will become attached to the stalks of the grass, above the reach of the

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The report then goes on to state some curious evidence with regard to the so-called "previous sewage contamination," which has been the great bugbear of the water companies during the last year or two. Dr. Frankland has shewn that this "previous sewage contamination" exists to a considerable extent in the water supplied to the inhabitants of the metropolis, and contends that such water is not fit to be supplied as a potable water, because the nitrates and nitrites contained therein must have had a sewage origin. From the Commissioners' report it will, however, be seen that the well-water supplied by the Croydon Local Board, and which is recognized as a magnificent potable water, contains ·531 parts in 100,000, or more than half a grain in 100,000, whilst in the water as sewage these nitrates and nitrites have all disappeared; but the ammonia has increased from ·001 to 2·191, and the organic nitrogen from ·007 to 1·156. After flowing off the land, the sewage contains 34·4 parts of solid residue, the ammonia being reduced to ·002 and the organic nitrogen to ·037, the nitrates and nitrites having increased to ·317. When it first passed on to the land, it contained 43·6 parts of solid residue in 100,000, and a mile below the outfall the water had 31· or one part less than the Croydon well-water.

At Mitcham, one mile lower down, the ammonia has all disappeared, and the nitrogen has again decreased to ·007, but the nitrates and nitrites have increased to ·403. This subject was discussed at a meeting of the Association of Medical Officers of Health, in London, some time since, and I asked Dr. Frankland to explain this anomaly. He did so, by stating that he believed that the Croydon well was contaminated with sewage elements, by percolation from the irrigated fields at Beddington. I pointed out the impossibility of this, by reason of the following facts, viz., that the analysis of the well from which the town of Croydon is supplied, and which was made by Professor Way before the irrigated fields were laid out, nearly corresponds with Professor Frankland's own analysis. Secondly, that such percolation could not take place to any extent, because the guage shews that if allowance is made for evaporation, nearly as much water passes away from the fields at the outfall, as passes on to them. Thirdly, that the level of the fields is below the level of the surface of the well from which the supply is taken; and,

absorbing ends of the roots (*m*), and that thus of necessity putrefaction must take place in a portion of the materials supplied; and by this means miasms may be produced dangerous to the health of the neighbourhood.

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lastly, that the river Wandle itself runs the whole length of the distance between the well and the fields, and that if any supply was wanted for the well, it would reach it from that stream, and not from fields at a lower level many feet below the source of supply.

The Commissioners contrast the condition of the Wandle at Mitcham with the Thames above Reading, and shew that in the former stream, the total solid residue is less than in the latter at Mitcham; ammonia is absent, organic nitrogen is less in amount, and the nitrates and nitrites exist in the proportions of ·403 to ·286, whilst at Mitcham carbon shews ·099, but in the Thames it is ·291. It must, in this case, be borne in mind that both at Beddington and at Carshalton, much sewage from those villages does find its way into the Wandle, not having gone over the irrigated land; and that, therefore, whatever contamination does exist in the water at Mitcham, may be fairly ascribed to those places, and not to defective action on the farm. At the time of examination, the whole of the sewage from the Female Orphan Asylum, at Beddington, numbering 200 inmates, was discharged into the centre of the stream more than a mile above the place at which the water was taken for examination by the Commissioners. We may reasonably assume, therefore, that this sewage contamination may account for the small amount of nitrates and nitrites which were there found.

(*m*) This was stated to be a fact before the Parliamentary Committees, and great danger was assumed to have arisen from it. The ideas of the witnesses broke down on cross-examination, for no evil was proved as having arisen from this source, and it was shewn not to belong to proper sewage farming. Some portions of a field badly laid out may so suffer, but a field ought not to be used for sewage irrigation if it is badly laid out; and sewage ought never to be allowed on the ground so abundantly as to flood the land above the rootlets, unless the crop is young and a long time likely to elapse before it is taken from the land. Crops nearly ready for removal ought not be irrigated at all. Thus the agriculturist, who applies sewage to his crop of rye-grass or anything else shortly before it is cut and ready for use, is acting wrongly, for by so doing he is increasing the chance of a possible danger—a small one it is true—but still a danger which, in a properly arranged ground, need never be incurred.

There seems some foundation for this argument; but the dense mass of rootlets I have mentioned, and through which it has to filter, soon renders it unimportant in those hot seasons when it is alone likely to occur (*n*). In a dry season, in the youngest grass, and when rain does not wash the plant, such a change may occur to a very slight extent, but nature has fully guarded against the contingency, by making the changes produced by the growing plant overtake and destroy the evil. The production of ozone takes place in the irrigated field, as well as in the aquarium. The oxygen that is given off by the rapidly growing rye-grass upon a small farm is ozonised. A double guard exists against any dangers—not only are the noxious elements contained in the sewage seized upon by the plant and fixed in the tissue of such plant, but should any change occur in those elements before they can be so fixed, and that change take them beyond the point at which they are valuable, should they lose their value by putrefaction, and develope vibriones and their attendant miasms, then the development of ozone, which is continually taking place in the growth of the plant, prevents the flight of the miasm in a dangerous form, oxidises it on the spot, and renders it harmless. The conditions present, if a proper

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(*n*) It is worthy of remark, that the effect of putrefaction will be greatest at those times during which vegetation is most active, and that whatever promotes the one will promote the other. For instance, the action which takes place in vegetation after a frost is most marked; the rise of sap in trees is very active indeed; and action is very rapid in the plants which flourish on irrigated meadows at the break up of a frost. It is true that the product may not, to the eye, appear so great as in a fine summer's day; but it is, nevertheless, as certain that in a given quantity of material produced in spring, as compared with a similar amount produced on a hot summer's day, the amount of nitrogen and carbon which will be fixed will be *cæteris paribus* equal, whilst it is the excess of the water that will make up the weight. The concentrated absorption which takes place in February, will as effectually purify the water as the more active growth of June and July, if a sufficient area is used, and the soil not allowed to become surcharged.

care has been used by the farmer, prevent the possibility of that state in which all free oxygen has been removed, and which Pasteur (*o*) has described as the period at which epidemic diseases arise.

If this theory is correct, and observations extending over a considerable period tend to corroborate it, there is good reason why rank vegetation should exist in malarious districts; for nature generally puts the bane and the antidote close together, and luxuriant vegetation may be taken to indicate the necessity for increase of oxygen at that spot. I have found distinct traces of ozone in the Beddington fields, when there has been none in the town: it has been noted how very rapidly metals rust upon sewage farms,—this easily accounts for it. The surface of the meadows have been tested at various times in the very hottest days of July, when no ozone has been detected in the town, but it has been generally found present over the sewage grass, on those parts of the farm in which vegetation was most luxuriant. I have found it more abundant there than elsewhere when there has been very little wind, and it has scarcely ever been absent. The production of ozone may explain the increase of appetite which is known to follow from a saunter among pine woods, in which I have also found it freely developed. It may also assist in accounting for one peculiarity which is a well-established fact upon well-managed sewage farms. I have often asked the men employed upon the farm, if their employment interferes with their health. On several occasions, from different men, the same answer has been received, viz.:—"Lord

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(*o*) Pasteur has published the idea that it is in those states of decomposition in which all free oxygen has been removed, that the germs of epidemic disease develope most rapidly, and run riot about the world. If this is so, it follows that the development of free oxygen must stay the progress of such epidemic disease. It is possible that instead of free oxygen, we should read oxygen in a state of change from one compound to another, or else oxygen in the ozonised form. If these are absent, then the germs of disease, whether of cholera or typhoid fever, or any other epidemic form, may become rampant, and pestilences arise. Whatever, therefore, developes oxygen and fixes nitrogen and ammonia, must tend to decrease the chance of epidemic disease.

bless you, no, but it do make us eat such a precious lot!" I was at first inclined to think that this answer was a little fun poked at my expense, but having had a similar reply from different men unknown to each other, and finding on further enquiry that the men really meant what they said, it seems that the oxidising property of the ozone there produced, has something to do with the increase of appetite complained of, acting upon the men in a manner similar to that of the air upon the digestive organs of those who pay a visit to the sea-side.

Next to the sea, the surface of a well-managed sewage farms affords the largest supply of ozone, for here we have a continual motion of fluid; an active evaporation is always going on; the temperature of the ground is much nearer to a medium, being cooler in summer, warmer in winter; and there is the most active vegetable growth that can possibly be produced. The production antozone, or peroxide of hydrogen, which probably accompanies the other chemical changes, may likewise exercise a very important influence upon certain elements contained in decomposing sewage, tending still further to render them innocuous, especially the sulphur compounds when they are met with, and which are not always taken out by the plant; but upon this point I have no evidence.

An important question often arises which bears closely upon this point—How near may a sewage farm be placed to a given population without injury to the people? From the preceding observations it is seen that it is possible for danger to arise, either by accident or design, for man is not infallible. It will be prudent, therefore, to have at least 100 yards between a row of houses and a sewage farm. Experience, as well as theory, has shown that this distance is amply sufficient. The visitor to Beddington will see a number of villas, which have been occupied for some years, with irrigated fields both in front and rear, whilst not a trace of enthetic disease has appeared in any of them, though the Beddington farm is capable of much improvement. At Norwood, the population is much greater and much nearer (*p*) to the fields, probably

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(*p*) This is corroborated by a special report made by Dr. Buchannan, of the Privy Council Office, upon the health of

400 persons living within 200 or 300 yards of the farm. Previously to its formation in that district fever abounded: since then, that disease has all but disappeared, and the mortality of the district has steadily declined. The death-rate for Norwood (the population of which is about 5,000) for the last six years, according to Dr. Westall's mortality tables, is as follows, viz.:—

1863	...	18·76	
1864	...	18·89	
1865	...	18·17	Sewage farm established.
1866	...	15·34	
1867	...	14·21	
1868	...	12·07	(*q*)
1869	...	13·20	

From this table it will be seen that the establishment of the sewage farm in 1865, was immediately followed by a decrease in mortality, which would not have been the case if miasms had been promoted by its formation. The Beddington farm, of nearly 300 acres, is within 500 yards of a considerable number of people, and the first outfall for the sewage is within 900 yards of the centre of the town. It lies to the westward of the town, and yet I can safely say that a continuance of west-wind is always accompanied by a

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people living near to the sewage farm at Rugby. It is said in that report, that the health of the children living in the midst of the irrigated districts, far from suffering, has actually improved. The editor of the *British Medical Journal* remarks, (Sept. 3, 1870)—"This is a somewhat unexpected result"; evidently unaware of the communication made at the Social Science Congress of 1869, in which the effect was broadly proclaimed, and its cause pointed out.

(*q*) It is not asserted that the low mortality in Norwood is due entirely to the establishment of the sewage farm, neither is it expected that the low rate can be maintained; but it is contended, if miasms were produced by sewage farms, then the mortality would have increased after the farm came into operation, and preventable diseases would have more abounded than before the event. We find the contrary to be the fact; and there is, therefore, strong corroborative evidence that miasms do not arise.

diminished amount of ordinary sickness in the district, and our annual mortality of the parish is generally below 20 in the 1000 (*r*).

(*r*) For the last three years the death-rate has been, for the whole of the district :—

1867	...	16·6
1868	...	18·36
1869	...	17·24.

No death from dysentery has been registered at all, and the few real cases of fever that are reported, are generally found to be due to some local cause which is discovered after the fever has arisen. In the greater number of instances it occurred in parts the farthest away from the outfall. The cases were found generally to be due to the sewer ventilating into the house instead of into the external air; and these unventilated sewers are generally at the summit, or extreme end of the main sewer, and are reduced to an unventilated state by people who will not obey the bye-laws of the Local Board and the ordinary rules of nature, viz., that no chance for stagnant air be allowed to exist.

It is not fair to adduce the death-rate of the whole parish of Croydon, as a proof of the advantages of sewage farming; but looking at the extended area under irrigation, the position of the farm in the teeth of the prevailing winds, it surely would tell upon the health of the place, if the conditions which are supposed to be likely to arise ever did shew themselves, for by their effects alone could we discover their presence The influence of the prevailing winds upon the general health of the district has been fully inquired into, and can easily be ascertained by any intelligent observer. The *Croydon Advertiser* publishes weekly a weather table prepared by Major Rickett, which gives the daily readings of the barometer, thermometer, and ozonometer, with the direction of the wind and the rainfall. This is compared with observations made by Mr. George Corden for Dr. Westall, who prepares the mortality tables for the Croydon Local Board of Health. This table shews, indisputably, that when the wind is in the east or north-east, the quantity of ozone in the air is very much less than when it is west and south-west. The air which has passed over London and its eastern suburbs, has had, as a rule, all the azone removed before it reaches Croydon.

Nevertheless, it is very difficult to draw just inferences from this: it is well known to the local medical men, that a continuance

At Norwood, moreover, a public footpath passes right through the irrigated fields, which is traversed by hundreds of persons for exercise and recreation, especially on Sundays. The persons so using the footpath have been frequently surprised, when they have been told that their walks for pleasure have been taken through the sewage farm of the Croydon Local Board of Health. The path is much more frequented than other footpaths in the neighbourhood, which would not be the case if the fields were the nuisance they are supposed to be.

The next point urged against sewage farms is, that from the very force of circumstances, the neighbouring wells must be contaminated. (*s*)

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of east or north-east wind prevents the rapid recovery of their patients, and that they anxiously long for a change to the south-west or west; that as soon as that change takes place, the progress of disease often ceases, and a rapid amendment is the result. This improvement may be imputed to the simple change of wind from east to west; but it may be fairly argued that this change is not alone sufficient to account for the all but invariable happy result; and if the benefit derived from a change of wind is not counter-balanced by that wind bringing the miasms from the sewage farm, then the miasms which are stated by those who know nothing about them, but what is drawn from inference, to be so very deleterious, cannot be very marked in their effects, or they would outweigh the benefits of a simple change of wind—they are shewn not to do so; the ordinary mortality of the distri ct is also shewn to be lower than in most other places which have not sewage farms close to their borders. I believe, therefore, that there is sufficient evidence to prove that these farms are not deleterious, but the contrary, and that they may be made a means of adding to the health of large populations living in their neighbourhood.

(*s*) Statements bearing upon these points were broadly made at the recent inquiries, which were apparently supported by supposed facts: it was asserted that serious results had followed the operations of the Croydon Local Board at Beddington. A local medical man was brought forward to prove that typhoid fever had occurred in the neighbourhood of the farm, and had penetrated to every cottage on the estate [see plan], the inhabitants being, according to the evidence, of *the very poorest class.* He said that almost every disease assumed a particular type attributable

This is a possible danger, but not a necessary one; if the ground is badly chosen, if the arrangements are not carefully made, if a 'fault' exist in the geological formation of the ground, and the source of a well, the water of which is used for dietetic purposes, is in close proximity to it,

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to sewage; that around the outfall of the farm the health of the people was deteriorated; that both typhoid fever and diphtheria extensively prevailed; and that these results were attributed to the sewage farm. These statements, roundly made before a Committee of the House of Commons, were at once brought to the notice of the local authority. The district in which the farm is situated is not under the sanitary control of the Croydon Local Board, lying beyond their jurisdiction, although it is within that of the Croydon Board of Guardians. The gentleman in question, Mr. Creasy, being their medical officer, had to report periodically to the latter body upon the state of this part of the Union. It appeared in evidence, that although this had existed since 1865, no official report had been made to the proper authority by the medical officer, and a neglect of duty (if the statement were true) was clearly chargeable against the gentleman who volunteered the information to the Committee of the House of Commons, and who ought to have made a report of the case to the Board of Guardians. They called for a report from him, and in that paper, dated June 13, 1870, it is stated by the same gentleman that the people affected being above *the condition of paupers*, had not to be reported upon to the Guardians. He states that the greatest defect arose from bad closet arrangement—"gene-"rally a common privy over a cesspool having an overflow into "a drain. The cesspools were full; the water used was pumped "from local wells, was complained of as bad, and in all was "of doubtful aspect and smell." The cesspools are reported as "situated within twenty yards of the houses." The reporter could not find any cause for the fever, either in the condition of the water or the close proximity of the cesspools; but he refers its origin to a culvert which was supposed to carry away effluent water from the Croydon sewage farm, and which ran past the whole of the houses at a distance of 85 yards [*vide* plan]. These houses had been, says the reporter, for some years the seat of disease, with much gastric irritation; and he sums up his report by stating "that the particular locality suffers from the propinquity of the Croydon sewage grounds, and that the wells are infected thereby." "No deaths have, however, been recorded."

and if that well is supplied by surface drainage, much mischief might happen. This is not, however, a necessary result: it is the duty of those laying out the ground to mark the position of every well, to study the character and the source of its supply, and so lay out the carriers upon the field, that it shall not be possible for the dreaded contamination to arise.

A copy of this report was sent by the Board of Guardians to the Croydon Local Board, and on its receipt the allegations therein contained were at once reported upon by the Board's engineer. His statement, submitted to the Board on June 21st, at once shewed the worthlessness of that contained in Mr. Creasy's evidence before the Parliamentary Committee, as well as exposed the contradictions contained in the report of the medical gentleman to the Board of Guardians. Mr. Creasy did not think that bad water of doubtful aspect and smell, drawn from wells in close proximity to full cesspools, would be local causes for fever, but refers the cases to a culvert 85 yards away, through which he supposes effluent waters from the sewage farm occasionally passed —this he calls sewage water. It was shown by the engineer to the Local Board, that no sewage water had ever passed through that culvert; and the effluent water passed only for a few days in the whole of the year. The nature and character of this effluent water is described by the "Commissioners on Water Supply," when it had entered the Wandle, "as contrasting favourably with the Thames above Reading," which clearly shows its true nature. The engineer's report also pointed out two or three very significant facts, bearing upon the matter. He presented a statement which had been prepared from the results of a house to house visitation, extended to the whole of 65 houses, being all that were in close proximity to the outfall, and all the houses to which Mr. Creasy's evidence referred. From this account it was seen that two circumstances determined the illnesses which had occurred, and which, notwithstanding the insanitary state of the drainage and water supply, had not been of a serious character, for no death had been registered from fever or dysentery. The first fact was, that those persons who drank water from surface wells away from the neighbourhood of cesspools, and which wells were fed by the real effluent stream from the farm, as well as those who drank from a stream which was fed by the effluent water, did not suffer from disease of any kind [*vide* plan]; whilst those few who had typhoid fever, either drank the bad

It is quite certain, that in a percolation of sewage through soil in which the strata are antagonistic to its progress, there will be a perfect re-arrangement of elements, by which all noxious ingredients will be changed into harmless matters, long before one hundred yards of earth have been traversed: we have also to bear a very important

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water mentioned in Mr. Creasy's report, or else, were exposed to noisome smells from the open sewer and full cesspools, close to the rear of the dwellings. Another circumstance clearly shewn was, that the wind had blown from the direction of the open sewer to the rear of the houses, when illness was present; whilst the irrigated land was in a point of the compass E.S.E. and S.E. of the people. It was shewn by reference to meteorological tables, prepared by a resident gentleman (Major Rickett), that the wind was seldom or ever in that quarter; and it seems, that on one day only during the time that some severe cases were reported, nor for some time previously, did the wind blow from the farm to the buildings. It should be said that the fatal cases were caused by scarlatina; and it is not asserted by sanitarians, that that disease is produced by sewage works—a circumstance apparently not within the knowledge of the complainants.

It is upon this evidence that Dr. Letheby makes an onslaught upon the Beddington farm, quoting Mr. Creasy's opinions, and saying that it damages the value of the neighbouring property, and that the houses in proximity are, as a consequence, unoccupied,—statements which, like the sanitary evidence, were quite visionary and unreal, as clearly proved before the Committees. This onslaught was made in a paper read before the meeting of the Metropolitan Association of Medical Officers of Health before alluded to, as well as before Committees of both Houses of Parliament. Dr. Letheby stated at the same meeting, what he considered to be the absolutely required conditions for successful sewage irrigation, which were, mainly, "porous soil, well drained, with a ready market for the disposal of its only mercantile produce, viz., Italian rye-grass, and that there must be two acres for each 100 persons." These (so-called) absolutely required conditions, at once prove how little real practical experience Dr. Letheby has ever had of sewage farming: they are all unnecessary. If Dr. Letheby had troubled himself to visit the market gardens at Beddington, about the very time he uttered those sentences, he would never have committed himself so much, for everything a

fact in mind, that sewage is expected to go over the ground —not into it. It is well known that earthy materials have the property of acting upon sewage, probably by a kind of catalysis in the act of filtration, so that if filtration is continued long enough, the materials which do get into the earth, are altogether changed into nitrites or nitrates, or some other comparatively harmless state, which is formed out of contained organic elements (*t*).

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garden can produce of delicate flavour and floral beauty, could be seen there in perfection. Violets, strawberries, mints, black currants, could each be distinguished by the odour exhaled from them, on the day after the ground had been irrigated with sewage: though the sun was broiling hot, no miasm could be perceived to prevent the odour of each being at once recognized, as the ground containing the crop of each was neared. At that time, the Beddington farm, of less than 300 acres, was successfully dealing with the sewage of 50,000 persons, and had been doing that duty for several years. According to Dr. Letheby it ought, at that moment, to be a pest-spot,—a focus for evil spreading mischief all over the country,—and not a farm at which daily fights were taking place among the cow-keepers, as to who should get the largest amount of the produce offered for sale.

It is a curious fact, that plants producing unmistakably fragrant odours of their own, do exceedingly well upon sewage: this seems to make such plants analogous to the sweet smelling æthers and beautiful colours which are obtained from gas-works' refuse, and is another proof of the manner in which repulsive things become beautiful in nature's laboratory.

(*t*) Dr. Frankland may or may not be right, in the opinion he forms as to the origin of nitrates or nitrites, from a previous sewage contamination; but so long as the water is not infested with organic germs, with living organisms, or with free ammonia and some of its compounds, the presence of minute quantities of nitrates and nitrites will not be in the least hurtful, but probably the contrary. The previous sewage contamination may have been thousands of years ago, or caused by farming operations carried on within the present century, and need not enter into consideration. If, however, the nitrates and nitrites should amount to more than a grain in 100,000 parts, it would be prudent to search for their origin, even if not accompanied with organic germs, so that immediate contamination might be detected as early as possible and its source sought for: if this source appears to be from some recent supply, change may be near, and would have to be averted.

Sewage water passed through twenty feet of earth of any kind—even sand—is so altered, and would be perfectly purified; but experience shows that it will not so pass for any lengthened period, for a layer of clayey matter is developed within a short distance of the surface of the soil, if the alumina therein is ever so little, and this soon renders the filter impervious to water. This action takes place upon irrigated lands, and would be perfect in its effect, if it were not for the countless swarms of worms which develope beneath the soil, pierce the aluminous layer, and allow of moderate percolation, though it is much limited in the way mentioned (*u*).

(*u*) There is a difference of opinion as to the propriety of under-draining land which is to be used for sewage irrigation. *Primâ facie* evidence would show that it is right to drain the land about to be so used by a deep system of drainage, so as to keep the land as dry as possible. It is, however, evident from the very nature of things, that the land cannot be dry; that if there is any outlet for sewage by drains sunk into the ground, it will soon worm its way through to that outlet, and sewage, not pure water, will flow off. Experience has shown that this is certain to arise. The rats, worms, and leeches, which rapidly develope in the carriers, make holes through which the sewage will go, without ever coming into contact with the vegetation or the earth, and the whole will fail, because if sewage gets into the ground beyond the upper roots of the crops, there will be at times putrefaction and its attendant evils. I should advise, therefore, that the surface of the land be so prepared that the sewage must run over it—not into it, or, at any rate, that it shall not run into it until it has passed over the surface; that under-draining is not necessary, but liable to lead to failure, if the surface of the land can be so prepared as to make the sewage pass over it, and pass off in a moderately quick manner into the carriers intended for the effluent water; and that the most important point is to get the water off the surface, without penetrating more than sufficient to get into the small cuttings required to carry off the effluent waters. If the surface is regulated aright, and no deep cuttings are made, there will be much less danger of evil, and a very great expense saved. The farmer would smile if he were advised to let his guano get deep into the ground, and not trouble himself about top-dressings; and the gardener likes his manure on the top of the soil, because

It is found, by actual measurement, on a well-regulated sewage farm, that the quantity of effluent water passing

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he finds, from experience, that his crops are better if the manure is kept on the surface. It will be evident, therefore, that an argillaceous soil will suit the purpose better than a pure sand; though it will be always best, if possible, to have a farm consisting of both kinds of soil, a medium being best for the consumption of the products of the farm, and the production of other crops which are requisite to make a sewage farm most profitable, and render the farmer independent of outside customers for his grass. The state in which portions of our farm at Beddington were allowed to remain, must not, by any possibility, arise. Cattle ought not to be kept on the farm where the fields are irrigated, as their feet produce a swampy state incompatible with proper sewage farming. This state mainly led to the determination of the Croydon Local Board to take the farm out of Mr. Marriage's hands,—the agreement with that gentleman expired Lady-day, 1870, and was not renewed.

Of course, if it is not possible from some local cause to get the land moderately dry at the surface, a deep draining will assist in promoting fertility, but the outlets will have to be narrowly watched, and the effluent water from the drain-pipes made to pass over grass land again, before it is allowed to pass into a running stream from which potable water may possibly be taken. The drains must be designed very carefully, and laid very deep in the soil, or else in a short time sewage, not pure water, will pass away; and, as before remarked, efforts must be made to keep the sewage near to the surface of the soil—not to get it deep into the ground, which must be the effect of under-drainage, unless the greatest care in detail is used.

The action of sewage in developing clayey matter, also leads to the necessity of breaking up the land, as often as it is seen that the sewage does not at all enter the first few inches of the soil. This necessity for breaking up grass land was not at first understood. The rye-grass was observed to fail, and after three years all but disappeared from the field, a fine thin grass growing in its place, not producing anything like the weight of herbage as was previously obtained from the proper rye-grass. It is true, that this was partly due to the fact that rye-grass cannot continue to grow, year after year, like ordinary grass—even if not allowed to perfect its seed, the position of the rootlets of the grass reduce this cause for failure to very narrow limits; but it is evident that this action of sewage must not be forgotten by the practical agriculturist.

away at the outfall, is nearly equal to that which goes on to the land as sewage, allowance being made for the necessary evaporation from the surface of the field (*v*). This proves that even on the gravel, as at Beddington, no appreciable percolation takes place if it is properly laid out.

(*v*) The evaporation which takes place from the surface of 300 acres of land under irrigation must be very considerable; on those days on which the air is dry, large quantities of water must pass off in this way, leaving a larger per centage of inorganic salts in the water. This evaporation has been measured, to some extent, by the engineer to the Local Board, and it is found to make a considerable difference in the quantity of water passing off the fields; so that an analysis of the effluent water which does not give any allowance for evaporation, may not give an accurate estimate, and tells rather against the result of irrigation, by making the purification of the water less decided then it really is. Then, as regards percolation into the soil, if there is a deep extent of sandy loam, of gravel, or chalk, it is evident that much percolation must take place, if there is any kind of outlet some distance below the level of the land: when this is the case, the land will take in a very much larger quantity of sewage, and therefore may have it in a much more diluted state than when it passes over clay soil. This point will have considerable bearing in choosing land for irrigation. If the sewage is rich, with a low average quantity per head of the population, a clay soil will be more suitable than when the sewage is weak, and the number of gallons per head is great. If the rainfall is great, and much of it received into the sewers, it will be wiser to have some sandy loam or gravel over which the storm-waters may pass, rather than an argillaceous farm. Mr. Latham has designed some pipes for the conveyance of sewage on to irrigated land, which are admirably adapted for the purpose they are intended to serve. They are cylinders made of tile-clay, with a series of holes upon one side for the sewage to flow from them by welling up on to the land. They act as carriers, and are sunk into the ground so as to be even with the surface of the field, and yet to occupy very little of that surface, and do not take away, therefore, from the area under cultivation. It will be observed that the vegetation is very luxuriant on either side of the cylinder, and grows there most rapidly after each cutting: the position of the carrier is at once seen on a field by the more luxuriant growth of grass near to it. These cylinders prevent any ill-consequence from the carriers

The third set of serious charges made against sewage farms is, that the cattle upon them are generally unhealthy, —that they are remarkably prone to various diseases,— "that the process tends to produce disease,"—and that the products of such cattle—the meat, the milk, and the butter—are unsafe for people to consume (*w*).

Those connected with sewage farms do not find that these are true assertions. The appearance of the cows at Beddington is admirable. Their coats are sleek and glossy, their flesh firm, and their contour and general appearance such as must delight the sight of a good farmer. These facts are well known to those cultivating such farms. The statement, therefore, published the other day in the *Times*, and repeated at a public dinner, consisting mainly of farmers, by a member of parliament for a part of the county of Surrey, viz. that the foot and mouth disease first made its appearance among the cattle pastured upon the Croydon sewage farm—that the cattle were dying by scores by rea-

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becoming foul; they cleanse themselves, and when examined after a cutting, are seen to be perfectly free from any noxious matter whatever,—they should always be used when the irrigated land is near to dwellings, for they obviate the evil consequences arising from fanciful ideas connected with the name of sewage.

(*w*) These opinions are strongly supported by Dr. Letheby, and no man has had greater opportunities of proving the truth of these assertions (if they were true). From his position as Medical Officer to the Corporation of the City of London, he has more to do with the discovery of diseased meat than any other man living. Tons are often reported as seized by his orders and condemned by the authorities. He has known whence this meat has been brought, and yet, when examined on this point, he was unable to say that he had any proof to offer in support of his opinions. This is the more curious, for large herds are now fed upon the products of sewage farms; and it is more than extraordinary that no diseased meat has come from such sources, independently of the effects of sewage upon the cattle themselves; for sewage-fed cattle are prone to disease as well as other cattle, though it would seem as if this, according to Dr. Letheby's evidence, was not in the same ratio, but in a minor degree,—and such is evidently Mr. Marriage's opinion.

son of the outbreak—took agriculturists by surprise. It was stated that this was the second outbreak of disease among the cattle pastured upon this farm. These statements, made upon such authority, will be copied into every paper, and used as an argument against sewage farms, wherever it is proposed to place one; for the *Times*, for some reason or other, did not insert Mr. Marriage's correction of the error, and writers have already assumed that the assertion is correct. I will now submit the actual facts. First, as regards the rinderpest, which Mr. Smee accuses the sewage farm of promoting. It can be easily shown by the record of the Inspector appointed by the Croydon Local Board, that, although Croydon and Norwood were in the very centre of a district greatly affected by the disease, the mortality among the cows which were fed upon the sewage grass in Croydon, was very much less than in other parts in and near the metropolis, which had not the benefit of such food. At Norwood, where the whole of the grass grown upon the sewage farm is sold to the cow-keepers in the neighbourhood, not a single case of rinderpest was reported in the Croydon part of the district. Some few steer-stock were slaughtered upon Mr. Marriage's farm, in 1866, because they had been infected from a certain cause: it was done as a precautionary measure, and nearly at the end of the epidemic. Until the epidemic was nearly over, not a sign of it was seen at Beddington, and it never made its appearance among the cows on that land at all. In 1869, the foot and mouth disease—which, by-the-bye, is not murrain—made its appearance at the outports as well as in South London, in Kent, and on the Surrey Hills, before it reached Mr. Marriage's farm, and then it first appeared among the steer-stock, and not among the cows. Mr. Marriage informs me that the first cases appeared in the beginning of August, about the 4th,* after an announcement had appeared in the daily journals of the prevalence

* Mr. Mitchell, Sanitary Inspector of the Parish of Croydon, reported to the Local Board that forty-seven head of cattle on Pollard's Hill (high ground to the north-east of Beddington, and on a different watershed) had had the foot and mouth disease on July 20, 1869: he reported that fact at Streatham police-station, on July 22nd.

of the disease elsewhere. He says, in a letter to me, "that the cases have been quite mild—not one fatal—not one slaughtered; that the whole are now (September 10) perfectly well, and that they did not require any medical treatment." Mr. Marriage states, that in his belief the mildness of the disease was due to the rich, fresh, succulent sewage grass with which they were fed—that his cases suffered much less than those not so fed. I think these facts are conclusive proofs of the unfounded nature of these charges against sewage farms (*x*).

It is acknowledged that cattle eat rye-grass most voraciously. The cow-keepers in the neighbourhood of sewage farms soon find this out; and also, what is to them a still more important fact, viz., that it produces a much more abundant supply of rich milk than any other similar kind of food. Now, a crowded population produces that sewage which brings the necessity for sewage farms. It is also in a corresponding ratio a market for milk: the poor of our cities, at the present time, do not get milk at all—and the so-called butter is scarcely produced by cows. The price of these articles, in their pure state, removes them altogether from the home of the poor man. It may be very pertinently asked, if a more sanitary act could be

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(*x*) The engineer to the Croydon Board, reporting upon this matter, says (page 11)—

"I have recently had cause to investigate a case which shews, conclusively, that irrigation grounds have the power of removing all traces of contagion from sewage which has been passed over them, and which shows that it is impossible for sewage after its application to land (in a proper manner) to transmit disease from one district to another. Eleven head of cattle were affected with rinderpest; they were in a homestead at the head of the farm, and at the time of the outbreak, forty head of cattle were pastured in the lower fields, and twenty cows, with twenty calves, were in the lower buildings. The whole of the drainage from the upper buildings, passed over the adjoining land to the outfall; and although the cattle were pastured on the irrigated land, and were watered by the effluent water after it had passed over the land, not a single case of cattle plague occurred amongst the animals on the lower portion of the farm."

performed under existing circumstances, than sending into the city in return for the sewage, those things which are really necessary articles of diet, but which cannot now be obtained. This return a sewage farm can give, and also assist in reducing the famine price which meat has nearly reached, mainly in consequence of the decrease of green food for cattle. (*y*)

(*y*) Dr. Letheby says, in his paper upon present prospects of sewage question in relation to public health,—"There is another very important objection to the system, viz., the danger of propagating parasitic diseases." He draws a terrible picture of the consequences likely to accrue, and brought Dr. Cobbold, our highest authority upon this subject, to support his view of the case. According to Dr. Cobbold, there are 3000 persons in London suffering from tape-worm, discharging millions of eggs daily; and, in his opinion, much danger would necessarily arise from their excreta being used for the purpose of sewage irrigation; he had himself seen a handful of large entozoic parasites taken from the Craigintenny meadows. Mr. Alfred Smee supported the idea before the various committees of the House of Commons, and said he fully subscribed to the evidence then given, and some other witnesses agreed thereto; but on cross-examination, not one of the theorists could give a single instance in which such results had occurred.

From a table which appears in the transactions of the Institution of Surveyors, and which was submitted by Mr. R. B. Grantham to that body, it appears that more than 5000 acres of land are now under irrigation in England alone, and yet no result of the kind indicated by Dr. Letheby has yet taken place. As regards the district of Croydon, inquiries have been made of the Medical men practising in the place, and especially of the Poor Law Medical Officers, and there is no evidence of anything of the kind in Croydon, several medical men stating that they have not met with any cases of tape-worm in their practice. The writer has only met with two within the last ten years, and those were subject to the disease before they came to reside in Croydon, and yet it is certain that much of the meat fattened on the sewage farm came into the Croydon market. Supposing that Dr. Cobbold's theory to be correct with regard to London, that about 1 in 1000 persons has tape-worm, then at least fifty such ought to be discharging ova on to the Croydon sewage farm, and the changes and dangers resulting from those chances must have

The character of the milk and butter obtained from cattle, is considered a good proof of the kind of food consumed by them. I will, upon this point, quote the authority of Mr. R. W. Fuller, an agriculturist and land agent of some standing in the south of London. He states (*Croydon Chronicle*, March 2nd, 1869), "that if there is one thing more than another by which improper food given to cows might be detected, it was in the flavour given to butter,—this was a test which never failed. Ever since Mr. Marriage had had the Beddington farm, he (Mr. Fuller) had purchased the grass grown upon those fields. His cows and horses were fed with the grass, and they were never so well or so healthy as when so fed. The milk was excellent and in superior quantity; and with regard to the butter, he could most positively assert that its taste and odour were perfect. His cows stood in their sheds with nothing to eat but the grass and a little artificial food, and no animals could look better or more healthy than they did."

Mr. Fuller stated at the same time, that the butter will quickly show if the animal has had a change of food: turnips, mangel-wurzel, and oil-cake, each rapidly making itself manifest by the odour and change of colour in the butter, but that rye-grass gives no odour, no colour, but that which properly belongs to the article.

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been placed freely within reach of the residents in Croydon, and must have shewn themselves ere this if the theory had had any foundation, or been likely to become a possible fact.

It seem curious that Dr. Letheby did not recognize the fact that, if correct, it would tell against any system of dealing with fresh sewage, as well as against irrigation; that if sewage is to be applied to the land at all before it is exposed to some destructive chemical process, the danger he predicts would necessarily arise if it was at all a possible event; and that safety alone can be obtained by the prohibition of the use of cesspool matter, or of human or any animal excreta in agriculture, if Dr. Cobbold's theory is to be believed. Fortunately, nature's great designer has not left humanity so unprotected, and vegetable life can appropriate the germ of parasitic disease, as well as the germs of any other kind of organic matter, and destroy their tendencies, when presented to plants in a proper form, which is undoubtedly suspension in water, and to which condition all manurial products must be reduced before they can be made beneficial to agriculture.

It has been broadly asserted that the milk from sewage farms is unwholesome, and does much injury to children consuming it. Now, if this were so, I should have proof of it very soon: a large portion of the milk produced at Beddington, is consumed by the families of London citizens, living in or near Croydon (*z*). The mortality amongst the children consuming it is remarkably small, whilst it is comparatively large among the poor, who scarcely get any milk at all; and my own observations go far to prove that the children who get plenty of milk, are the healthiest part of the population, and the least troubled with diarrhœa and gastric maladies in general (*aa*).

Lastly, it will not be out of place to say a few words upon the temperature at which sewage is applied to land.

(*z*) I have examined into the condition of every fatal case of diarrhœa in the months of July and August, during the last two years, and I find a complete support of the opinion stated above. In the months of July and August of last year, twenty-two cases were registered as caused by diarrhœa in the district of Croydon, and every case so registered occurred in children under two years of age,—fourteen were under six months: nearly the whole were children of the poor, and scarcely any brought up upon cow's milk. The corresponding two months of this year have had a larger mortality, viz., 47; of these, 45 occurred in children less than one year of age. Most of these cases have been investigated, and there has not been proof that a single child had had milk from the sewage farm, though the inquiry was made without the reason being stated. They were, in most instances, children of the poor, who, unfortunately, are not able to buy milk for their infants. It is, therefore, evident that those children most dependant upon cow's milk, viz., those between one and two years of age, altogether escape from any attack of the disease which sewage milk is said to produce. This house to house inquiry elicited the fact, that the majority of these deaths occurred in families in depressed circumstances, with either unhealthy or wretched mothers, whose natural supply had, in many instances, failed, or who too often were careless of the ties of maternal affection: a few cases could not be traced, the families having disappeared from the house soon after the death of the child.

(*aa*) It has been said that the aphthous mouth often seen among children, is due to the milk of cows which have been affected with foot and mouth disease.

A visit to the meadows during the continuance of frost or snow is instructive. Vegetation still goes on; the frost must be severe and long-continued to put a stop to the process of sewer irrigation, and even then the stoppage is caused as much by the failure of supply, as by the cold on the ground; if the frost is long-continued the surface freezes, but the sewage continues to flow on to the land.

If the water is kept moving over the field, the surface does not easily freeze, and the roots of the plants are much better protected when enveloped in water, than when in the frozen ground. Mr. B. Latham has published some important facts bearing upon this point. He shows that when the greatest degree of temperature is required, the

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I have carefully inquired into this point. I have met very frequently with this aphthous state of mouth; but the majority of the cases have been observed among persons who are exposed to the influence of sewer-gas or cesspool emanations, rather than to such milk. The first ten cases that I was called upon to treat this autumn, occurred in children of parents who lived in detached houses away from the town, and who were not fed with milk from diseased cows most certainly, but with milk from private sources, and who were exposed to cesspool, not sewer, influences.

The majority of children in Croydon, having milk from cow-keepers, have probably had milk more or less infected during some portion of the autumn; yet, cases of aphthæ have been quite infrequent among them, compared with the small minority of persons not so supplied, whilst it has been more frequent among those having no milk at all, than among those abundantly supplied. These facts quite upset the theory of those who contend that the disease is dependent upon such milk. The use of milk from diseased animals, is not to be encouraged under any circumstances, and nature stops it as much as possible, by quickly arresting the supply from diseased cows; but it is best to saddle the right horse, and I think aphthæ is more often due to want of milk, and the presence of decomposing or fermenting animal matter of another kind, than to milk: and whilst agreeing with the medical officer of Privy Council, that "milk from animals suffering from foot and mouth (or any other) disease, ought not to be unrestrictedly sold for human consumption," yet I can endorse the report of Dr. Thorn, that "in a very large num-"ber of cases the milk of cows undoubtedly affected, has been "used without producing noticeable morbid effects."

sewage possesses it: that this temperature increases with the duration of the frost, probably arising from the fact that much less cold water is used in cold weather than at other times. He points out that the temperature varies according to the source of the water supply.

Thus the water of the town of Croydon being obtained from a deep well, produces sewage having a higher and more uniform temperature than that produced at South Norwood, where the water supply is from the Lambeth Company. At Norwood the sewage had an average temperature of 41 degrees, whilst the air ranged between 33 degrees and 10 degrees; but at Croydon, the air ranging between 31 degrees and 24 degrees, the temperature of the sewage was 51 degrees. This proves that the sewage raises the temperature of the land in cold weather, whilst the converse is the case in great heat: the soil is cooler in hot summers than the surrounding land.

Hence it must happen, that an extended area under irrigation must have some influence in moderating the temperature of the neighbourhood, making it approach nearer to a general mean. These facts also quite dispose of the assertion that frost and snow must necessarily arrest the action of irrigation, and give rise to much mischief on the change to milder weather. If the frost is severe or of long continuance it must be felt, but not on the irrigated land to an injurious extent, for very little sewage will get there at all,—vegetation will not be required to purify it; but when a thaw occurs, the roots of the rye-grass are found to come immediately into action, and the warm weather, which usually follows a frost continuous enough to freeze the surface, is accompanied by a most rapid development of vegetation upon the fields,—and this, as a consequence, by a purification of the sewage; so that, whether in the depths of winter or the intense heat of the hottest summer, the land presents an evergreen appearance most refreshing, and such farms, if properly managed, must benefit and not injure the neighbourhood.

It will be serviceable to make a few further words, in explanation of the Map which is appended to this paper.

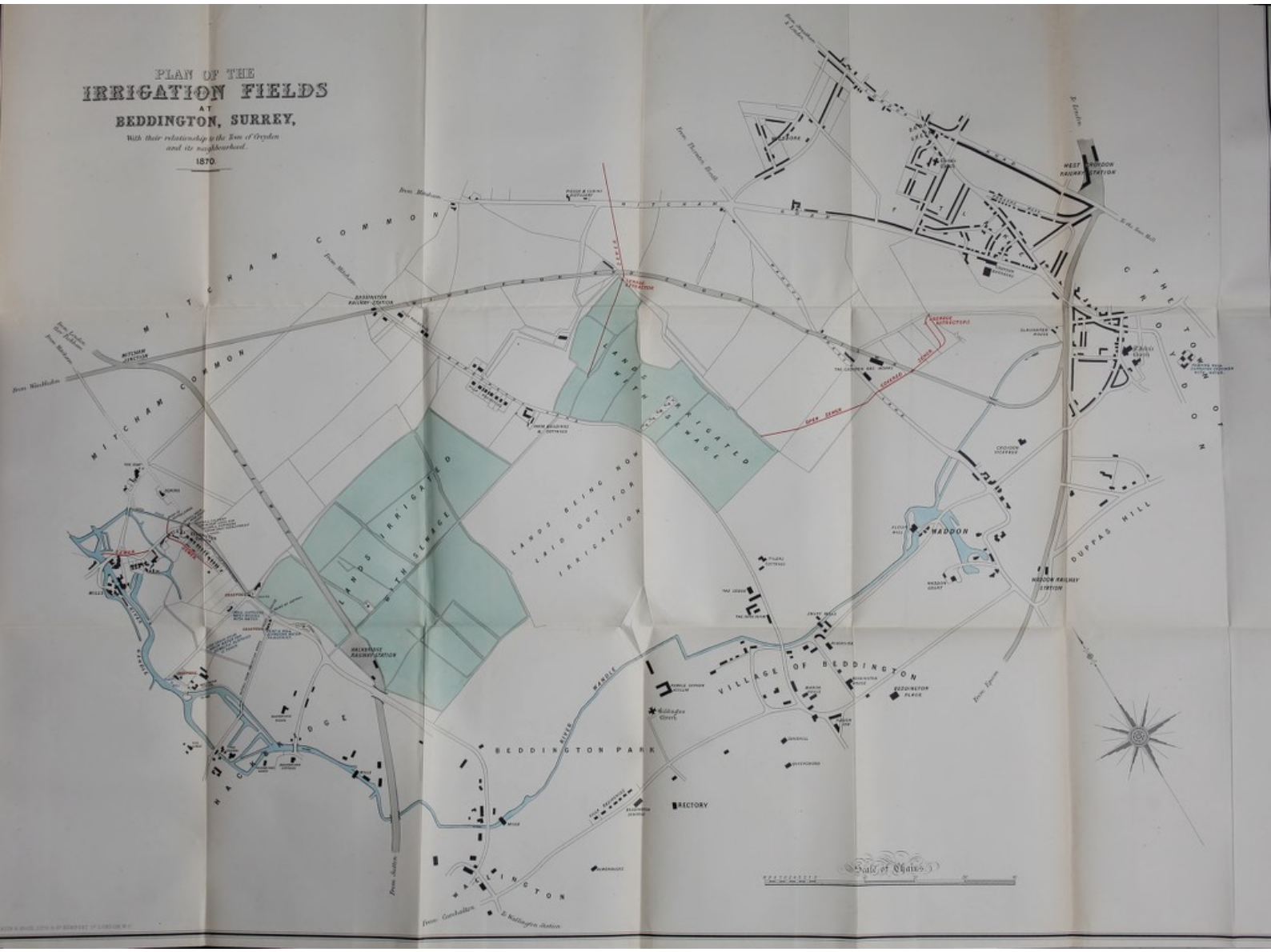
It has been prepared by a friend, partly from plans belonging to the Croydon Local Board, and which were executed by

the Board's engineer, and partly from the Ordnance Survey. It shews the position of most of the houses within 1000 yards of the land, as well as the position of the town and suburbs of Croydon, the hamlet of Waddon, the village of Beddington,—also, a portion of Hackbridge and Beddington Corner. The position of the well which supplies the district of Croydon with water, is also shewn. It may be stated, that the surface of the water in the well is a considerable height above the surface of the fields themselves; and that the course of the river Wandle will be observed running from the well towards the fields, and separating them from the town and the well. The position of the land lately taken by the Board, now being laid out for the purposes of irrigation, is shewn; and also, the situation of the Female Orphan Asylum. It has been found difficult to insert all the lines of houses; those only in the outskirts have been distinctly indicated.

The position of the various cesspools, wells, and outfalls at Beddington Corner, have also been marked on the plan. A number of new houses recently erected have not been inserted, though a few have been added which are not in former maps.

Whilst this paper has been in the printer's hands, the writer has had the benefit of studying Professor Corfield's compilation on the "Treatment and Utilization of Sewage," and on the last leaf of that work he is made aware, for the first time, of the fact that Dr. Daubeny had already shewn that plants evolve ozone in the act of growth. He has not had the opportunity of consulting Dr. Daubeny's paper in the *Journal of the Chemical Society for* 1867. It is evident that to Dr. Daubeny belongs the credit of first promulgating the fact of this production of ozone, though the writer of this paper believes that he was the first to prove its existence in fields irrigated with sewage, where least of all was its presence *a priori* to be expected: it was this unlooked for presence

that led the writer to institute the experiments, which convinced him that a natural manufactory of invigorating produce existed, instead of dangerous miasms, and led him ultimately to form the conclusion, that azone was a product of the act of vegetable growth, and that the establishment of such manufactures near to large towns, must be beneficial to them, and might be promoted by local authorities, without any fear of dangerous results if properly managed.


PLAN OF THE
IRRIGATION FIELDS
AT
BEDDINGTON, SURREY,
With their relationship to the Town of Croydon
and its neighbourhood.
1870.
MITCHAM COMMON
LANDS WITH IRRIGATED SEWAGE
LANDS BEING NOW LAID OUT FOR IRRIGATION
WADDON
DUPPAS HILL
CROYDON
BEDDINGTON PARK
VILLAGE OF BEDDINGTON
RECTORY
WALLINGTON
WEST WADDON RAILWAY STATION
WADDON RAILWAY STATION
BEDDINGTON RAILWAY STATION
WALLINGTON RAILWAY STATION
MITCHAM JUNCTION RAILWAY STATION
SEWAGE INTERCEPTOR
OPEN SEWER
COVERED SEWER
Scale of Chains

INFLUENCE OF SEWER GAS

ON THE PUBLIC HEALTH,

AND THE

THEORY OF VENTILATION AS REQUIRED IN SEWERS;

By ALFRED CARPENTER, M.D.:

Read at a Meeting of the Health Department, Monday, June 7th, 1869.

The influence of sewer gas upon the public health is one of those matters which, though suspected for a long time by the close observers of nature, and for some years plainly asserted by physicians, is now only becoming an established fact in the public mind.

As a consequence of the impression produced by this fact, the laws of nature are frequently ignored by those whose duty it is to take measures for the prevention of the influence; thus the knowledge gained is rendered nugatory, and opprobrium is often thrown upon things which do not deserve it.

It was not until the general introduction into towns of water-closets and pipe sewers, that the injury produced by sewer gas was sufficiently isolated to be positively identified. Previous to that time its effects were occasional only, and always combined with other causes, which prevented its identification as

a positive factor in the production of disease. They were shown in promoting the spread of epidemics by emanations from stagnant ditches and the elongated cesspools formerly called sewers, as also by miasms from the seething filth surrounding populous districts. These effects became more manifest on those days and at those periods of time when the air was stagnant, and the telluric influences (whether magnetic or otherwise) were those of a negative character, and when putrefactive changes were more than usually promoted.

Cesspools and privies became so offensive to the nose, that the invention of the water-closet was hailed as a boon by the luxurious and the lovers of comfort, and ultimately it became a necessity in every well-regulated establishment. Cesspools were denounced: the smell from the open privy was an abomination which could not be allowed. The result of this change in the habits of the people has been a clever contrivance, by which the gases developed by commencing decomposition in the cesspool, which gases used to escape into the open air, and not do much damage, except at uncertain intervals, are quietly and continuously conveyed into the houses of the people, in a form more dangerous than those decided stinks which arose from the effects of more advanced decomposition in the open air. This result of the introduction of water-closets within the walls of our homes, naturally casts a reflection upon the w.c. which is not altogether deserved, and which need not necessarily be borne. The mischief has arisen from a neglect of a natural law—viz., not providing for exits as well as entrances; sewers not being, like soda-water or champagne bottles, sufficiently impermeable to allow of being charged with the gas under pressure.

It was not to be expected that civil engineers would know anything about the dangers of sewer gas, until its power had been pointed out by medical men and others who had become cognisant of its effects, and from the causes previously mentioned there was no positive evidence before the scientific world. In

the early sanitary works, therefore, which were carried out under the supervision and with the approval of the general Board of Health, and under the authority of the Public Health Act of 1848, the consequences of sewer gas not being foreseen, were not guarded against ; no provisions were made to prevent its ascent into the house, or for its exit into the open air before it could reach the inside of the dwelling.* The rapid spread of luxurious habits among the people, the introduction of low fire-places and register stoves, and the measures adopted to exclude draughts, by having exceedingly close-fitting windows and doors, prevented its easy exit, and its baneful influence became manifest, often without the real cause being at that time at all suspected. From these circumstances, it oftens happens that the easiest way for air to enter the house is by the sewer. Thus it was that many towns, having availed themselves of the provisions of the Public Health Act, and the services of the engineers approved by the first Board of Health, found, to their cost, that after an arduous battle with the preservers of filth, and the powerful anti-

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* Mr. Edwin Chadwick repudiates this statement, and refers me to his own report made in 1842, on the sanitary condition of the labouring population of Great Britain, for evidence of his own denunciation of the effects of sewer gas. From this report I gather that the consequences were certainly foreseen by Mr. Chadwick ; but whilst he believed that the pipe sewers were self-cleansing, he did not deem it necessary to insist upon safety valves against the chance of the consequences of deposit, and authorities who had to carry out the works were quite ignorant of such necessity. Deposit in sewers was the rule, and self-cleansing sewers the exception. If Mr. Chadwick had been dictator, such a condition would not have arisen, for he would have had well-laid sewer pipes everywhere, in spite of the obnoxious rate-payer. I only, therefore, state a fact as far as the effect of the works is concerned ; and beg to bear testimony to the searching inquiry made by Mr. Chadwick in his report, which I had not consulted when I read the paper. It is to be regretted that early sanitarians were not sufficiently inoculated with Mr. Chadwick's knowledge upon this point.

rate party of the period, at the very time when they began to crow over their victory they had a still more arduous battle to wage, because fever would develope itself where it seemed that it had no business to come. Thus the town of Croydon suffered in the moment of victory, even before its first works were completed. The local authority, at its wit's end to discover the cause of this untoward state of things, searched everywhere for advice, and had a multitude of counsellors, without, at that time, being able to find out the cause of the partial success only of the plan they had adopted.

True, it was generally suspected—and several eminent men mentioned, among the faults of the system, that proper ventilation was not provided, and suggested various alterations. Thus, Mr. Simon, who was requested by the Local Board to advise them upon the matter, says—

"If you have given your constituents rapid inodorous sewerage, with pure and constant water supply, instead of cesspools with their soakage; if you have made six feet difference in the water-level of your low-lying district; if you have removed such ponds and ditches of filth as existed within your town;—these are inestimable contributions to the public health, which must bear their fruits so soon as you remove those interfering causes which have hitherto masked the result."

Well, the interfering causes, as pointed out by Mr. Simon and other eminent men, were removed, as well as the knowledge of the day would permit,—certainly with advantage, and with a decrease of the clearly introduced disease, which disease, as Mr. Simon remarked—

"Was not in poor houses, not in ill-drained houses, not in dirty houses, not in low-lying damp houses, but in houses where, least of all, one would expect any ordinary cause of fever to be in operation."

Nevertheless, fever would recur,—fever always the same in type, "the enteric or typhoid" form, with rose-coloured spots, often with abdominal complications, and always in those houses nearest to the top of the sewer (perhaps I should say generally) and those farthest from the outfall. At first, it was the centre

of the town which suffered, but as the drainage area extended the outskirts became more liable, whilst the centre, and the houses on the first-formed sewers, escaped. Attention was continually drawn to individual cases; they were often associated with smells, suggesting that foul air found its way into the house by some opening in communication with the sewer, which was not protected by an efficient trap. Orders were given to trap the opening, and it was supposed that the mischief was remedied,—so it seemed to be as far as that house was concerned; but the disease often made its appearance soon afterwards, in the next house, or in near neighbourhood, upon the same line of sewer, or even in the same house again, as soon as something happened by which the trap was put out of order, and rendered inoperative; at times, trapping did not stay the mischief, because ineffective; and it was thought then, that the smell had nothing to do with the disease.

Many facts have been brought to my observation as to the power of sewer gas, or some matter conveyed by sewer gas, to produce disease. As a factor in the production of typhoid fever, its power is now well known: many other disorders of the system have been directly traced to its influence—thus, diarrhœa; dyspepsia in all its forms; palpitation of the heart; various forms of asthma,—indeed it may help to explain some of the vagaries of this curious disease; convulsions, especially in teething infants; headaches, both persistent and intermittent. The evils which sometimes attend or follow upon the puerperal state,—as milk fever, abscesses in the breast, and phlegmasia dolens or white leg, are frequently caused by it. I believe that these latter cases have been so associated, from observing their frequent occurrence in new houses, before the plan now adopted in our district was carried out, compared with their infrequency since the adoption of that plan.

It seems to me that, in a great number of instances, the necessity for a change of air, after a serious illness, has arisen

rather from the difficulty of escaping from the effects of sewer gas, than from any real want of power on the part of the body to overcome the weakness induced by the effect of illness. Some constitutions are much more liable to suffer than others; it evidently, in some cases, has a very curious effect upon the nervous system. It is no unusual thing for a person to faint away without any known assignable cause, but which may really be the effect of sewer miasm. I have notes of a case in which a lady could not go into certain houses because she always fainted there, and those houses were undoubtedly imperfect in their sewer arrangements. If it was not for the introduction of such gas into our houses when no ozone is present to alter its form, or to be in excess of the quantity necessary to destroy the miasm present in the air, the absolute requirement of change of air would be comparatively infrequent.

This idea may seem far-fetched, because, in many cases of illness, smells have not been perceived, or even scarcely suspected. But if there is an untrapped opening into an imperfectly ventilated sewer, or if it is trapped in the ordinary way, and is in connection with the ordinary London sewer, which, as a rule, is very imperfectly ventilated, then it is evident that such a gas can get into the house. We know that it is not the solid stinks that are most dangerous to the public health, but the insidious miasms, often unperceived, and, until their effects are produced, unsuspected.

If we see those effects upon the human body—effects which have been proved to have been caused by such miasms elsewhere, and we know that it is possible for such miasms to be thus present—surely it is not necessary to complete the chain and prove the truth of the problem, by smelling the smell upon which the disease depends; a smell which is easily overpowered by the other scents always existing in ordinary households, and which themselves assist in de-ozonising the atmosphere. Ozone, I contend, is the agent which will alone remove the injurious consequences

of sewer gas. It is not an absolute proof that no evil arises from an opening, because at that opening the smell is not perceived. I have traced smells from places which, at the moment of exit, have been unperceived, but soon afterwards have been most decided stinks, the oxidizing influence of the air producing perfumes of various kinds—sometimes agreeable, at others, and more often, the contrary. This effect has been very marked at certain oil-cloth works near our town. The emanations from that place are most unmistakable, yet, on a cold frosty evening, the smell, close to the place, has not been noticeable, whilst half a mile away, the odour has been most offensive.

This is neither the time nor place in which to detail cases which have come under my own observation; but I may be allowed to adduce the fact, that, previously to the introduction of the plan now adopted in my own town, occasional outbreaks of fever used to puzzle, notwithstanding the insertion of ventilating pipes, and the occasional use of the rain-water pipes for the same purpose.

On inquiry, and after continual research, I found that these cases always occurred after dry weather, and shortly after a succeeding heavy rainfall. That the cases occurred near to the dead ends of long lines of pipe sewers, that an extension of those sewers removed the fever higher up, and relieved the houses formerly affected. That the fatal cases most often occurred in houses at the very end of a sewer, and farthest from the outfall. That the inmates of those houses had been probably breathing the sewer gas for a long period, in a less concentrated form, before its final onslaught, and before the system became sufficiently charged to enable a change to arise in the blood, the total of which is called "typhoid fever." If the total is not reached,* the disturbance may take on one of the disorders I have

* This total is probably a condition of blood which allows the germ which is required for the production of typhoid, to itself become reproductive in the fluids of the body.

already mentioned, or even merely produce a want of power. Chemists tell us what small amounts of material help to entirely change the form of bodies, and alter their constituent particles. Who shall say how much the ordinary chemical actions which take place in the nutrition or purification of the body, may be interfered with by such gases? It seems certain, that one effect is the decrease of red blood corpuscles, but how brought about, we are only able to conjecture.

When a stink is perceived at a particular spot, or in a particular house, orders are generally given to stop the place of issue by trapping the offending opening, with the beneficial result of removing the smell, and staying the progress of disease in that particular house or place; but no means are taken to prevent its influence being felt elsewhere. The mischief is simply transferred in a selfish kind of way, and the public suffer for it. I have had much experience of this kind of thing in our district, and soon saw that trapping was not a proper remedy, unless it was accompanied by the provision of another exit in a safer situation. This has been clearly made out upon lines of ordinary sewers, but it has been even more manifest in detached sewers,—that is, sewers not connected with any general system. The effects of trapping were very marked last year at the Warehousemen and Clerks' Schools, on Russell Hill. These schools accommodate some 160 children: they were opened nearly three years ago, and at first the children were in the enjoyment of very good health, but in the autumn of 1867 typhoid fever made its appearance. It seems that a smell, slight at first, but afterwards very intense, had been perceived in the laundry. The place of exit was trapped, and the smell prevented at that place, but as no other place of exit was provided for the sewer gas until it reached the interior of the building, it was conveyed from the cesspool by the pipe sewers into the lower part of the building, and then into the class-rooms. Now, in cold damp weather, they do not ventilate such buildings so much as should be done. The rooms being warmed by hot-water pipes,

have no open chimneys to produce draughts. The hot summer was followed by heavy rains, fires had not been commenced, and the rooms were not chilled by having the windows opened. The children would get up in the morning and go down to work in their class-rooms before breakfast, and inhale the sewer gas, when they were least able to resist its influence, and when it was most concentrated, viz., on cold damp mornings after heavy and warm rains had stirred up the deposits in the sewers and cesspools. The result of this action was, that nearly 40 per cent. of the children suffered from mild typhoid fever.

The same result happened this spring at the Female Orphan Asylum, at Beddington. No provision was made for the ventilation of the sewers in connection with the building, but an accidental opening—accidental at least as far as ventilation was concerned—existed in the plug which acted as an overflow-pipe in the latrines. The latrines were in close communication with the class-rooms, into which the children used to go in the early morning. The class-rooms were not provided with any efficient and certain means of ventilation, like the Russell Hill Schools; they are warmed by hot-water pipes instead of open fire-places. Foul air once in the room, could not easily get out; and in a short time about 30 per cent. of the children suffered from the effects of sewer gas.

Similar results have happened in other schools, both public and private, within my own observation, but I need not multiply instances. I may, however, give one more illustration—that afforded by the book kept by our Local Board for the registration of stoppages in sewers. Our engineer, Mr. Latham, says, that before the introduction of the plan now adopted by our Local Board, stoppage in the sewer was always coincident, in point of time, with illness in the houses affected by the stoppage. I have at times been able to draw attention to a defective sewer, simply from observing on that line of sewer rather more than the ordinary amount of illness of a slight kind, and it has always been

found that that sewer had a defective ventilation, and by remedying that defect, the illness on that line of sewer decreased.

The frequent occurrence of these cases, led me to consult all the publications upon the subject that I could find—being convinced that a remedy existed. I found especial assistance from the reports of Dr. Letheby and Mr. Heyward, which were published by the City Commission of Sewers in 1858. But while they acknowledged the sufficiency of cause, they did not point out an effective or practical remedy; meanwhile, openings were multiplied, as strongly recommended by Mr. Rawlinson; and eventually the Croydon Local Board determined, three years ago, to adopt the principle of opening the extremity of every sewer, and of every branch or house drain in connection with the sewer, and make every house ventilate its own house drain; the Local Board also had openings made into the sewers at 100 yards interval, so as to allow of a constant and continuous current of air. By this means, the effects of sewer gas have been entirely obviated, and the consequences removed, in those portions of our district to which the law is made to apply, in a most marked and decisive manner.

The early sanitarians reasoned in favour of small sewers, partly on the idea that they would keep perfectly clean, and that no decomposition could take place, and therefore that no gas products would be formed. Theory and practice do not, however, go together: sewers are never constructed in ordinary towns, as the early sanitarians intended that they should be,—they do not, as a rule, flush clean,—they are often badly laid, and, consequently, deposits take place in them; decomposition, with the liberation of sewer gas, results. Now, this sewer gas makes its way more easily out of the large sewers of London, with the many open gratings existing therein, so as to some extent to obviate the chance of pressure upon the traps, which pressure exists much more forcibly in the pipe-sewers of less extensive drainage areas. The sewer gas will form, at times, very abundantly in

the house drains,—the houses being like gas receivers, open at the bottom only, the sewer products will make their way through the traps into such houses; and if the traps become, as is often the case, untrapped, especially in dry weather, there is a ready means for the entrance of the gas into the house, independently of the means afforded by the water in the trap itself, which is a ready conductor of the miasms—absorbing the agent on one side, and giving it off on the other.

Theoretically, ventilation of sewers ought not to be necessary for, theoretically, no deposit ought to exist in a sewer; but, practically, so perfect a state is not at all times possible, and an efficient system of ventilation must be provided.

The experience obtained in extended drainage areas, as well as that from more isolated districts, has shown that trapping is only stopping the danger at one point, and forcing it in another direction quite as perilous to those exposed to its influences. It follows, therefore, that the only satisfactory solution of the difficulty, is the prevention of the intrusion of the gas into houses at all, and the prevention of its collection in sewers, in that concentrated form which leads to mischief. Its formation cannot be prevented—not at least until sewers are so constructed, as to their fall and their workmanship, that no deposit is likely to take place in them at all, and that no settlement of the bed on which they rest shall change their level, so long as the character and quantity of sewage continues the same. Whilst, therefore, these gases will form, how can we best avoid their influences?

The nature of sewer gas has been well pointed out by various chemists and medical authorities,—all concur in the belief that dilution destroys it; that if sufficiently diluted with air, it becomes inocuous, and its sting is taken away: when it first escapes from a sewer, it carries with it some condition which is injurious to life, tending to prevent some necessary change in the blood, or other vital tissues, either by its own power, or by means of a property to which it simply bears the relation of carrier.

If it be mixed with sufficient air, especially if that air be ozonised, the miasm becomes oxidized and comparatively harmless, or if not so oxidized its presence is not injurious to life. Just as a minute quantity of urea in the blood is not injurious, yet, if the purifying influence of the circulation through the kidney be interfered with or obstructed, a rapid change for the worse results. So again with carbonic acid; if the ventilation of lung structure is interfered with, serious damage is suffered,—even the ordinary ventilation through the pores of the skin must not be stopped, or some change takes place in the body which is not consistent with perfect health.

It is seen that the circulation of air, or of air-carrying fluids, is incessant in both plants and animals; that this incessant action is the result, in a great measure, of chemical and physical changes in the moving fluids; that the safety of animal as well as of vegetable life, depends upon this incessant movement. That if this movement can be produced and continued in sewers, no sewer gas could exist in a form sufficiently concentrated to be hurtful to human life.

Professor Graham and others have pointed out, that nature has given to gases a law by which they have a tendency to diffuse themselves inversely as the square roots of their densities. This law certainly comes into play as soon as ever the gases are disengaged—at once tending to produce motion in the air. This motion will be assisted by the continuous changes of temperature, following upon the quantity of hot water going into the sewer; it will also be encouraged by the presence of a flowing stream, varying in depth, and keeping up a varying circulation, causing an incessant motion of the air: as sewage rushes down, air must rush up to occupy the vacant place. Our problem, therefore is, how to render this circulation positively continuous, and to prevent its sinking into that dead calm which arises when the forces oppose one another, and which then allows the air to become saturated with sewer miasm. This has been effected

most perfectly in our district, by compelling every new house to have ventilation for itself. The soil-pipe is continued upwards, in a straight line above the level of the pan, between the trap and the sewer, and it is made to terminate by an open extremity above the eaves of the house, away from the window, and not close to or level with the chimney. Every connection with the sewer requiring the presence of a trap, has that trap guarded from the consequences of pressure, by a ventilator similar to the soil-pipe, the latter being placed as close to the trap as possible. It is found necessary to make these shafts ascend straight up, and not curve or turn at right angles, or their efficiency is interfered with. The result of making these innumerable openings at the higher points of the sewer, has been to promote a rapid circulation through the sewer, by which all sewer gas is removed as quickly as formed by dilution and deoxidization, and no concentration can take place. If any of the traps, which may be considered absolutely necessary in the house, should get out of order, then the introduced gas would be comparatively harmless because so diluted; but every communication with the sewer, other than that of the w.c., must be indirect only.

These innumerable openings act like the pores on the skin, or like the stomates upon the leaves of plants: they are themselves causes of motion, for the air in the sewer of a large town, will always have a temperature and density different from that outside,—it will always be warmer in cold weather, whilst in hot weather it will be much more loaded with moisture. Differences of temperature, density, and moisture, will always be sufficient to determine a circulation, provided entrances exist for fresh air, as well as exits for that which has passed through the sewer.

The ordinary manholes and gullies in the streets will provide these openings, and more often lead to a down draught than to any upward current of foul air. I have often found this to be the case, in the ventilating places which have been opened near the lower ends of our Croydon sewers,—air enters instead

of finding an exit. The principle to be obviated is stagnation, whether of solid, of liquid, or gas—deposit must not be allowed, fluid must always run off: let there be also innumerable openings near the tops of the houses, and it may be safely assumed that no stagnation will exist in the sewers themselves, for these openings will be the promoters of incessant movement. Let every water-closet have its movement promoter—its safety-valve in the pipe I have mentioned: let every trap, which it is absolutely necessary to use for the protection of the inmates of a house, be in a similar manner protected: let every pipe, not actually conveying sewage, have an indirect communication with the sewer only. Let all openings in the streets be untrapped, and protected by proper ventilation through charcoal, and everything done which will promote sewer circulation,—disease in every way will become, as it has been in Croydon, more tractable, and the effects of drain poison almost unknown.

It may be argued that these recommendations apply only to pipe sewers, and will not do for the large culverts now being constructed in London. This I deny; they can be ventilated as well as the Southwark subway, or the metropolitan railway tunnels. If they contain deposit they are badly constructed, and such bad work ought to be remedied. It is becoming more and more certain, however, that more mischief arises in the house drains, where stagnation can take place, than in the main sewers in which the main current is ever flowing; it never stagnates sufficiently long to allow of decomposition taking place, except under the most exceptional circumstances, which would be fully guarded against, by the precaution of having proper charcoal ventilators in the manholes of the streets, at those places at which an up-current might be established—as at the top of a sewer having a rapid fall towards one having a smaller fall. These ventilators are often used in our streets; a most efficient one has been lately perfected, by means of which the charcoal is protected from rain, and the air compelled to pass through a

double sieve, in the way shown the other evening at the Society of Arts. Various other ways may be adopted, for the purpose of promoting rapid circulation in the large sewers, better known to engineers than to myself; but the correct theory of sewer ventilation is undoubtedly motion. Motion is success—stagnation is destruction or defeat. I have not supported by figures the proposition I have submitted, because it has been found impossible to isolate the districts, so as to place them under the same conditions; but I may simply state, that the mortality for the parish of Croydon for the quarter ending March 30, 1869—the quarter which generally has the highest rate of mortality—was 18·53; the deaths from fever in the same quarter were *nil*, among nearly 60,000 people. The mortality for London in the same quarter was 25·0; that for all England 24·84.

In conclusion, I beg to thank you, Mr. Chairman and gentlemen, for your kind attention, and to beg your indulgence for imperfections. The idea of reading the Paper arose from hearing the other evening, at the Society of Arts, a Paper upon house-drains, which seemed only to urge traps as a remedy for smells. I say, ventilate—don't trap.

F. WARREN, PRINTER, HIGH STREET, CROYDON.

Metropolitan Board of Works.

REPORT

ON THE

DEODORIZATION OF SEWAGE.

BY

DR. HOFMANN, F.R.S.,

AND

DR. FRANKLAND, F.R.S.

PURSUANT TO THE ORDER OF THE BOARD,
27th May, 1859.

Presented, 12*th August*, 1859.

Reed and Pardon, Paternoster Row, Printers to the Metropolitan Board of Works.

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No. 24.

Metropolitan Board of Works.

REPORT

On the Deodorization of Sewage, addressed to the Chairman of the Metropolitan Board of Works.

Sir,

Having been requested by a Resolution of your Board, bearing date the 27th day of May, 1859, to undertake the duty of advising the Board as to the selection, from the various schemes proposed for the deodorization of Sewage, of a process combining both efficiency and economy, we now beg leave to report to you the results of a minute inquiry into this subject.

In conducting our investigation, we have carefully kept in view the final plan of dealing with the Sewage adopted by the Board, the principal features of which were lucidly described to us in a letter from your Chief Engineer.

Not the least arduous part of our labours consisted in the careful examination of the numerous, and in many cases ponderous, documents addressed to the Board on this sub-

ject, and transmitted to us for consideration. Short abstracts of these proposals will be found in the Appendix.

This examination led us to the conclusion that a comparatively very small number only of these proposals admit of application in conformity with the plan of dealing with the Sewage finally adopted by the Board.

The comparatively small number admitting of such application, experienced a further limitation when the several processes were submitted to experimental trial. In fact, of all the proposals, old and new, referred to us, there is only one which appears to satisfy in the necessary degree the conditions involved in the circumstances of the case.

The agent to which we allude is that described as "DALES' *Muriate of Iron*," essentially a concentrated solution of perchloride of iron, the disinfectant properties of which were some years ago pointed out by Mr. Ellerman. This we have submitted to an extensive series of comparative trials with the well-known disinfectants, lime and chloride of lime, which, probably owing to their long-established character, are not included in the proposals before us.

These trials lead to the conclusion that the deodorization of Sewage may be effected either by perchloride of iron, chloride of lime, or lime; but that, if quantities of equal value*

* We have endeavoured to arrive at the average prices of these three agents. It appears that they are subject to considerable fluctuation. As the average result of our inquiries, we have taken the value of lime at 9s. per cubic yard = 18 bushels; the value of chloride of lime of 36 per cent. (about the strength of that used in our experiments), at £12 per ton; and that of the perchloride of iron solution, specific gravity 1.45, at 6d. per gallon. Probably these prices would be subject to a certain amount of reduction if very large quantities were consumed. We should state further, that the estimation of the value of perchloride of iron is founded upon our knowledge of the price of its ingredients and the cost of manufacture, although Messrs. Ellerman and Dales, who have proposed this liquid, quote 1s. 6d. as their maximum price, per gallon.

be applied, the perchloride of iron is markedly superior to either of the others, whilst chloride of lime acts much more powerfully than lime.

These statements refer both to the immediate action of the three agents upon Sewage, and to the permanency of the effect produced; but when examined from the latter point of view, the superiority of the perchloride of iron is exhibited even in a still more marked degree.

It may be stated that these results were obtained by operating upon Sewage, such as flows from the mouths of the chief Metropolitan Sewers during the hottest season of the year, our experiments having been performed during the latter half of the month of July.

Since the calculations as to the cost of deodorization are based upon these experiments, it may not be out of place here to mention briefly the mode in which they were conducted. In order to enable us to operate upon a sufficiently large scale, brickwork tanks, lined with cement, and holding 7,500 gallons each, were constructed at the outfall of the King's Scholars' Pond Sewer. The Sewage was lifted into these tanks by means of a steam pump, and the various deodorizing agents were incorporated, either by their gradual introduction into the shoots during the process of filling, or by diffusing them through the mass of the liquid by means of mechanical agitation.

From a number of experiments thus conducted, it appears that each of the three agents above mentioned will effect the immediate deodorization of 7,500 gallons of Sewage when applied in the following proportions:—

Perchloride of iron	½ gallon.
Chloride of lime	3 lbs.
Lime	1 bushel.

From these results it follows that 1,000,000 gallons of Sewage require respectively—

	£	s.	d.
66 gallons of perchloride of iron, costing .	1	13	3
400 lbs. of chloride of lime	2	2	10½
132½ bushels of lime	3	6	6

During the performance of these experiments, which, as already stated, were made during the hottest portion of a dry season, we were surprised to find that the liquid flowing from the outfall of the Sewer was by no means strongly offensive ; it was only after preservation in tanks for twenty-four hours, or upwards, that a really powerful odour manifested itself. This circumstance rendered it of the highest importance to inquire more closely into the degree of permanency of the effect produced by the several agents under consideration.

For this purpose, three equal quantities of Sewage were collected, and perfectly deodorized respectively by perchloride of iron, chloride of lime, and lime : they were then allowed to stand. After two days, the Sewage disinfected by lime became slightly tainted, whilst that deodorized by chloride of lime and perchloride of iron remained perfectly odourless. At the end of three days, the limed Sewage had become decidedly offensive, whilst the other two specimens still remained free from smell. After four days, the odour of the limed Sewage had become worse, but that treated with chloride of lime likewise began to exhibit an offensive character, whilst the Sewage to which perchloride of iron had been added remained perfectly inodorous. Even after the lapse of nine days, the condition of the latter had not changed. In other experiments the same relative permanency of effect has been observed.

Another important element in estimating the comparative fitness of an agent for the treatment of Sewage, is, the time required for clarification after the addition of the disinfectant. In this respect, also, the results of the preceding experiments lead us to give a decided preference to perchloride of iron.

It now remains to apply the results thus obtained to the circumstances of the case before us. From the statements in Mr. Bazalgette's letter, it appears that it is at present contemplated to collect the larger proportion of Sewage in two reservoirs, to be constructed respectively at Barking Creek and Crossness Point, in which it would be allowed to settle for about nine hours and a half, in order to be discharged into the river during the first two hours and a half of the ebb tide. The third portion of Sewage, we learn from Mr. Bazalgette's letter, will be pumped into the river all the year round at a point near Cremorne Gardens, termed the outfall for the Western Division. The subjoined table gives the quantities of Sewage discharged at present daily, according to Mr. Bazalgette's estimate, and likewise the quantities anticipated in future years.

	PRESENT.	PROSPECTIVE.
Discharge of Sewage at Barking Creek .	56,536,875	62,500,000
Do. Crossness Point . . .	20,066,250	35,937,500
Do. The outfall of Western Division	4,646,875	9,375,000
Total .	81,250,000	107,812,500

The Sewage discharged at Barking Creek and Crossness Point would probably not require deodorization, except during the hot season of the year—say during three months. Supposing the deodorization to be effected by perchloride of iron, the disinfection of this portion of the Sewage at the

present rate of flow would involve an expenditure of £11,620 13*s*. 9*d*. for the three months. We are, however, of opinion that in practice the Sewage discharged into the river at this distance from the Metropolis would rarely require deodorization for so long a period as three months. In fact, we are not without hope that the Sewage, supposing it to arrive at these outfalls in a condition similar to that in which it is at present discharged from the King's Scholars' Pond Sewer, would, when properly freed from suspended matter, only require deodorization under particularly unfavourable circumstances.

With regard to the Sewage discharged at the outfall of the Western Division, it will be indispensable to submit it to a systematic deodorization the whole year round. Owing to the comparatively small fraction of the Sewage delivered at this point, a very moderate sum would cover the expense—£2,821 3*s*. 0*d*. being the cost of the disinfectant for the year.

Having thus stated the results of our experiments regarding the process of deodorization, it remains only to draw particular attention to the importance of discharging the Sewage into the river as free from mechanically-suspended matter as possible. We have found that this suspended matter, when separated even from the deodorized Sewage, rapidly passes in warm weather into a state of active putrefaction. The removal of this matter would, in a great measure, prevent the formation of any offensive deposit upon the banks of the Thames, not to speak of the improvement in the appearance of the river which would thus be secured. We are therefore of opinion that filtration should be invariably employed at the outfall of the Western Division, and that subsidence, if not actual filtration, should be resorted to at the two remaining outfalls.

The putrefactive tendency of the deposit separated by filtration or subsidence renders its rapid removal from the reservoirs or filters a matter of the utmost importance, especially during summer; for the process of putrefaction, when once commenced, can be arrested only by quantities of disinfectants practically impossible.

It is not within our province to enter into details respecting the mechanical arrangements necessary for the application of the disinfectant or for the filtration and subsidence of the Sewage; but we beg to express our opinion, based upon the experience acquired during this investigation, in manipulating with comparatively large quantities, that the disinfection of vast volumes of Sewage can be more easily accomplished than is generally believed, and than we ourselves anticipated at the commencement of our inquiry. The actual process of deodorization will probably present less difficulty than the mechanical separation of the deposit by filtration or subsidence. This separation will involve the temporary storage of immense quantities of Sewage, the rapid removal of large quantities of deposit, and a number of operations which can be successfully carried out only with considerable system and under strict inspection. Operations of this kind should be as far as possible conducted at a distance from densely populated districts; and we consider it therefore a happy feature of the scheme adopted by the Board, that a small fraction only of the total amount of Sewage requires to be manipulated in the immediate neighbourhood of London.

We have, &c.

(Signed) A. W. HOFMANN,
E. FRANKLAND.

London, August, 1859.

APPENDIX.

In the body of the Report we have alluded to the considerable number of proposals addressed to the Metropolitan Board of Works, and referred by them to us for examination. In order to divest the Report as much as possible of embarrassing detail, we have refrained from entering into a description of each of the several suggestions which have been made. We have, however, thought it desirable to give condensed abstracts of these proposals, in this Appendix.

John T. Barry, Esq., proposes proto-sulphate of iron as a disinfectant for Sewage, and also suggests that charcoal might be introduced into the air-spaces of Sewers, in order to destroy noxious gases.

G. Lindsey Blyth, Esq., recommends that superphosphate of magnesia should be mixed with the Sewage, which should then be precipitated with lime, or another alkaline earth, the object being the production of a manure.

W. Burness, Esq., recommends separate systems of drainage for Sewage, and for surface water. The latter he would filter, if necessary, before its discharge into the Thames; the Sewage he would pump to the proper level, and pass through suitable pipes for distribution in the surrounding agricultural districts, completing the distribution before

the Sewage had time to putrify and become offensive. He is of opinion that the value of liquid manure is much greater than that indicated by its constituents, because "during the process of decomposition of animal and vegetable matter, oxygen is worked up both from water and the atmosphere; consequently hydrogen is liberated from the former, and nitrogen from the latter; so that these two, uniting, form ammonia, one of the best fertilizers."

Gurney Burt, Esq., states that he will shortly make a proposal for utilizing the London Sewage, without deodorization, by distributing it over the country, by means of the railways.

Henry Callen, Esq., recommends the deodorization of Sewage by galvanic or electric agency.

John Chisholm, Esq., makes a similar proposal.

Henry Bollman Condy, Esq., calls attention to the manganates and permanganates as powerful agents of deodorization and disinfection.

Henry Cornfoot, Esq., suggests ferruginous sulphate of alumina, commonly called Moll's Patent Reactive, as a deodorizer for Sewage.

Daniell Dealey, Esq., Chemist, and William Richards, Esq., Engineer, propose to generate chlorine from "a mixture of muriatic acid and quick lime," on board a steamer which is to be "constantly running up and down the river, and discharging the gas on both sides as it goes along."

Richard Dover, Esq., advises to flush the Sewers daily "with the antiseptic hydrochloric acid, and liquefied proto-sulphate of iron, and chloride of sodium combined."

C. F. Ellerman, Esq., recalls attention to the use of perchloride of iron, which he proposed some years ago as a disinfectant.

Richard Ely, Esq., intimates that he has a process for the precipitation of Sewage in reservoirs, of which no further description was obtained.

Charles F. A. Glassford, Esq., proposes to carry off the rain water in the Sewers, and to make such arrangements in the houses as to allow only a limited quantity of water to become mixed with the excreta. This mixture is to be collected in vessels to be daily discharged into reservoirs, where it is to be mixed with sulphuric acid, and allowed to settle. The liquor is to be then evaporated, and the solid matter squeezed through such filter-presses as are used at the Leicester Manure Works.

G. Garbert, Esq., of Mauritius, suggests the abolition of water-closets, and the substitution of boxes containing peat charcoal.

M. Gronvelle proposes to deodorize by means of a pyrito-aluminous lignite, commonly called "cendre noir," which is stated to be extensively used by the scavengers in Paris.

William Goreham, Esq., communicates the following plan :— To form reservoirs at the mouths of the Sewers; to allow the Sewage to settle in these reservoirs; to remove the sediment by trays, and to disinfect and dry the contents of the latter by placing them in chambers through which the products of combustion of a suitable furnace are passing.

John Hitchman, Esq., gives his arguments in favour of

"The rainfall to the river,
The sewage to the land."

Mr. Howard, British Minister in Lisbon, reports on a contract between the Municipality of that town and a Company formed for collecting the excreta and converting them into Sewage. The Company propose to supply each house with a separating apparatus, and with the necessary disinfectant (the nature of which is not stated). The Municipality will compel the inhabitants to use the apparatus, and proposes to furnish the land for the works.

Henry Kemp, Esq., suggests "pyritous peat" for deodorizing Sewage. In a second communication Mr. Kemp enters into some details regarding the mode of applying the peat, which he proposes to enclose in wire cages attached to the sterns of the river steamers; and he advises the introduction of similar cages into the mouths of the Sewers.

Charles F. Kirkman, Esq., offers to exhibit upon a large scale the practicability of a plan which he has successfully employed upon a small scale. He does not state the nature of the plan in his original communication, but in a subsequent letter mentions that his method is not a chemical one.

James Knight, Esq., proposes to establish a number of filter-beds on each side of the mouth of a Sewer, and to allow only the clear water from which the solid matter has been deposited, to flow into the Thames.

C. N. Kottula, Esq., proposes to remove the Thames' nuisance by increasing the specific gravity of the river over that of sea-water, "so that the river-water may become heavier than that of the sea; whereby the former, instead of being driven back by the incoming tide, will give way to the flow of the sea-water, and will allow it to flow up, while

the river-water will run out, or, at all events, remain under the sea-water." He thinks he can accomplish this object "by dosing into the river at various points common salt."

M. G. M. Legé suggests to attach to the drain of each house a receptacle so constructed as to allow of the separation of the liquids from the solids; the former to be permitted to pass into the Sewers, and the latter being removed once in eight or ten days, to be converted into manure.

M. Louis Napoleon Legras states, that he has invented a deodorizer which is applicable to London Sewage water, and which produces a valuable manure. The nature of the agent is not stated, and no information could be obtained on application.

A. McDougall, Esq., and Dr. Angus Smith, propose the use of carbolate of lime in solution, and also of a solid mixture of sulphites and carbolates. These substances are to be added to the Sewage to produce immediate and permanent deodorization.

F. C. Maguire, Esq., advises to convey the Sewage to railway stations, and then to transmit it to the surrounding agricultural districts through earthenware or iron pipes. If necessary and practicable, he would filter it through dry Sewers constructed over the present drains, converting the solid matter into manure, and deodorizing the filtered liquid in subterraneous deodorizing docks; the deodorized fluid to be then pumped into reservoirs at levels, sufficient to allow of its being conveyed in pipes along the various lines of railway to the provinces. He proposes no method of deodorization.

M. J. Marino, of Copenhagen, communicates a plan for inodorous water-closets.

Dr. Henry Medlock suggests that Sewage would probably be deodorized by means of scrap iron, and subsequent filtration through beds of sand and charcoal; but he states that he has not yet had an opportunity of testing the efficacy of this suggestion, on a sufficient scale and by a sufficient number of experiments.

M. Moll, *vide* Henry Cornfoot, Esq.

George F. Morrell, Esq., calls attention to the deodorizing properties of chloride of zinc.

The Rev. Henry Moule proposes to separate the Sewage from the rainfall; the liquid portion of the former to be evaporated, the solid to be dried and deodorized. The ordinary modes of evaporating are stated to be chimerical, but the plan proposed is rendered perfectly possible "by the discovery in November last of something in the nature of steam which was hitherto unknown."

W. Oldham, Esq., suggests to separate the solid filth from the Sewage, and to distribute the liquid over the land in the neighbourhood.

M. Paulet, Fils, recommends the use of a mixture of sulphate oleate and chloride of zinc, and of sulphate of manganese, for the deodorization of Sewage.

William Richards, Esq., *vide* Daniell Dealey, Esq.

Dr. T. Angus Smith, *vide* A. Macdougall, Esq.

Rudolph Turecki, Esq., states that he has discovered a material which enables him to disinfect excrementitious matters, and to convert them into manure; but he does not state the nature of the materials which he employs.

Mr. Wells is in possession of a method for the treatment

of Sewage, but states that it is not chemical, and is communicable only by personal interview.

Sir William Worsley suggests the conveyance of the Sewage to a cesspool in the Greenwich Marshes, thence to flow into the river at the turn of tide. No method of deodorization is suggested.

A glance at these proposals will show at once how few of them address themselves to the special question submitted to us for inquiry. A final plan of disposing of the Sewage having been fixed upon by the Board, our investigation was of necessity limited to a comparison of the efficiency of the several deodorizing agents proposed.

After experiments continued for several weeks, we arrived at the conclusions already stated in our Report.

In these experiments we had occasion to observe, that most of the agents proposed possess the disinfecting power which their inventors have pointed out, and many of them in so marked a manner as to render them undoubtedly valuable for a variety of special purposes. Not one of them, however, in our opinion,—with the exception of the agent suggested in the Report,—possesses that combination of properties which could warrant us in recommending it to the Metropolitan Board of Works, for the deodorization of the London Sewage.

Reed and Pardon, Printers, Paternoster-row, London.