14

REPORT

ON THE

Means of Deodorising the Sewage

OF GLASGOW,

ADDRESSED

TO THE SANITARY COMMITTEE OF THE TOWN COUNCIL.

BY

THOMAS ANDERSON, M.D., F.R.S.E.,
REGIUS PROFESSOR OF CHEMISTRY IN THE UNIVERSITY OF GLASGOW,

AND

JOHN FREDERIC BATEMAN, C.E.

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ERRATA.

Page 18, 5th line from top,—For "*arranged in such as*," read "*arranged in such manner as*."

" 19, 22nd " " —For "*Dr. Small*," read "*Dr. Smith*."

" 19, 24th " " —For "£400," read "£4000."

" 25, 9th " " —For "*sound*," read "*small*."

REPORT.

The Interim Report by Mr. Napier in May, 1857, exhibited the progress which had been made up to that time in the Experiments undertaken for the purpose of deodorising and precipitating the sewage waters of Pinkstone Burn. Since that period considerable progress has been made in our inquiries, and though the subject is still far from exhausted, we are now in a position to indicate to the Sanitary Committee the conclusions at which we have arrived, and to make some suggestions as to the mode in which the sewage of towns may be most advantageously treated.

The experiments at the Pinkstone Burn were, in the first instance, confined to examining the action of slacked lime upon the water, applied in a manner very similar to that which has been used at Leicester, Manchester, and elsewhere. The results of these experiments have been fully narrated in Mr. Napier's Report, but it is necessary to recur to them shortly here for the purpose of rendering intelligible some of the conclusions to be afterwards stated.

The average daily run of the Pinkstone Burn amounts to about two million gallons, and this quantity of water, under ordinary circumstances, carries down with it in mechanical suspension about 7 tons of solid matter, or about 2555 tons per annum, capable of producing from 12000 to 15000 tons of mud of ordinary consistence, which must be annually deposited in the estuary of the Clyde. The complete precipitation of the whole water was found by Mr. Napier to require about 5¼ tons of lime per diem, but as from the defective nature of the apparatus there was a considerable loss of lime, Mr. Napier is of opinion that, with a more satisfactory arrangement, 4 tons of lime would be sufficient for the purpose. The effect of the lime upon the water was quite instantaneous, the smell immediately disappeared, and the precipitate began to sink to the bottom, leaving a fluid which was perfectly clear, although generally of a light straw tint. The smell did not return even after some days exposure to the air at a summer heat, but in particular states of the water was partially restored by the addition of strong acids. The precipitate, in a perfectly dry state, amounted to 5110 tons annually, but if merely dried sufficiently to admit of its being easily carried off in carts, it would amount to about 20,000 tons yearly, or 55 cart loads for every working day.

The cost of the operation, assuming 4 tons of lime per day to be sufficient, and including the expense of removing the precipitate from the tanks in the moist state would amount to £1,370 annually, so that the expense of precipitation alone, exclusive of drying, would be 5s. 4d. for each ton of dry matter obtained.

It is somewhat difficult to estimate the annual cost of treating the entire sewage of the City with lime, because no data exist for accurately determining its total quantity, but excluding the Clyde and the Kelvin, it cannot be less than 20 times the volume of the Pinkstone Burn or 40 million gallons per day. The daily supply of water from the Water Works is now 17 or 18 million gallons, and is expected to be still larger when the Loch Katrine water is introduced, all of which must of course pass into the sewers, and in addition, there are the Molendinar Burn and other streams, with a large amount of water from the Canal and various local contributions which go to swell the amount.

It is possible that some of the other sewers contain a larger amount of solid matter than the Pinkstone Burn, but assuming the latter to be a fair sample of the rest, and about one twentieth of the whole, the gross result would be as follows :—

The annual deposit of mud between Glasgow and Greenock, exclusive of what may be brought down by the Clyde, the Kelvin and the Cart, would be about 320,000 tons, and if the whole of the sewage were subjected to precipitation by lime, the amount of the soft residuum capable of being carted away would be 408,800 tons per annum, or 1,300 cart loads for every working day, and if reduced to a perfectly dry state it would amount to 102,200 tons. The annual cost of the mere precipitation and removal of the deposit from the tanks would be £27,400.

Our next object was to ascertain the probability of any part of this large outlay being recovered by the sale of the deposit as a manure, and for this purpose it was necessary to have a proper estimate of its manurial value. As removed from the tanks the deposit contains a quantity of moisture amounting on the average to about 80 per cent., but varying within pretty wide limits in different samples, and in order that fairly comparable results might be obtained we have determined the value of the dry matter after complete removal of the moisture by exposure to a temperature of 212°.

A specimen which was considered to be a fair average of a large quantity of the dry Pinkstone Burn deposit was found to contain—

Organic Matter, - - - - -	47.49
Peroxide of Iron, - - - - -	2.65
Alumina, - - - - - -	7.97
Phosphoric Acid, - - - - -	1.44
Carbonate of Lime, - - - - -	29.41
Magnesia, - - - - - -	0.50
Potash, - - - - - - -	0.39
Soda, - - - - - - -	0.38
Chlorine, - - - - - - -	0.16
Sulphuric Acid, - - - - -	0.70
Sand, - - - - - - -	8.91
	100.00
Ammonia, - - - - - -	3.51

Another sample prepared in exactly the same manner, but at a different time, gave on partial analysis :—

Phosphoric Acid, - - - - - -	4.17
Ammonia, - - - - - - -	2.62

In estimating the value of manures it has been customary to compare them with Peruvian Guano, which, from its extensive use and well known properties, affords a convenient standard, and calculating on this principle, the first of these samples is worth £2 13s. per ton, the second, about £2 5s. Assuming the deposit as removed from the tanks to contain 80 per cent. of water, it would be worth about 10s. per ton ; but in this crude and moist state it would, of course, be quite unsaleable, and it would be absolutely necessary to get rid of the greater part of the water so as to leave a material containing about 80 per cent. of solid matter, which would then be worth about £2 per ton. No data founded on experience on the large scale exist for determining the cost of the drying process to which the deposit would have to be subjected. Mr. Wicksteed, who is the patentee of the process in operation at Leicester, estimates it at 4s. 2d. per ton, and he states the whole cost of manufacture, including interest on capital, to amount to 12s. 8d. per ton. This estimate appears to us to be much too low, and we are of opinion that it could not be safely reckoned at less than double that sum, or say £1 5s. per ton.

As the manure, according to the analyses already given, is worth about £2 per ton, it at first sight appears that a considerable profit is to be derived from this operation. But it is important to notice that though the value just given is obtained by putting upon its constituents the same prices as those used in valuing guano, it could not compete with it or other concentrated manures at that rate, and the reason for this becomes obvious when we contrast the total expenses of the application of a ton of guano and an equivalent quantity of the lime precipitate to the soil. This may be most simply illustrated by reference to a particular case. Supposing a ton of guano to be carried 10 miles by railway and 5 miles by road, the entire cost of its application to the soil would be as follows :—

1 Ton Guano, - - - -	£13	0	0
Cartage to Station, - - -	0	1	6
Carriage by Railway 10 miles, -	0	0	10
Cartage 5 miles, - - -	0	5	0
Application, - - - -	0	0	8
	£13	8	0

But in order to produce the same manurial effect the farmer must employ 6½ tons of the sewage manure, and the cost would be :—

6½ tons Lime deposit, - -	£13	0	0
Cartage to Station, - - -	0	9	0
Carriage by Railway 10 miles -	0	5	5
Cartage 5 miles, - - -	1	12	6
Application, - - - -	0	4	4
Total cost of Lime deposit, -	£15	12	0
,, of Guano, - -	13	8	0
Difference, - - -	£ 2	4	0

Hence the 6½ tons of sewage deposit cost £2 4s., or almost exactly 7s. per ton more than its value. A farmer so situated could not afford to give more than £1 13s. per ton for the sewage manure, and for every mile of greater distance from the manufactory a proportionately increased deduction would have to be made. If we add to this the expense of agents for the sale of the manure, the risk of bad debts, and various other commercial charges, it will be obvious that the profit to be derived from the manufacture is highly problematical. But in all that precedes we have taken the most favourable view of the case, and assumed that the deposit from the whole sewage of Glasgow would be equal to that obtained in the course of the experiments at the Pinkstone Burn, an assumption which the experience of other places by no means warrants. On the contrary, the deposit in question is of materially higher quality than any yet examined, as will be obvious from the subjoined estimates of the value of the absolutely dry deposits deduced from the analyses of different chemists :—

Leicester, - - -	£0	15	5	(*Voelcker.*)
Do., - - -	0	17	0	(*Versmann.*)
Clifton Union, - - -	0	16	9	(*Hofmann.*)
London, - - - -	1	18	8	(*Do.*)
Pinkstone Burn, - -	2	13	0	(*Anderson.*)
Average, - - -	£1	8	2	

In comparing these analyses we are at once struck by the greatly inferior value of the three first, and the difference becomes still more interesting when we know that they are deposits actually prepared on the large scale as manufacturing products ; while the two last were made for experimental purposes, and under the immediate superintendence of scientific chemists who watched the whole details of the process in each instance. It is impossible to resist the inference that when the operation comes to be carried out by ordinary workmen, and upon the whole sewage of Glasgow, the product will more nearly resemble that obtained at Leicester and Clifton. But assuming it to reach the average of the whole samples, and making a deduction of one-fifth on the supposition that the manure as delivered to the consumers would contain 20 per cent. of water, its value would not exceed £1 2s. 6d. per ton, and even this price could not be obtained in practice, because it would unquestionably vary much in composition at different times, and in any such manufacture the quality of each quantity sent out of the works could not be guaranteed, so that it would be necessary to fix the price, not at the average, but at the minimum value of that produced. To this must be added the uncertainty of sale, a difficulty which has been experienced to a great extent at Leicester, where, though offered at 3s. per ton, it has accumulated for want of sale in immense quantities. It is probable that the manure would be more readily purchased by the farmers in this neighbourhood, but when it is borne in mind that the total produce of the Glasgow sewers may amount to perhaps 120,000 tons per annum, its complete absorption for agricultural purposes is very unlikely. It is obvious also that unless each year's production were sold within its own year the whole economy of the works would be disarranged and additional expenses entailed.

On the conclusion of the lime experiments your reporters were desirous of submitting to examination the process of precipitation, patented by Mr. Manning, to which their attention had been specially directed by the Sanitary Committee. Application was accordingly made to that gentleman, and he was informed that the tanks erected at the Pinkstone Burn would be placed at his disposal, for the purpose of illustrating his process and affording an opportunity of determining its value. After much correspondence and delay, Mr. Manning objected to the construction of the tanks, which he considered were not well adapted to his process, and stated that he should prefer exhibiting it at the works he was then erecting at Edinburgh. Our object being to examine the process under the most favourable circumstances, Mr. Manning's proposition was readily agreed to, and he undertook to give us due notice when his apparatus was ready for work. After repeated delays, Mr. Manning at length announced that his preparations were complete, and Mr. Napier proceeded to Edinburgh for the purpose of inspecting the process which it was resolved should be carried out entirely by Mr. Manning and in the manner which he thought best. Mr. Napier adhered strictly to this arrangement, confining himself to noting the quantities of the materials used and the results, and having obtained specimens of the precipitants and of the product he returned to Glasgow.

Mr. Manning's works are situated by the side of an open sewer at the South Back of the Canongate, Edinburgh, and consist of two precipitating tanks communicating with a third smaller and on a lower level, intended for the reception of the deposit after precipitation and from which it is lifted by a Jacob's ladder into a large vessel where the fluid part is drained off and it is converted into a dry manure. Each of the precipitating tanks is furnished with a stirring apparatus composed of long wooden arms driven by steam, and close to them is placed a large tub from which the precipitating ingredients after being mixed with water are allowed to flow into the tanks.

The precipitating ingredients are three in number:—

1st. Alum sludge; a refuse matter consisting chiefly of sub-sulphates of iron, and alumina deposited during the evaporation of the fluid from which alum is prepared. Its cost at the alum works is 7s. 6d. per ton.

2d. Prussiate maker's charcoal which is a refuse product of the manufacture of prussiate of potash, containing about 30 per cent. of charcoal along with a good deal of peroxide of iron and saline matters. Its price is from 5s. to 7s. per ton.

3d. Refuse lime from the manufactures of chloroform, obtained free of cost.

The average quantity of sewage let into the tanks at each filling amounted, according to Mr. Napier's measurement, to 29,219 gallons, and the charge of precipitating materials employed was 6 cwt. of alum sludge, 3 cwt. of waste lime and 2 cwt. of charcoal. These materials were mixed with water in the tub already mentioned, and when the tank was nearly full the stirring apparatus was set in motion and the precipitating mixture allowed to flow into the water during its passage into the tanks. The stirring apparatus was kept in motion for about ten minutes after the tank was full, when it was stopped and the deposit allowed to subside, which it did after the lapse of from three-quarters of an hour to an hour, when the supernatant fluid was run off. The tank was then again filled and the agitator set in motion, by which means the deposit was stirred up and served to precipitate a second quantity of the water without further addition of the ingredients. After a considerable quantity of the deposit had accumulated, it was only necessary to add the precipitants to every third charge of the tanks, and when it became too bulky it was allowed to flow into the deeper tank from which it passes to the filtering apparatus where the further process of manufacture is carried out.

Taking into account the repeated use of the precipitants, Mr. Napier assumes that the charge of the materials added in the operations he inspected serves on the average for precipitating 73,047 gallons of sewage. On this assumption the cost of precipitating 1,000,000 gallons, and the quantity of materials required will be as follows :—

4 tons 2 cwt. Alum Sludge, - -	£1	10	9
1 „ 7 „ Charcoal, - - -	0	8	3
2 „ 1 „ Waste Lime, - -	0	0	0
	£1	19	0

giving for the total sewage of Glasgow £28,470 per annum, which estimate, however, does not include the cost of carriage of materials, labour, nor the expense of removing the deposit from the tanks.

The success of Mr. Manning's process as inspected by Mr. Napier was far from perfect, for though the grosser impurities of the sewage were precipitated, the fluid was in no instance either limpid or inodorous, but always retained a muddy appearance and distinct sewage smell. It is only justice, however, to Mr. Manning, to observe that the cause of this defect may be fairly attributed to the fact that his object at Edinburgh is not so much to deodorise the sewage as to manufacture a manure from it, and hence in his operations the quantity of precipitants is reduced to the minimun requisite for the latter purpose. Mr. Napier found that when the charge of the precipitants was increased by about a third, a perfectly limpid and inodorous fluid was obtained, but in order to secure this result it was necessary to add the same proportion of the ingredients every time the tank was filled, thus at once increasing the cost of the operation to about three times that already given.

The necessity for using a much larger quantity of the precipitants was further borne out by experiments on the small scale with the water of several of the Glasgow sewers. Mr. Napier experimented on the Pinkstone, Gallowgate, and Gorbals sewers in this way, and found that to thoroughly precipitate and deodorise a million gallons each, would require the following quantities of the materials :—

	Sludge.	Lime.	Charcoal.
Pinkstone, - - -	19,500 lbs.	12,600	6,700
Gallowgate, - -	16,600 "	11,400	5,400
Gorbals, - - -	40,600 "	50,000	26,000

and if we suppose a mixture of equal quantities of the water of these sewers to be operated upon, the expense per million gallons would be—

14 tons 13 cwt. Alum Sludge, - - -	£5	10	1½
5 " 15 " Charcoal, - - - -	1	13	6½
11 " Lime, - - - - -	0	0	0
	£7	3	8

Thus making the entire annual charge for the City of Glasgow to amount to £104,876.

This estimate it must be understood was obtained not from experiments in the tanks, but by operating on the small scale and cannot therefore pretend to absolute precision, but it is a sufficient approximation to the truth to show that the outlay requisite for completely deodorising the sewers of Glasgow, will materially exceed the estimate formed from Mr. Manning's operations at Edinburgh.

Independently of the increased quantity of the precipitants, there are other sources of expense which are not taken into consideration in these estimates, but which must be incurred in carrying out the process on the large scale.

It is obvious that whenever the operation extends to a whole town no adequate supplies of waste lime can be obtained free of expense, and it would consequently be necessary to purchase lime from the kiln, adding at the lowest estimate and assuming that one ton of quick lime will do the work of four tons of waste lime, about £6 per day or £2,190 a year to the expense, while at the higher estimate, the additional expenditure would be £20 a day or £7,300 a year. The same observation applies to alum sludge, of which the production is necessarily limited by the manufacture of alum. We do not know the exact proportion which the sludge bears to the alum produced, but it is less than five per cent., and as the total quantity of alum manufactured in Scotland is under 6000 tons, the annual production of sludge cannot exceed 300 tons, while the quantity required to precipitate the Glasgow sewers amounts, at the lowest estimate, to nearly 30,000 tons.

Mr. Manning has forseen this difficulty and has taken a subsequent patent for the manufacture of a substitute for alum sludge. He proposes to treat alum shale in exactly the same manner as that at present in use for the manufacture of alum, but in place of drawing off the fluid from the sludge produced during the boiling, the whole is to be evaporated to complete dryness, by which means a residue is obtained which has nearly four times the precipitating power of the common sludge, and which Mr. Manning expects to produce for 5s. per ton. Had this report been addressed to persons familiar with the manufacture of alum, we should have left this statement to speak for itself, for they would at once see the impossibility of obtaining the product in question at this rate. We may state, however, that it requires 5 tons of good alum shale to produce one ton of alum, but as the quantity of such shale is limited it would be necessary to use that of inferior quality, of which, perhaps, 10 or 20 tons would be required to produce a ton of Mr. Manning's material; and taking this and the general expenses of such a manufacture into consideration, we are fully satisfied that it could not be produced for less than £2. As 4 tons of alum sludge, which are capable of producing the same affect, can be obtained for £1 10s., the use of the new product would add about 30 per cent. to the estimates already given.

In estimating the value of the precipitate obtained by Mr. Manning's process, exactly the same steps were followed as in the lime experiments. Mr. Napier selected a fair sample of the precipitate produced at Mr. Manning's works at Edinburgh during his visit, which was brought to Glasgow, and analysed after drying at 212°. The results were :—

Organic matters, - - - - -	49.96
Peroxide of iron and alumina, - - -	13.39
Lime, - - - - - - -	6.22
Magnesia, - - - - - - -	0.52
Potash, - - - - - - -	0.29
Soda, - - - - - - - -	0.17
Common salt, - - - - - -	0.16
Sulphuric acid, - - - - - -	0.90
Phosphoric acid, - - - - - -	1.38
Carbonic acid, - - - - - -	5.61
Sand and siliceous matters, - - -	22.00
	100.00
Ammonia, - - - - - - -	2.56

The value of this manure in the dry state is therefore about £2 2s. per ton, or assuming the manufactured article to contain 20 per cent. of moisture, its price would be £1 14s.

As this value is considerably below that of the lime precipitate, we think it unnecessary to enter into further details regarding Mr. Manning's process, as all the observations made in reference to the former apply with double force to the latter, and we have no hesitation in expressing our opinion that there is no prospect of Mr. Manning's plan being carried out with profit.

As a commercial speculation, therefore, the manufacture of the sewage residuum into a manure is by no means hopeful. It is scarcely necessary for us, however, to remark that the question of profit is a matter of comparatively little importance, and we should consider that we had sufficiently fulfilled the requirements of the Sanitary Committee if we could show that the disinfection of the Glasgow sewage could be carried out with a certain loss, the limits of which could be accurately defined. But we are not in a position to do this. The experiments we have made regarding the two processes already described have enabled us to determine the cost of mere precipitation, and we should have no difficulty in furnishing similar data regarding any other process submitted to us should that appear desirable. It is, however, impossible for us to determine with any degree of certainty the cost of the further processes required to bring the product into a marketable condition, because we have no means of testing the plans, generally involving rather complicated mechanical arrangements, which have been proposed for the purpose. Such opinions therefore, as we have ventured to express upon this part of the subject, have been derived from our knowledge of branches of manufacture invôlving the drying and reducing to a portable state similar commercial products and being fully cognisant of the expense attending these operations, we are satisfied that they would prove by far the most expensive part of the process, while it is also questionable whether any of them could be carried into operation on the large scale without producing a serious nuisance in the neighbourhood of the works.

On the other hand we have no data for estimating the price the farmer could afford to give for the deposit. In the preceding pages we have chosen to compare it with Peruvian Guano, because that substance has been commonly used as a standard of comparison with other artificial manures. But the justice of applying this system of valuation to a sewage deposit is to say the least of it very doubtful, for practically each great class of artificial manures must be and actually is estimated by reference to a standard of its own, which is fixed by purely commercial considerations. The force of this may be best understood by the statement of the fact that, if the mode of valuation in use for Peruvian Guano be applied to farm yard manure, its value will be found to vary between 10s. and 15s. per ton, while its current price is only 5s. As far as general composition is concerned sewage manure is really in many respects much more comparable to farm yard manure than to guano, and with the fact just stated regarding the former, we are satisfied that the sum obtainable for the sewage precipitate would be much below the estimates we have formed, and in that case the loss on the operation would be very large, while the risk of the product accumulating at the works would be exceedingly great.

While we found these opinions to some extent on the results of our experiments, we must also observe that they are borne out by a common sense consideration of the whole subject, and we are particularly anxious to place this in a distinct point of view, because it appears to us that the public are greatly misled by the current statements regarding sewage matter. It is frequently stated that the annual value of the excreta of each individual of the population amounts to about £1, on which principle the total value for the City of Glasgow is estimated at £400,000. Without entering into any discussion regarding the precise accuracy of this estimate, it will suffice for our purpose to remark that this value could only apply to it *in a marketable condition*, while the very first operation of our present sanitary arrangements, by diluting these matters with an enormous quantity of water renders them entirely unmarketable and consequently annihilates their value, and then the assistance of the chemist is demanded in the hope that he may be able to undo this work and render back the matters which have been thus made valueless, with the additional proviso that they shall be inoffensive and innoxious. We have no hesitation in asserting that this problem does not admit of an *economic* solution, and we are satisfied that the first step towards arriving at useful practical results is to disabuse the public mind of any such expectation. No process of precipitation can possibly recover the whole of these excreta, because the most important and valuable of their constituents cannot be thrown down by any agent, and must necessarily escape with the clear water, while that actually precipitated carries down with it a large quantity of valueless matters, which increase the bulk and deteriorate the value so much as to to render the product of little practical use, and prevent its competing, except at a mere nominal price, with concentrated manures.

While there is no prospect of a successful result attending any of the processes of precipitation as at present proposed, the idea that chemical agency cannot be usefully applied must not be hastily adopted, for any engineering operations which would effectually remove the sewage from the River Clyde, would be so expensive that a considerable annual loss resulting from the chemical purification of the water would be considerably under the interest of the engineering outlay. With a view to the elucidation of this matter we have considered the whole question in a different point of view, and shall now proceed to state generally the plans which we think merit consideration.

None of the methods of deodorising sewage appear to us to go to the root of the matter and they are all defective, chiefly because they have been hampered with the condition of recovering the valuable matters and converting them into a marketable manure, which makes it necessary to apply the process to the sewers at their outlet. Admitting the possibility of doing this in an effectual manner, it is obvious that though a great boon to the population on the banks of the river it would be of comparatively little advantage to the inhabitants of the city itself, because the sewers would continue to be filled with noxious and offensive matters stagnating in them often for a long period of time and undergoing putrefaction there. In the case of a small town where the fall is good, the condition of the sewers themselves is of comparatively little importance, for their contents scarcely remain in them sufficiently long for putrefaction to advance to any great extent, but rapidly reach their outlet generally in a river, where they mix with a large volume of running water, which is the most important and powerful natural deodoriser. But in a large town, where the fall is defective, the sewage remains for a long time in the sewers, and when it at length reaches the river, putrefaction has reached a stage at which running water is comparatively powerless to arrest it. For exactly the same reason, deodorisers, applied to the sewage, after it has stagnated in the sewers, must be either larger in quantity or of a more powerful nature than would be necessary if the water could be treated when it enters in place of when it leaves the sewers, and whether it be taken in an economic or a sanitary point of view, our impression is, that deodorisation ought to take place within the sewers themselves. In fact, the perfection of such an arrangement would be to have each house furnished with a reservoir of some deodoriser which might be allowed to flow in a continuous current into its sewers, but it is scarcely necessary to observe, that any such plan could not be easily carried out in practice, and the nearest approach to it, which could be successfully worked, would be to divide the city into a certain number of districts, in each of which the minor sewers should be made to converge to some central point, where a station should be erected for throwing a deodoriser into the main sewer. These stations would have to be arranged in such as to admit of the greatest possible amount of fall in the small sewers, so that their contents may reach the deodorising station as rapidly as possible. Beyond this point the fall in the main sewers would be of less importance, although even the disinfected sewage should be got rid of without unnecessary delay.

The most important consideration in carrying out a plan such as that now referred to, is the substance to be employed as a deodoriser. It is obvious that any agent which deodorises by precipitation would be objectionable owing to the risk of the precipitate accumulating in and choking the sewers—an event almost certain to occur, except in places were an unusual amount of fall could be secured. For this reason lime and all other substances hitherto suggested, which deodorise only when added in sufficient quantity to produce a deposit, are precluded, and it is necessary to seek for some substance of opposite properties, and which shall deodorise without precipitating, or, if possible, shall increase the tendency of the insoluble matters to remain in suspension. The latter requirement cannot well be fulfilled in practice, nor is the number of substances which deodorise without precipitating very large. That which will at once suggest itself to every chemist as the agent most likely to be economically applied to this purpose is sulphurous acid, which is well known to be a powerful deodoriser and disinfectant. Dr. Smith and Mr. M'Dougall of Manchester, who have devoted much attention to the use of sulphurous acid, have proposed to employ it along with carbolic acid, a substance extracted from coal tar and remarkable for its powerfully antiseptic properties, so that when a mixture of these two agents is employed the sulphurous acid deodorises the putrid matters, while the carbolic acid arrests the tendency to further change. Dr. Smith and Mr. M'Dougall consider that two pounds of sulphurous acid and an ounce of carbolic acid will suffice for deodorising the excreta of 300 persons for one day, and that the cost of these materials will be about a penny, which gives, for the annual expense of deodorising a town of 400,000 inhabitants, about £1900. They propose to prepare their deodoriser at different stations throughout the town, and throw it at once into the sewers; and they state that each of these stations will cost £500, and require the services of a man and a boy. The plan thus described is no more than a general sketch, and does not permit us to form a satisfactory estimate of the total expenses. Indeed, the complete arrangement would involve a consideration of the general distribution of the sewers, so as to determine the number of deodorising stations which it would be necessary to erect, and on this point, as being a matter of detail, we have not as yet ventured to enter. It is easy, however, to form some sort of general idea from the data which have been furnished; and we would remark that the estimated quantity of sulphurous and carbolic acids is founded on the assumption that the excreta of each individual contain 2 oz. of dry matter per day, but as drainings from stables, the refuse of manufactories, and various other animal and vegetable matters find their way into the sewers, it may be safely assumed that double the quantity stated by Dr. Small and Mr. M'Dougall will be required in practice, and the cost of the material will consequently amount to about £400 per annum. It is probable that about 20 different stations for the manufacture of the deodoriser will be required for the City of Glasgow, involving, therefore, an outlay of £10,000, and we may estimate the cost as follows :—

Cost of materials, - - - -	£4000
Wages (20 men and 20 boys), - -	1250
Interest on outlay, and wear and tear, -	1000
	£6250

The sum actually required may be greater or less than this, and must depend on the amount of deodoriser and the number of stations found necessary on practice ; but we think it would not be safe to estimate it at less than £6000.

As regards the prospect of this plan proving successful, our statements must also be of a very general nature. We have made various experiments on a small scale which leave no doubt as to the deodorising effect of the mixture of sulphurous and carbolic acids, but from the nature of the process it is difficult to estimate in this way the quantity which would be required on the large scale, because we have no guide such as is offered by precipitation for determining when the operation is complete, and are compelled to trust to the sense of smell, which is a somewhat fallacious index. We have resolved, therefore, to make an experiment on a sufficient scale to deodorise the whole of the Kelvin, and to keep it so for some time so as fully to test the efficacy of this process. Mr. M'Dougall has accordingly prepared for us a large quantity of material for the purpose of testing his process, and we are only waiting a suitable opportunity for the trial. Unfortunately the state of the sewers during the present summer has been very unfavourable for such experiments, because from the large fall of rain they have been unusually clear, and the Kelvin has been almost free of smell, so that we are compelled to reserve our experiment until its state is such as to afford us a satisfactory proof of the effect these agents produce.

It may be objected to this plan that though it might deodorise the river, it would still leave it as disagreeable as ever to the eye. But we do not attach much importance to this objection, for it is not to be expected that any process applied to the sewers will convert the Clyde into a clear and pellucid stream, while on the other hand, should it ever be desirable to attempt the application of the Glasgow sewage to the purpose of liquid manuring, the use of the deodoriser should be found to act well in practice, would do away with the great objection which has been always offered to that process, for the deodorised sewage could be applied to the land and even conveyed in open conduits without producing the slightest nuisance to the neighbourhood.

We would by no means have it supposed that we suggest this as a plan to be at once adopted, but merely as a subject meriting further enquiry, which may or may not prove practically useful on the large scale, for we believe it is only by pretty large and somewhat long continued experience that all the advantages and disadvantages of the process can be satisfactorily elucidated. But having satisfied ourselves that, though the precipitation and deodorisation of sewage can be well effected by lime and other processes at a cost which can be accurately defined, the precipitate itself in place of being a set off against this cost is more likely to increase it by entailing the necessity for further manufacturing and large commercial transactions, the expense of which cannot be estimated, we have thought it right to indicate the plan which, so far as we can see, combines the greatest amount of sanitary advantage with the smallest expenditure compatible with the existing or any modified arrangement of sewers.

Looking at the question in its widest aspect, it is doubtful whether any of these plans reach the root of the evil, and we are inclined to go much further and to express our belief, that the principle on which the refuse matters of towns are now universally got rid of is radically wrong. The system of sweeping them away by means of an abundant supply of water is no doubt very simple, and has certain advantages, provided it could be effectually carried out. But the imperfect success attending it in practice is sufficiently attested by the present state of the sewers in all our large towns. Nor can we fail to see that a great part of this want of success is the natural and unavoidable consequence of a system which, by the facilities it affords for getting rid of refuse, renders individual sanitary precautions less a duty than they were under the older arrangements. The sewers are open to all without let or hindrance, and every description of waste is indiscriminately thrown into them in its most offensive condition, and provided an individual gets rid of his own refuse, he considers himself at liberty to disregard the convenience and comfort of his neighbour, or at all events, to throw upon the public the burden of getting rid of a nuisance which he might have abated at a less cost than the public can, and it may be in some instances with absolute profit to himself. The cure for all this lies in the fact, that there is really a large amount of preventable contamination of our sewers, which should never be allowed to flow into them, but should be preserved apart and submitted to some process for the preparation of manures, which it would then be possible to produce with much greater prospect of success than after they have been diluted with the enormous quantities of water passing through the sewers. Many manufacturers are in this predicament, and as a remarkable instance of the practical application of the principle, now actually in use, Teal's patent for the recovery of the fat from the soap liquor of wool scouring may be mentioned, which process is successfully in use in Glasgow and many other places, with the effect of converting a very filthy matter into a clear though not a colourless fluid. We would not by any means have it supposed that similar results are to be obtained from the refuse of all manufacturing processes, but no doubt there are others to which some mode of purification might be applied.

These observations apply with equal force to excrementitious matters; and we are fully persuaded that if these substances are to be converted into a manure with any prospect of profit, it must be by excluding them from the sewers and preserving them in an inoffensive state by means of a dry deodoriser. If this could be successfnlly done, the advantage to the sewers is sufficiently obvious, for it is these excrementitious matters which are the most offensive part of their contents, and it would have the effect also of doing away with the existing system of water-closets, which in a sanitary point of view, are quite behind the age. In expressing this opinion, we are well aware that we run the risk of being misrepresented and described as the advocates of an obsolete system which has been properly abandoned, and the offensive and noxious character of the old plan will be contrasted with the many advantages of the water-closet. We by no means advise a return to the old system in its primitive form, for that cannot for a moment be supported, but it appears to us that had the ingenuity which for a long series of years has been devoted to the contrivance of ingenious water-closets, been turned to plans for the effectual application of dry deodorisers, that the result in a sanitary point of view would have been quite as good, probably better, and the product might be converted by a simple process into a manure which would probably sell at about £3 per ton. We refrain from entering into details regarding this plan, but its importance must not be underrated. At present but a small proportion, not above one-fourth of the houses in Glasgow are furnished with water-closets, and their rapid increase must tend to magnify very greatly the evils at present experienced. The plans proposed for precipitating and deodorising the sewers are no more than palliatives, and with the extension of the city and the increase in the number of water-closets, these palliative measures must become day by day more costly, so that it is really a matter for grave consideration whether the attention of the public should not be directed to the contrivance of some substitute for the conveniences now in use, which shall fulfil sanitary requirements without contaminating the sewers, and yield a marketable manure.

The importance of adopting some plan of excluding from the river the offensive contents of the sewers, has been made still more obvious, by a series of experiments which have been going on simultaneously with those relating to the precipitation and deodorisation, and which have an important bearing on both the chemical and engineering features of the case. The experiments, though not yet carried out as far as is desirable, already exhibit very important data for our guidance in determining the best mode of treating the sewage, and of preventing the pollution of the river. While it was well known, and would probably be universally admitted, that the sewage of the city, after flowing into the Clyde, remained there a long time, driven backwards and forwards by the tides, before it finally escaped to sea; and while it would most likely also be admitted, that the improvements in the river, which have so largely benefitted the navigation, by increasing the depth of water, have, at the same time, penned back the natural current of the stream, and retarded the downward passage of the fresh water and the sewage; the extent of the evil, and the length of time which was really required to carry the sewage clear of the river, were unknown, and could scarcely be guessed at with a probability of being near the truth.

Experiments were therefore suggested for the purpose of ascertaining how long the sewage remained within the upper reaches of the river; and they were constructed by Mr. Ure, with the consent of the Clyde Trustees, partly in June, 1857, and partly during the present summer. The latter are not yet complete, but the data obtained in 1857, seems to give a general idea of the facts. The experiments were made with a number of floats, introduced into the river at various points between the Victoria bridge, at Glasgow, and Dumbarton rock. These floats were followed by two men in a boat, night and day, in their journeys up and down the river, as they were carried backwards and forwards by the tide, for several days together. The floats were put into the water at high water of spring tides, a day or two before the highest tides, the natural volume of the river being very low at the time. This period of tide would be the most favourable for the rapid descent of the sewage, which may be supposed to have entered the river at the same time, and the experiments were not conducted long enough to determine what would have been the state of things with the sewage which would enter at low water of neap tides. They are, therefore, not yet as complete as they ought to be, but they nevertheless throw considerable light on the subject, and enable us to make some proximate calculation.

The results are pretty much the following.—That sewage, entering the river at Victoria Bridge at high water of spring tides, when the natural volume of the river is small, as in summer or dry weather, will not reach Govan Ferry in less than a week, nor the mouth of the River Cart in less than a fortnight. The distance to Govan Ferry is about 2¼ miles, and to Cart mouth 6 miles; so that, the average downward progress is something less than half-a-mile a day. In fact, the float put in at Victoria Bridge only descended the river (1½ miles) in five days, and did not in that time reach Govan Ferry, where the second float had been introduced, by three-quarters of a mile. Had the float been put in at Victoria Bridge at low water of neap tides, it would have been carried high up above the city, and would probably not have reached the mouth of the Cart in less than three weeks.

The other experiments which were made by floats introduced at Govan Ferry, Renfrew Ferry, Erskine Ferry, and Dumbarton Ferry, do not afford the means of accurate calculation by reason of one float not always reaching the point at which the next lowest had been started during the period of observation; but from the speed at which they respectively descended the river, there can be no doubt that sewage water entering the Clyde at Glasgow at low water, when the natural volume of the river is sound, will be considerably more than a month in reaching Dumbarton.

The importance of ascertaining this fact with greater certainty, and also of ascertaining to what distance the sewage water, which has arrived at Dumbarton at low water of neap tides, will be driven up the river again by the succeeding springs, will be very apparent whether the question of disposing of the sewage of the city be considered in an Engineering or a Chemical point of view. If it has finally to be conveyed by Engineering works to some outlet on the Clyde, this information is necessary for the purpose of determining the proper point for the outlet and the proper period for allowing the sewage to flow into the river. If deodorization can be practically and economically applied, it is important to learn for what length of time it must be effectual in repressing all disagreeable or noxious evaporations.

The great importance of those parts of our enquiry has become gradually more and more evident, and it has been considered desirable to extend these experiments so as to ascertain the rate of progress of the sewage in the river at different states of the tide. These experiments are now nearly completed, and though we shall not attempt to go into their details now, it may be stated that they fully bear out the conclusions drawn from those of last year as to the very slow progress of the sewage in the Clyde.

In concluding, we may be allowed to sum up the results of our enquiries as follows :—

1st. There is no doubt that the process of deodorising, by precipitation, can be effectually carried out by several different processes, but the outlay will be exceedingly large, as there is no prospect of selling the precipitate at a price which will cover the cost of manufacture.

2nd. That any engineering operations, having for their object to carry the sewage down to the lower part of the river, would be of an expensive and difficult character, because, from the tendency of sewage to remain in the river for a long time, as shewn by the experiments with floats, it would be necessary to convey it to a very great distance.

3rd. That the most advisable plan would be to use a deodoriser, which does not precipitate, and which could be thrown into the sewer, so as to sweeten their contents, and admit of their being run into the river without producing a nuisance.

The last plan is that which, should the statements of Dr. Smith and Mr. M'Dougall prove correct, is likely to be carried out at the smallest expense; and it has the advantage of leaving the sewage in a state in which it could be used for irrigation, if that should at any future time be considered desirable. But before pronouncing an opinion either for or against this process, we must await the result of further experiments with the material furnished us by Mr. M'Dougall, meanwhile we must guard ourselves against the supposition that any statements of cost are more than approximations. The greatest difficulty with which we have to deal is the almost entire absence of information derived from extensive experience regarding any of the proposed processes for treating sewages; so that, while the experimental facts may be safely relied on, we think it quite possible that the expenses of the processes may prove in practice higher than we have estimated them.

We have the honour to be,

Gentlemen,

Your very obedt. Servants,

THOMAS ANDERSON.

J. F. BATEMAN.

APPENDIX.

Report on Mr. Manning's process as carried out at his works at Edinburgh, and on Experiments with the Glasgow Sewage, by Mr. James Napier.

At the request of the Sanitary Committee, and after consulting with Professor Anderson, and arranging with Mr. Manning as to his convenience, I went to Edinburgh to see and report upon Mr. Manning's process for purifying the sewage waters of the City, and I may here mention, that every facility was given me for inspecting the operations.

Mr. Manning's works are situated at South back of Cannongate, at the side of an open sewer or burn, and are composed of two circular depositing tanks, built of bricks, and lined over the bottom with ashphalte, and measuring each 40 feet diameter by 6 feet deep, and covered over with boards. The bottom of the tanks have a slight incline to one side, where there is a sluice which goes direct to the bottom of the tank, leading into a third and deeper tank, into which the deposit from the precipitating tanks is allowed to run, and from which it is afterwards raised by a series of buckets, or Jacob's ladder, into a large wooden vessel, where it is drained and pressed to a solid consistency. Another sluice is at the higher side of the precipitating tanks for letting off the clarified water. The outlet at this sluice is ten inches above the bottom of the tanks, by which means the precipitated sludge is retained, while the purified water is being let off. Each of the tanks is furnished with apparatus for stirring, composed of long wooden arms, stretching from a central perpendicular shaft going to the bottom of the tank, which are made to revolve by a steam engine. At the side of the two precipitating tanks, and raised above the surface, is a large tub, in which are mixed the matters used for purifying the waters, and so arranged, that when these matters are well mixed, by pulling out a plug from the bottom of the tub, the precipitants are allowed to run into the water as it is passing into the tanks.

The water of the sewer is let into the tanks by intercepting its passage in the sewer by means of a sluice, when it flows by another channel leading direct to the tanks, in the course of this channel are two deep wells for preventing sand and loose stones being carried into the tanks; by means of small sluices the water is let into or shut off from any of the tanks as required.

The average quantity of water passing into the tanks during my stay, was from 280 to 300 gallons per minute. The average depth of the water let into the tanks, each time measuring from the top of the bridge at the outlet sluice to the top of the sluice, was 3 feet 9 inches, giving 29,219 gallons.

When the tanks were within a few inches of being full, the purifying matters, which were previously mixed in the large tub, were let in, at the same time the stirring apparatus was set in motion, and continued until about 10 minutes after all the purifying mixture was let in and the tank full. In from 45 minutes to 1 hour the precipitate was completely subsided, and the supernatant water let off, which took from 15 to 20 minutes. As each tank required from 95 to 100 minutes to fill, there was ample time for the precipitate to subside and let out the pure water of one tank while the other was filling.

The charge of stuff put into each tank was made up of 6 cwt. of the refuse of Alum makers, called *Alum Sludge*, costing 7/6 per ton, 3 cwt. of waste lime, from the manufacture of chloroform, obtained for the carting away, and 2 cwt. of charcoal, a refuse from the manufacture of prussiate of potash, costing from 5/ to 7/ per ton. These quantities of materials served for two fulls of a tank for some time after the tank had been cleaned of its deposit; but after there was a considerable accumulation of deposit, these quantities served for three fulls of the tank, therefore, taking an average of 2½ fulls for each charge of stuff, giving 73,047 gallons for the quantity of precipitants named above.

The composition of these precipitants, in the condition in which they were mixed, I found to be—

ALUM SLUDGE.

Alumina, ...	7·4
Silica, ...	5·5
Peroxide of Iron, ...	18·8
Sulphuric Acid, ...	29·1
Lime, ...	2·8
Coaly Matters, ...	1·2
Chlorine, ...	0·5
Water of Combination, ...	8·2
Water at 212°, ...	26·5
	100·0

Of these there is dissolved out in water 21·5 per cent., being principally Sulphuric Acid and a little Oxide of Iron and Lime.

CHARCOAL.

Carbon, ...	31·9	
Peroxide of Iron, ...	14·2	
Sulphide of Iron, ...	4·5	
Lime, ...	2·3	
Sulphuric Acid, ...	4·0	
		56·9
Chlorine, ...	0·7	
Sand, ...	10·0	
Water at 212°, ...	31·6	
Alkaline Matters' Trace, ...		42·3
		99·2

LIME.

Carbonate of Lime, ...	13·6
Sulphate of Lime, ...	4·7
Hydrate of Lime, ...	14·5
Chloride of Lime, ...	4·5
Chloride of Calcium, ...	5·0
Silica, ...	0·8
Alumina, with a trace of Oxide of Iron, ...	1·1
Water at 212°, ...	55·2
	99·4

The small quantity of soluble matters in these materials is worthy of remark.

In the operations during my stay at the Works, there was no instance when the water let off was either clear or pure, whether from the first, second, or third full of the tank, after the purifying matters were added. The water let off had an ashy or clayey colour, which long standing did not take away, and still retained a perceptible sewage smell. I would, however, remark that the stuffs Mr. Manning uses are capable of making the water clear and free of smell. The sewer being operated upon is a very bad one, and the proportions of purifying matters used were insufficient, but by using one-third more of each ingredient to that given, the water was rendered as clear and limpid as the finest spring, and entirely free of sewage smell, and has retained its purity and appearance after being six weeks kept in a close and warm place; but on adding more sewage to the precipitate, more of the precipitants were required, nearly as much as the first charge.

I brought with me from Edinburgh a quantity of Mr. Manning's precipitants to apply to the Glasgow sewers, and compare the effect and cost of these with other precipitants. I also brought products of Mr. Manning's operations in Edinburgh for analysis. It is but right to state that my experiments in Glasgow were not done in tanks, but in the Laboratory, with the water from different sewers brought to me at different times of the day.

The sewage experimented upon in Glasgow were Pinkstone Burn, St. Enoch's Burn, Gallowgate Burn, and Gorbals. During the experiments upon these sewers separately, I was struck with the appearance of St. Enoch's Burn—it contained a considerable quantity of a light brownish matter floating in it, which deposited in a few minutes, leaving the water clear, but having a light straw tint, and *without smell.* Thinking that this may have been the result of some accidental circumstance, I procured quantities upon two other separate days, and different hours of the day, and found it to be all of the same character. Both the deposit and water were then subjected to analysis. The solid matters which precipitated by standing amounted to 80 grains per gallon, and were composed of—

Carbonaceous Matters, ...	18·6
Silica or Sand, ...	27·3
Alumina, ...	21·3
Peroxide of Iron, ...	4·8
Oxide of Manganese, ...	2·3
Lime, ...	2·0
Sulphuric Acid, ...	2·8
Chlorine, ...	0·6
	79·7

The loss by burning at a red heat were taken as Carbonaceous Matters.

The clear water in the three different days differed in the quantity of salts they contained in solution, but not in the kind. One of them being taken immediately after a heavy fall of rain had only half of the other two. The following I give as the mean of the two strongest. Salts held in solution, per gallon of water, 144 grains, dried at 212°.

Chloride of Manganese, ...	47·8
Perchloride of Iron, ...	47·4
Chloride of Calcium, ...	16·5
Sulphate of Lime, ...	12·4
Silica, ...	2·8
Carbon, ...	1·2
Alkaline Chlorides, ...	15·9
	144·0

These analyses showed at once the cause of the deodorising of the sewer, and verified what Mr. James Young had shown several years ago, that Protochloride of Manganese was a powerful deodoriser. The Perchloride of Iron has also the same property.

It was evident from these results that if the St. Enoch Sewer was deodorised by the Iron and Manganese Salts being let into them, the same effects would be produced in the other sewers by the same cause. I therefore mixed the Gorbals and Gallowgate Sewers with an equal quantity of St. Enoch Sewer, and after stirring well, the sewage smell was removed, but not so perfectly as in the St. Enoch Sewer alone, probably from the sewage having been kept some time before the mixing, which would not be the case in the St. Enoch's Sewers, for the odour is much more easily prevented in new matters than it is after decomposition has fairly begun. I also found that by adding two parts of St. Enoch's to one part of the Pinkstone, the whole was both clarified and deodorised.

As there was not a sufficient quantity of St. Enoch's burn to deodorise all the sewage of the City, I then thought by what means a greater supply of these salts that affected the deodorising could be obtained, and thinking it probable that they issued as waste from St. Rollox Works. I with the approval of Professor Anderson went to these works, and found that the materials referred to in St. Enoch's burn evidently proceeded from these works, and I also found that large quantities of hydrated peroxide of iron, with a small quantity of manganese, were constantly accumulating there, which when dissolved in hydrochloric acid, formed the requisite salts for deodorising, and that quantities of these salts were constantly let off from these works.

Laying aside the consideration of this view of the question for a little, I will now give the results of the experiments for purifying the several sewers with lime, and with Mr. Manning's materials, and also with these in connection with the St. Enoch's Burn, as it is presently constituted, taking in the first instance the relative cost of purifying 1,000,000 gallons of sewage by Mr. Manning's materials,—

	Alum Sludge.	Lime.	Charcoal.
Gallowgate, ...	19,500 lbs.	12,600 lbs.	6,700 lbs.
Gorbals, ...	16,600	11,400	5,400
Pinkstone, ...	40,600	50,000	26,000
	3 |98,700	3 |74,000	3 |38,700
	32,900	24,666	12,900

thus a mixture of these sewers require for making the water clear and free of smell for 1,000,000 gallons.

	£	s.	d.
Alum Sludge, 293¾ cwt., @ 4½d.	£5	10	1½
Charcoal, 115 cwt., say @ 3½d.	1	13	6½
220 cwt. Lime @	0	0	0
	£7	3	8

Nothing is here allowed for cartage, which would vary according to distance. Lime shell cost, delivered in Glasgow, 12/6 per ton. In slaking I found an average of 10 per cent. of unburned lime; one ton of Lime shell produced, after deducting this 10 per cent., 25½ cwt. of slaked lime in the state in which it was added to the tanks, making it 6d. per cwt. A mixture of the three sewers required (50 cwt. @ 6d., £1 5 0) 50 cwt. of the slaked lime for 1,000,000 gallons.

The next question was, what effect a mixture of a small quantity of St. Enoch's sewer with these others have along with these precipitants? Would the precipitation of the salts in St. Enoch's aid the precipitation of the impurities in the other sewers? The following are the results obtained, by mixing equal parts of the four sewers, namely, Pinkstone, St. Enoch's, Gallowgate and Gorbals, calculating as above upon 1,000,000 gallons with

Mr. Manning's materials, ...	£3	15	0
With Lime	0	7	6

Taking the quantities which were applied to the Edinburgh sewers as the basis for calculation, without reference to the water being perfectly clarified, for in my experiments I never found these proportions making clear water, even with the Glasgow sewers, namely, 6 cwt. alum sludge, 3 cwt. lime, and 2 cwt. charcoal for 73,047 gallons, 1,000,000 gallons will require—

82 cwt. Alum Sludge @ 4½d.	£1	10	9
41 " Lime, ...	0	0	0
27½ " Charcoal, @ 3½d.	0	8	0
	1	18	9

The whole sewage of the City has been calculated at 50,000,000 gallons daily. The cost per year for this quantity of sewage will therefore be,

BY MR. MANNING,

Without St. Enoch's, ...	£131,095	16	8
With one-fourth St. Enoch's, ...	68,437	10	0
Edinburgh data, ...	46,146	0	8

WITH LIME.

Without St. Enoch's, ...	£22,812	10	0
With St. Enoch's, ...	6,843	15	0

I may here mention in connection with the matters in St. Enoch's, that the refuse peroxide of iron left when making sulphuric acid from iron pyrites, often contains small portions of soluble per sulphate of iron which, when put into the sewers along with lime, has a similar effect in facilitating the precipitation of the organic matters of the sewers, to the salts in St. Enoch's burn.

I may also mention that, in operating with Mr. Manning's precipitants, I found that the lime which he uses, if used in about double the quantity recommended by Mr. Manning, will clarify the water without the addition of the other matters.

As to the purity of the water after being acted upon by these several precipitants, it may be stated, that in no case is the water in a state of perfect purity, having always in it less or more soluble salts. With the lime alone, the clarified water is occasionally of a straw tint, especially that of the Pinkstone burn, but when the lime is mixed with the St. Enoch's, and also when purified by Mr. Manning's precipitants, there is no colour. The water in general is as pure to the eye as ordinary river water, and in many cases could be drunk without any very disagreeable taste being experienced, and during these experiments, I supplied a fish globe with the water as decanted from the precipitants; changing the water daily as there was a paucity of air in the water, and the fish lived as well and healthy like as when in the water which is supplied to the City. The only smell observed, and that only occasionally and very faint, was the odour of brewers' wash. The matters held in solution after clarification were exceedingly varied in quantity, being sometimes the double of other times, within a few hours. The following deduced from several analyses will give an idea of the quality and quantity of these purified sewers.—The solid matters after evaporation were dried at 212° and then burned—the loss by burning is called carbonaceous matters. The contents of one gallon evaporated may be stated at 102 grains composed of—

Carbonaceous matters burned off, ...	29·5
Silica, ...	1·4
Alumina, ...	1·6
Lime, ...	26.7
Carbonic Acid, ...	10 3
Sulphuric Acid, ...	7·5
Chlorine, ...	11·8
Magnesia, ...	1·7
Phosphoric Acid, ...	trace
Potash, ...	3 8
Soda, ...	7·7
	102·0

These matters were in combination forming salts. This water put into the river, would not be detrimental to any process of manufacture for which the water of the river was used.

The next thing is the quantity of solid matters deposited by the sewers *with* and *without* precipitants. In all the sewers there is a quantity of solid matter floating in them that deposits by a few minutes repose. This deposit, in ordinary sewers, has a striking similarity of character, having about 42 per cent. of organic matters, and 58 per cent. of earthy matters, composed of silica, alumina, oxide of iron and lime. The average quantity of these solid matters in the four different sewers under examination, taken at different hours of the day, and in different states of the sewers, were 50 grains per gallon, dried at 212° Fah. The different sewers gave—

Gallowgate, - - - - - - -	23 grains.
Gorbals, - - - - - - - -	27 ,,
St. Enoch's, - - - - - - -	70 ,,
Pinkstone, - - - - - - -	80 ,,
	200

This solid matter, in a million gallons of the mixed sewers, will be 7,140 lbs., being per year 58,172 tons of *dry* matter. By experiments I found that this solid matter, in a wet state, but sufficiently consistent to be cut into cubes and retain its shape, contains 70 per cent. of water; and that in a state from which the water is merely drained off, as it would be retained upon a punt when dredging, it retains 86 per cent. water, hence, there will be in this state, as dredged, 415,525 tons per year, but in the more solid form, suitable for carting, 193,906 tons. All this, however, may not require to be dredged from the river, as portions may be carried down by the current, and also part may be decomposed and dissolved, giving off gaseous emanations, but in either way they deteriorate the Clyde; and this altogether apart from the soluble sewage matter's undergoing constant decomposition.

In my experiments with the different precipitants, they were applied, without previously separating the solid matters floating in the sewage, and consequently, the weights obtained and referred to, include this solid matter. By Mr. Manning's matters, the quantity of precipitate deposited is fully five times more than the quantity of solid matter given above; and that by lime alone is two and one-half times the quantity given above, while that with lime, and St. Enoch's sewers does not exceed two times that given above. These will therefore stand as follows, taking it with 70 per cent. of water, which is the condition fit for cartage:—

By Mr. Manning's process, - - -	969,530 tons.
By Lime alone, - - - - - -	484,765 "
By Lime and St. Enoch's, - - - -	387,812 "

The great excess by Mr. Manning's process is doubtless owing to the great quantity of insoluble matters in his precipitants. Should these deposits have a manurial value and a market obtained for them, Mr. Manning's materials yield by far the largest product.

Should it be advisable to use precipitants, and setting the manurial value of the deposit aside, and providing for its removal from the tanks or place of deposit, to prevent undue accumulation, I would suggest that the operations be performed near the river; say that the whole sewage of the north side of the river was conducted by a main sewer to the side of Kelvin above the Clyde, the deposit could be lifted direct from the tanks by a series of buckets into punts, and conveyed either up or down the river to places of deposit, to fill up ground on the banks of the river, as is done with the dredging matter of the river at present, and thus much of the present dredging of the river saved, and the water kept clear and free of nuisance. A similar arrangement could be made for the south side of the River. Or were the liquid refuse let out from St. Rollox Works, which could be greatly increased in quantity and value by dissolving the accumulating peroxide of iron, referred to in a former part of this Report, supplied at the fountain-head to Pinkstone, St. Enoch's, and Molendinar Burns, the principal portion of the city would thus be deodorised; and if led into tanks, as suggested, all the sewers from other sources will thus be mixed and deodorised *without any precipitants*, and the solid matters prevented going into the river; and although it will not be valuable as a manure, it will be excellent for filling up.

Another question suggested itself during these operations, which is clearly connected with the composition of the sewers and the interest of the river—namely, the effect these sewage waters will have upon the sheathing of vessels lying in the river.

These sewers, not deodorised, all contain sulphur, or matters capable of decomposing and giving off sulphur, which has an extraordinary affinity for copper. The persalts of iron, such as that existing in St. Enoch's Burn, are also powerful solvents of copper or yellow metal, even more powerful than the same quantity of sulphuric or muriatic acids would have were they not combined with the peroxide of iron.

I submitted pieces of copper and yellow metal sheathing to the action of these sewage waters separately, and the results are as follows, giving the number of grains dissolved, from a square foot of these metals kept in the sewage waters for 24 hours without any agitation, taking the mean of a good many trials, for sometimes the action was much more rapid than at others, owing to the state of the sewer:—

	Copper.	Yellow Metal.
Pinkstone Burn, - - -	10·2 grains.	9·0 grains.
St. Enoch's Burn, - - -	13·2 "	20·5 "
Gallowgate, - - - -	2·9 "	1·3 "
Gorbals, - - - -	5·0 "	4·4 "
Giving a mean of - -	7·9 "	8·8 "

It must be borne in mind, however, that the action will be much less after the sewers become dilute by the waters of the river; at the same time, I may remark, that the action of these matters upon sheathing is seldom equal over the whole surface of the vessel, but generally in patches; so that, were the action of the river equal to only two grains per square foot in 24 hours over the whole surface, by this irregular action, caused by galvanic influence, small portions of the surface may be acted upon at a much higher rate than given above, while other portions will not be acted upon at all, being protected at the expense of the few feet acted upon.

The water, after being purified by any of the precipitants, had no perceptible action upon either copper or yellow metal after being kept in it for several days.

JAMES NAPIER.