TOWN EXCRETA; ITS UTILIZATION.

LONDON SEWAGE,

SHALL IT BE WASTED? OR ECONOMISED?

BEING

A PLAN FOR THE COLLECTION AND TREATMENT OF
THE FÆCAL MATTER OF TOWNS;

FOR PURIFYING THE SEWERS AND RIVERS, AND REMOVING THE CHIEF
IMPURITIES WHICH RENDER THEM DANGEROUS TO THE
HEALTH OF COMMUNITIES;

WITH ESPECIAL AND IMMEDIATE REFERENCE TO THE METROPOLIS,
THE RIVER THAMES, AND THE BOARD OF WORKS'
MAIN DRAINAGE SCHEME.

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with the author's compts

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PREFACE.

THE following pages have been written with the view of showing the great value of the excretage—sewage—matter of our towns, and how it can be collected and economised. The former is already admitted and extensively known; but the latter has not yet been effected so as to yield results satisfactory to the capitalist or to the agriculturist. My attention has been lately particularly drawn to the subject by the condition of the sewage of London, by the unwholesome state of the sewers and the river-banks, by the hopelessness of any proposed remedy, by the attempts of the Board of Works to extricate the inhabitants of the metropolis from their perilous position and remove the chief source of danger, by the prospect of this being but partially accomplished through the expenditure of millions of pounds, and by, *at the same time,* the absolute waste and destruction of fertilising material sufficient for the cultivation and growth of vegetable and animal matter for the sustenance of the whole population.

To remedy this, and to save this vast wealth from waste, as well as to extricate the authorities from their pecuniary difficulties, I have drawn up, as briefly and clearly as I could, a plan which is undoubtedly practicable, and will be found by the Chemist to be based only on well-known and undeniable data; and by the Engineer to present no real difficulty in carrying out. The plan and its anticipated results are also based upon an experience of nearly twenty years in carrying out a great number of processes of chemical manufactures on an extensive scale, and upon results obtained thirteen years ago in the manufacture of manures from those excrementitious matters—urine and night-soil.

But this matter is not applicable alone to London, it is equally so to every town and city. Its application alone to the larger towns throughout these islands may with certainty be valued at not less than 5,000,000*l.* of savings annually, which would be well applied in obtaining further measures of social advancement and sanitary reform.

It will be interesting to those towns which have not yet abandoned the old cesspool system, or adopted any of the *modern* methods of drainage, to learn, that they may now do so with such advantage, that, whilst the health and comfort of the whole population is increased, a new and annually increasing source of wealth is established.

In my estimates of quantity I have taken the best authenticated results; and in those of values I have only taken the most moderately fair and average prices. My wish has been not only rather to under-estimate the value of the raw materials and manufactured products, but to give the full costs of the extraneous matters, and under-estimate the quantities producible. A glance at the valuations of the sewage of London by several eminent authorities will prove this, and show that I have stated the lowest amount yet given.

It is for the public, now, to examine this matter carefully, and decide whether they will allow their wasted but valuable excretage to contribute still to their discomfort and dissolution, or whether it shall be economised and become a new source of wealth to the country.

Greenwich,
28*th October*, 1858.

TOWN EXCRETA, &c.

One of the greatest difficulties of the day appears to be how to get rid—economically, safely, and satisfactorily—of the sewage matters of our towns. The metropolis has been particularly perplexed upon this subject, and for years past great efforts have been made to ascertain what was best to be done with its sewage, so as to save the further pollution of the Thames, free the city from its presence, remove a chief source of disease and death, and, if possible, to utilize matter which every intelligent person admits must be of enormous value to agriculture. The reports published by Government upon the various schemes proposed to the Boards of Works, and to the engineers appointed by Government to examine these plans, show very conclusively how little hope there is that anything can be done to make profitable use—to the inhabitants—of the sewage, and that nothing serviceable can be accomplished without great outlay: the *present* outlay of several millions, and the *future* annual outlay of from 100,000*l.* to 200,000*l.* for the repairs and charges contingent to the peculiar works proposed. There appears *now* no course open for the citizens of London, but the expenditure of an indefinite number of millions, in carrying out a scheme which merely shifts the evil to another locality, offers as yet no prospect of cash returns, and a very faint probability of the future application of the sewage matters to the irrigation of land in the neighbourhood. The labours of Engineers have as yet only resulted in showing how the sewage can be removed to a distance, and at an enormous outlay; and of Chemists in showing of what valuable matters the sewage consists, the practical impossibility of deodorizing or disinfecting it, and the practical inutility of every attempt at manufacturing manures from the sewage by precipitation or filtration. The sewage of London has therefore, at last, after exhausting every hope of rendering it harmless to the citizens, or of retaining any of the rich fertilizing matters which it contains, been handed over to the care of engineers. Five or more millions are therefore as speedily as possible to be expended in carefully collecting and conveying to a distance a million's worth of guano, and there throwing it away, and 200,000*l.* annually thereafter in maintaining the apparatus in good condition, and so as to secure the proper execution of this wasteful work.

Professor Owen, speaking of this subject, in his Address at the recent meeting of the British Association in Leeds, says:—"Were agriculture adequately advanced, the great problem of the London sewage would be speedily solved. Can it be supposed, if the rural districts about the metropolis were in a condition to avail themselves of a daily supply of pipe water, not more than equivalent to that which a heavy shower of rain throws down on 2,000 acres of land, but a supply charged with 30 tons of nitrogenous ammoniacal principles, that such supply would not be forthcoming, and made capable of being distributed when called for within a radius of 100 miles? To send ships for foreign ammoniacal or phosphatic excreta to the coast of Peru, and to pollute by the waste of similar home products the noble river bisecting the metropolis, and washing the very walls of our Houses of Parliament, are flagrant signs of the desert and uncultivated state of a field where science and practice have still to co-operate for the public benefit."

Now, this stinging accusation will be equally applicable when the engineers have perfected their plans, and expended the vast sums required for their operations, save only the walls of our houses and wharves will not be so frequently washed with a polluted stream.

The subsequent probable utilization by irrigation of the sewage, instead of discharging it into the river a few miles below the city, is a matter into which I need but enter very briefly. Admirable papers upon this subject have appeared from time to time for years past, by most able and competent authors, and the matter is well before the public. The sewage, largely diluted as it is, would be of great advantage to certain crops, as grasses; and would be eagerly consumed by the farmer if presented to him at a fair price, that is to say, at *three farthings per ton;* at any higher price it would not be worth his attention. It is, however, extremely doubtful whether the revenue derivable at this rate per ton would be more than sufficient to clear the charges connected with the distribution of such enormous bulks of material. I must here refer to the excellent paper by Mr. Lawes, published in the 'Journal of the Society of Arts,' vol. III. p. 263, in which the utilization of the sewage of London *as it is*, is amply discussed in all its bearings.

It has also been proposed to apply the process carried out by Mr. Wicksteed at Leicester, of treating the sewage with caustic lime, collecting, pressing, and drying the deposited matters, obtaining these as a firm and portable manure; but this plan offers very slight advantages indeed, from the fact that only about one-third of the mineral and organic matters contained in the sewage are precipitated, and that the whole, nearly, of the valuable constituents, are driven off, or lost in the supernatant liquors. Also that the manure, so obtained from the sewage of Leicester, is not valued at more than 17*s.* per ton, while the cost of the materials, working expenses, &c., are 12*s.* 8½*d.* per ton, leaving a difference of only 4*s.* 3½*d.* for profit and for carriage of the manure to the farmer. Drs. Hoffmann and Witt, in their Report upon the chemical value of the sewage (Main Drainage, Appendix I.), have examined this subject very minutely, and shown the practical inutility of this scheme. They have also reported upon other methods of precipitation and filtration of the sewage; but no satisfactory results have been obtained from any of the processes hitherto proposed. Such then are very briefly the present position and prospects of the Sewage Question, and such the circumstances immediately in reference to London and its sewage, which have induced me to apply myself to the consideration of this subject, and to propose a plan for freeing the Thames from the excreta in the sewage; for obtaining the whole of the valuable constituents and rich fertilizing matters now miserably poured into the river, and wasted; for enconomising for agricultural purposes a home guano which shall equal the finest brought from Peru, which thus will liberate hundreds of ships, and thousands of men, at present engaged in this guano trade; and for realizing to the citizens of London a clear revenue of half a million annually.

As all my readers may not be equally familiar with the opinions of chemists and practical men upon the value of the excrementitious matters of towns, I quote a few opinions of the most prominent agricultural philosophers of the day.

The learned German chemist Liebig (Application of Chemistry to Agriculture and Physiology, p. 193, 2nd edit.) says:—"When it is considered that with every pound of ammonia which evaporates a loss of 60 pounds of corn is sustained, and that with every pound of urine a pound of wheat might be produced, the indifference with which these liquid excrements are regarded is quite incomprehensible. In most places only the solid excrements impregnated with the liquid are used, and the dunghills containing them are protected neither from evaporation nor from rain. The solid excrements contain the insoluble, the liquid all the soluble phosphates, and the latter contain likewise all the potash which existed as organic salts in the plants consumed by the animals."

Again he says (Letters on Chemistry, p. 496):—"It is unquestionable, that, with the exception of a certain quantity of carbon and hydrogen which are secreted through the skin and lungs, we obtain, in the solid and fluid excrements of man and animals, all the elements of their food. We obtain, daily, in the form of urea, all the nitrogen taken in the food, both of the young and the adult; and further, in the urine, the whole amount of the alkalies, soluble phosphates and sulphate, contained in all the various aliments." "Thus we see that in the solid and fluid excrements of man and animals, all the nitrogen—in short, all the constituent ingredients of the consumed food, soluble and insoluble —are returned; and as food is primarily derived from the fields, we possess in those excrements all the ingredients which we have taken from it in the form of seeds, roots, or herbs." At page 501 he says, "There can be no doubt that, in applying these excrements to the soil, we return to it those constituents which the crops have removed from it, and we renew its capability of nourishing new crops; in one word, we restore the disturbed equilibrium; and consequently, knowing that the elements of the food derived from the soil enter into the urine and solid excrements of the animals it nourishes, we can with the greatest facility determine the exact value of the different kinds of manure. The solid and liquid excreta of an animal have the highest value as manure for those plants on which the animal has fed, &c. The fluid and solid excrements of man contain the mineral elements of grain and seeds in the greatest quantity."

At p. 523 he says, "If it were possible to restore to the soil of England and Scotland the phosphates which during the last fifty years have been carried to the sea by the Thames and the Clyde, it would be equivalent to manuring with millions of hundredweights of bones, and the produce of the land would increase one-third, or perhaps double itself, in five to ten years." Mr. Lawes, in his paper already alluded to, says, "The amount of the constituents voided by the total population of London in one year, if entirely freed from water, is seen to be 51,286¾ tons. Of this about ⅕th is mineral matter; and the nitrogen it contains amounts to about ⅙th of the whole, namely, 8,859¾ tons, which is equal to 10,758¼ tons of ammonia. Now little more than half a hundredweight of ammonia is the usual artificial dressing for an acre of cereal grain, and it might be calculated to yield an increase of crop of 10 to 12 bushels of wheat, or this 10,758¼ tons of ammonia would afford a produce of about 600,000 quarters of wheat, if it could be conveniently applied for such a purpose. The intrinsic value of the sewage of London, considered in this merely chemical point of view, is therefore enormous. Indeed, according to the above supposition it would return to the metropolis nearly one-third of the wheat consumed by its population. If, however, it were thus devoted exclusively to the growth of corn, it would at the rate above mentioned extend over more than 400,000 acres of land."

Dr. Playfair says, "When we consider the immense value of night-soil as a manure, it is quite astounding that so little attention is paid to preserve it. The quantity is immense which is carried down by the drains in London to the river Thames, serving no other purpose than to pollute its waters. It has been shown, by a very simple calculation, that the value of the manure thus lost amounts annually to several *millions of pounds sterling.* A substance which by its putrefaction generates miasmata, may, by artificial means, be rendered totally inoffensive, inodorous, and transportable, and yet prejudice prevents these means being resorted to."

Extract from article by Rev. W. R. Bowditch, of Wakefield, in last number of the Journal of the Royal Agricultural Society.

"I must observe, however, that the most prolific source of grass manure is human excreta, now expensively wasted in town-sewage. Large sums of money are now expended to enable us to waste what may be economised with advantage in every way. The present absurd water-carriage of excreta must be abandoned, and sewers employed for their legitimate purpose, viz.:—to carry away waste water to its natural receptacle, the river. Moveable boxes should be attached to every house, and removed weekly in summer, fortnightly in winter. A cistern filled with dry pounded clay would be placed overhead, and a simple mechanical contrivance would throw down a measured quantity of this every time the handle was raised, as water is now let down a closet. Nature's deodorizer and disinfectant would prevent the escape of injurious exhalations, and the refuse would be removed by water or other carriage some miles into the country, to await under sheds the farmer's season of use. This manure could be screened and applied by distributors, and would produce crops of grass which experience alone will enable us to estimate. Every element of grass is contained in this manure in large abundance; and while its preparation formed a sanitary improvement of much value to towns, its use would be a boon of enormous value to the country."

The money-value of the fertilizing matters lost in the sewage of London has been variously estimated at from a half million to one and a half million pounds sterling per annum. Drs. Hoffmann and Witt, in their Report appended to the 'Main Drainage,' estimate the annual value as follows:—

For urine	£1,222,750
For solid excreta	221,427
	£1,444,177

They arrive at nearly the same result by a careful examination of the sewage, and determination of the constituents by the usual agricultural values, and they thus state the

Daily value of the sewage to be	£3,796
Or total annual value	1,385,540

In these calculations the population is assumed to be about 2,600,000, and the average quantity of sewage flowing into the river daily at about 95,000,000 of gallons.

Mr. Dugald Campbell, analytical chemist, London, in his evidence before the government referees on the Main Drainage of London Plans, has estimated the value of the London sewage, assuming the population to be 2,600,000, at 836,000*l.* He values the solid matter in it at rather more than 15*l.* per ton, the salts of ammonia being worth 14*l.*, salts of potash, magnesia, &c., making up the difference.

But these valuable fertilizing materials are carried off into the sewers, and finally into the river, with such an enormous body of water as to render their separation from the sewage a matter of utter impossibility; besides this, the organic matter of the excreta begins to decompose instantly it enters the sewers, yields from that instant the most offensive exhalations, and is constantly reducing in amount and value. Dr. Letheby, in his late excellent Report presented to the City Commission of Sewers, has entered very minutely into the nature of the sewage, its constitution and changes, and very clearly shown the great evils attendant upon the present sewage system. I must refer the reader to that paper for much most valuable information and details, which I have not space to enter upon here. Briefly, however, I may state that the average daily sewage amounts to about 95,000,000 of gallons, equal in weight to about 424,107 tons, and is calculated (by Dr. Letheby) to contain about 2993½ tons of moist excrements, or of dry material, daily, about 162½ tons; from this it appears that each ton of moist excreta (that is urine and fæces) sent into the sewers is dissolved in, and diluted with, about 141½ tons of water; that with each ton of dry matter of excreta there is the enormous quantity of about 2781 tons of water. Each ton of sewage, therefore, on the average, only contains about 16lbs. of moist, or about 13⅗ oz. of dry excreta. In this calculation there is not included the matter derived from the water supplied to the metropolis, pulverization of the streets, washing waters, nor wastes from factories, &c., which, however, possess but little value as manure. Mr. Lawes computes the dry solid matters contained in one ton of sewage to be still less than this, viz. at only 9 oz., but his estimate was made upwards of three and a half years ago, and such estimates depend upon the assumed quantity of water, and upon the weight of the excrementitious matter per individual of the population. The possibility, therefore, of extracting these matters from the sewage must be deemed to be practically hopeless, so that, unless a totally different course be adopted with the excreta, the inhabitants of London and all other towns must still be content to pour their millions' worth of manures into the rivers, to be lost.

Before leaving this part of my subject I would draw particular attention to that part of Dr. Letheby's paper, 'On the putrefactive Decomposition of Sewage,' in which he very clearly and beautifully describes the chemical changes which are continually going on in the sewers, the immediate decay to which all organic matters on entering them are subject, the constant production and emanation of foul gases and highly offensive exhalations, the nature and names of which are still unknown. He observes that, "under ordinary circumstances, the solid excrements do not ferment in less than three or four days;" while, on the contrary, in the sewers, "putrefaction begins at once, and it is always of the same kind as that already in progress in the old sewer matter." Finally, on this subject, he says—"In seeking to know what part of the sewage it is which undergoes decomposition, *I have ascertained beyond doubt that it is the solid part which ferments, and this will keep up the putrefactive action for months, evolving large quantities of ammonia, sulphuretted hydrogen, marsh gas, and carbonic acid. It is the sedentary matter, therefore, which is the chief cause of the offensive effluvium.*" From what has been already stated we may now easily draw several important conclusions:—

First. That there is extremely little prospect of utilizing the sewage *as it is*, from the very minute proportion of fertilizing matters it contains, or of realising any pecuniary advantage to the citizens from its application to land by irrigation.

Second. That the excreta will continue to be practically lost, and be the constant source of great danger to human health and life, unless these matters can be otherwise intercepted, collected, and conveyed away.

Third. That if the access of the excreta be carefully and *completely excluded from the sewers, the sewers kept for their legitimate and proper uses*, they would no longer be a source of danger and annoyance, and the river would be freed from the pollution to which it is at present subjected.

Fourth. That the excreta, thus collected, would then become a source of valuable home manure, and its manufacture and sale would realize a splendid annual revenue after paying all charges.

Previous to entering upon the details of the plan I have to propose for utilizing the excreta, and purifying the river, I think it will be advantageous to say a few words on the population of the metropolis, and on the amount of excrementitious matter to be dealt with :—

I.—The Population of London.

The following table, which I have extracted from the large volume lately published on the *Main Drainage*, shows at a glance the actual numbers of the population of the sub-districts in 1851, and also the assumed number to which the population will increase.

Table showing the Districts and sub-Districts into which the Metropolis is divided, the area in acres to Population in 1851, the number per acre, and the number per square mile, together with the assumed number to which the Population will increase.

	Population in 1851.					Assumed Number to which the Population will increase.			
Names of the Sub-districts in London.	Area in Acres.	No. per Acre.	No. per square mile.	Actual Number.	Total.	No. per Acre.	No. per square mile.	Actual Number.	Total.
West districts	10,387	36	23,040	376,427		45	28,800	469,674	
North ,,	13,533	36	23,040	490,396		63	40,320	871,385	
Central ,,	1,839	214	136,960	393,256		217	138,880	399,256	
East ,,	5,797	84	53,760	485,522		106	67,840	614,910	
South ,,	43,695	14	8,960	616,635		28	17,920	1,222,864	
Totals	75,251	31	19,840	..	2,362,236	47	30,080	..	3,578,089

The population in 1851 amounted to 2,362,236, and if to this we add the same ratio of increase that occurred between 1841 and 1851, viz. 21 per cent., we shall obtain for the year 1861—or 3 years hence—a population of 2,858,305. This shows an annual average increase of 49,606 for each of the 10 years following 1851, so that the actual population for this year, 1858, would be upwards of 2,700,000.

II.—The quantity of Excreta per individual.

Mr. Lawes, in the paper already referred to, has at very great care and trouble collected together the results of every previous experimenter upon this subject, and the following is the summary of excrements voided per 24 hours :—

Summary.	Fresh excrements in ozs.		
	Fæces.	Urine.	Total.
Mean of Males under 16 years	2·96	19·53	22 49
,, from 16 to 50 years	4·17	46·01	50·18
,, from 50 years upwards	6·20	42·05	48·25
,, all ages	4·24	41·38	48·10
Mean of Females not over 16 years		14·18	
,, Adult Females	1·24	36·66	37·90
,, Females of all ages	1·24	31·04	32·28

The mean of these results for all ages will be as nearly as possible :—

Of liquid excrement 36¼ oz. per day, per individual.
Of solid ,, 2¾ ,, ,, ,,

Total .. 39 oz.

These figures deserve the greatest confidence as they are derived from the collected results of Lecanu, Thomson, Becquérel, Lehmann, Dalton, and others, all eminent chemists who have devoted much time and attention to the subject. According to some chemists these quantities are somewhat under the truth; for example, Professor Way informs me that he has adopted the following figures for "the average of a mixed population of all ages and ranks :"—

Of liquid excrement 3lbs. (48 oz.) per 24 hours.
Of solid ,, ¼lb. (4 ,,) ,,

Total .. .. 52 oz. ,,

which is upwards of 33 per cent. higher than the summaried results by Mr. Lawes.

III.—The total Excreta of London.

Taking then the population at 2,700,000, and the excreta per individual at a total of 39 oz. as per Mr. Lawes, we arrive at the following results :—

a. The liquid amounts to a total of 6,117,187 lbs. per day,
Equal to .. .. .. 611,718 gallons ,,
Or in weight to nearly .. 2,731 tons of urine.

b. The solid will amount to a total of 464,062 lbs. per day,
Or in weight to upwards of .. 207 tons of solid excrement.

That is to say, there is a present daily produce of about 3000 tons of most valuable manure swept away from the metropolis, and washed into the sea. Of the value of this matter I shall speak presently when I have described the nature and composition of the several products into which these 3000 tons may be manufactured. It will be observed that I have adopted the lower estimate of Mr. Lawes for the daily excreta, instead of that of Professor Way, which would indicate a total produce of upwards of 4000 tons daily. If we suppose that the latter quantity is theoretically correct, there is no doubt the practical result obtained would be nearer the former estimate, from the numerous sources of loss of excreta which will always occur.

We are now in a position to explain and examine the details of the plan I have to submit for the collection and treatment of the excreta, and for the manufacture of the products therefrom. It will be evident, from what I have already remarked in reference to the nature of sewage, and the enormous bulk of water with which it is diluted, that it is quite hopeless to expect to obtain the valuable manuring ingredients therefrom by any direct operation. The methods proposed by precipitation and filtration have been all tried, and abandoned as useless and impracticable, so that there is no method known which has not been tried, and no method tried but has been given up. It is also evident, that if the excreta of towns and cities is ever to be economized, and turned to the purposes for which it is so admirably and naturally adapted, it must *never enter the sewers*, it must *never become sewage*. The pecuniary advantages which will result from such a system has been, and will be again, remarked upon and illustrated; the sanitary advantages—which indeed are those chiefly to be considered—will be incalculable.

I may remark here that the difficulties in carrying out the following scheme may be considerable, but they are entirely, in my opinion, mechanical, and as such, of course, in England above all countries, are surmountable. The mechanical contrivances and arrangements, which I have designed to meet the various requirements, are such only as will answer the purpose, will practically attain the object, but may not be such as would be found the best in practice, or sufficient in the judgment of eminent engineers. Of chemical difficulties there are none, the operations are all simple, and will be found perfectly effective.

Outline of the Plan.

It consists, briefly, in the collection of the excreta with as small a quantity of water as possible—instead of washing it into the sewers with a large and unknown quantity—in collecting it in sunk vessels from which it is periodically, daily or oftener, withdrawn through iron pipes by means of pumping machinery, and discharged into reservoirs, each sufficient for at least the produce of 24 hours. It is here mixed with oil of vitriol sufficient to decompose the urea, and to form sulphate of ammonia, and allowed to settle. The clear *liquid* is pumped into boilers and evaporating vessels, and there concentrated until crystallization occurs, and the salts are separated from the water. The solid matter, which falls to the bottom of the reservoirs, is drawn through pipes from the bottom by pumps, and forced into a filtering apparatus, which expresses the liquid, and produces the *solid* matter in a state of almost dryness. These two products form manures which contain all the fertilizing properties of urine and fæces, and may be sold separately or together, mixed in the relative proportions yielded daily, in which condition it is a rich manure having in abundance all the mineral and organic constituents required by plants in their food.

Details of the Plan.

The arrangements for effecting these several operations may be described under several heads, and in the order of succession of processes, as follows :—

First. The form of water-closet required. As it is of the first importance—for the economical success of the whole plan—to obtain the excreta with as small a quantity of water as possible, consistent with perfect cleanliness of the closet, it is necessary to provide :—

1st. A stop-cock or valve, which shall deliver when opened only *a certain and determinate quantity of water*, or, in other words, it must be self-closing and self-measuring.

2nd. That the delivery of this water should only occur *after* the closet has been used, and the contents of the pan discharged into the vessel underneath ; the fresh water then entering sweeps the sides of the pan or basin, removes any adhering matter, and *remains* in the pan until again discharged with excreta as before.

3rd. A small cistern or vessel under the closet-pan, wherein the excreta may collect until *two* or more gallons are accumulated ; this allows the solid matter to become softened and intermixed (dissolved in, to some extent) with the liquid, and will materially reduce the possibility of stoppage in the conveying pipes, with the additional advantage obtained from the rush of a considerable bulk or volume of liquid matter suddenly released into the pipes. It is possible that this may not be so imperative as I deem it, and that it may be sufficient merely to enlarge the size of the lower compartment of the present closet arrangements, and to cause the excreta, &c., to escape through a curved pipe or syphon trap of the ordinary kind, but having a larger or higher bend; if so, many of the closets now in use will be sufficient for the new requirement, if merely supplied with the self-regulating valve. This would of course greatly reduce the expense to be incurred by the adoption of my plan, and also the time required in getting it into operation.

For the first and principal purpose, I have obtained, through the kindness of the inventor, Mr. Morris, engineer of the East Kent Waterworks, a stop-cock or valve, which will accomplish the very important function of delivering any desired quantity of water, ounces or gallons, with equal certainty and precision. This valve has simply to be attached to the left rod of the closet, substituted, it may be, for the stop-cock at present in use, and opened by the lifting up and pressing down, or return of the handle which empties the pan.

I have designed a form of closet which unites all these requisites, and have submitted it to several well-known manufacturers in London, who consider it well adapted for the purpose, and capable of being made at a very moderate price.

Such a closet, with attached box and valves complete—the closet-pan or basin and the lower box or cistern being of cast iron enamelled—I am enabled to state through the kindness of Messrs. Tylor and Sons of Warwick Lane, may be manufactured and supplied in quantity for about 3*l.* each. It is quite possible that the half of that sum would be amply sufficient where a very large number—as fifty thousand—were required to be supplied by one manufacturer, and that the above sum would furnish not only the apparatus, but supply all the necessary labour and expense of fitting up and completing. The whole arrangement is simple in its parts, and may be economical in cost if desired. More expensive and perhaps better arrangements can be designed, but I believe the above will answer the intended purpose fully.

We have now to inquire and determine what is the quantity of water required to be supplied to *carry off the excreta* and secure *perfect cleanliness* in the closet. What is the minimum that can be used to secure these objects? and the maximum, having in view the after *economical* utilization of the closet products?

I have shown that, according to the statistics collected and tabulated by Mr. Lawes, the average weight of solid excrement voided per diem by each individual of the population amounts to $2\frac{3}{4}$ ounces, say 3 ounces in round numbers: now what quantity of water will be necessary to remove these 3 ounces from the pan? Four times this volume—viz. 12 ounces—will I think be found amply sufficient for the purpose. If we suppose that the fæces of an adult will occasionally amount to 6 ounces, or more than double the ascertained average quantity, 12 ounces of water will yet be double the volume of the fæces, and still sufficient for the purpose. But the fæces when voided are generally if not always accompanied by urine, which will assist the carriage of the solid excrement, by increasing the volume of liquid matter.

I may assert here without fear of contradiction that water-closets have *never* been made having in view specially the economization of the water employed, but rather that an abundance of water should always be supplied, the cost of the water being as nothing, the desire to be free from disagreeable smell everything, and the value of the excreta being unrecognized—perhaps the sudden injection of the solid excrement into the pipes and drains rendered a larger supply of water necessary, to flush off the impediments which would be thus more likely to occur. The advantages, therefore, of *accumulating* the excrement in the vessel under the pan, as I propose, and giving time for the disintegration and blending of the more solid parts, will now be more apparent. The whole matter will be more liquid and less likely to choke the conveying pipes. The small amount of water employed will also considerably reduce the amount of fermentation which always results with water alone, or when a large quantity of water is mixed with the excreta. I have already remarked—and would draw particular attention to the fact now—that Dr. Letheby says, "Under ordinary circumstances the solid excrements do not ferment in less than three or four days." In no circumstances would it be likely the accumulations in the underneath vessel would remain there over two days, in the most cases the discharge would occur at least once in 24 hours, so that the offensive gaseous matters resulting from fermentation would seldom if ever be experienced. To remove these, if delay should occur in the emptying of the box, I provide an air tube, connected to the upper part of the box and passing through the wall of the closet to the air outside: it should be led upwards outside the building for several feet, and should be filled in the lower part with coarsely ground wood or peat charcoal. A continuous draught outwards through this pipe may be established by allowing a slight access of air through the upper part of the box, which will carry off with it any disagreeable smell that may arise. The charcoal will destroy, will deodorize, the offensive air on its passage, so that no inconvenience will be experienced in the vicinity of the exit pipe. This power of charcoal is now well known, thanks to Dr. Stenhouse, and will yet play a very important part as an air deodorizer.

We will, therefore, assume for the present that 12 ounces of water will be the maximum required. It will be seen by a reference to page 13 that this amounts to almost exactly one-third of the volume of urine voided per individual, and will form one-fourth, or 25 per cent., of the total liquid to be evaporated and concentrated. I shall be able to show further on that a larger volume of water than this may be used in the closets—*if found necessary* or advisable for sanitary purposes—and yet obtain a satisfactory economical result.

Second. The conveyance of the excreta from the closets, and collection in underground tanks or cisterns.

The fluid matters, when liberated from the cistern under the closet by the action of the float upon the valve, flow downwards through lengths of $2\frac{1}{2}$ or 3 inch cast-iron, zinc, or earthenware pipes, having tight or close joints to avoid leakage, into lengths of the same pipe laid underground, and running *parallel* with the lines of houses, *but at the back or rear.* In this way the course of the under piping will run as near to the houses and water-closets as the out-buildings or offices will permit. Expense will be thus avoided both by the greater economy in length of pipe required, and by the greater facility and convenience of laying the pipes in the gardens, or courtyards, over that of having to open the streets, and bring the pipes through the houses—from back to front, as is now universally the case—to the junctions in the streets. It is of course essential in every case that the underground pipes have sufficient fall to carry off the matters freely, and deliver without impediment. The lines of pipe should obviously take the same fall as the ground, whenever it has a fall, and take the falling direction. Each row of houses will require a line of pipe, unless the rows of houses are close to each other, in which case one line of pipe may be sufficient for both rows. This, however, must be determined by the amount of pipe required, and also by the general inclination of the ground; but these are very simple mechanical matters, and will offer no difficulties to the engineer. The pipes from each row of houses, forming the block or parallelogram, are brought together at the lowest point or level, and are there to be connected to a receiver, or underground tank, placed to receive the excreta from the pipes. These vessels may be of iron, and have a capacity of from 500 to 2000 gallons, more or less, as the district drained may require, that being regulated by the number of houses or number of water-closets connected with the series—or they may be brick vessels built in cement and domed over, and of any capacity required. Where the excreta drainage of a large district has to be collected together, perhaps a brick vessel will be found the most advantageous, economical, and lasting; but this matter will be best decided by circumstances of position and expense.

The size of receiver required in any position may be easily determined thus. For a block of say 100 houses, possessing say 100 closets, drained into one receiver, we require a mean capacity of 245½ gallons. Each house in London contains an average of 7·7 individuals, or for 100 houses 770 persons, each voiding an average daily of 39 ounces of excreta, and employing say 12 ounces of water, equal to 51 ounces per individual, or to 245½ gallons for the whole. I would recommend the receiver to be of double this capacity, however, so as to contain, if requisite, the produce of 48 hours.

From these numbers the capacity of receiver required for any number of houses may be readily ascertained. I should remark that the capacity required is that of the vessel below the line of the inlet pipes. From the top of each receiver a pipe of say 3 inches in diameter — and containing a small quantity of coarsely powdered charcoal—should project upwards to a height of 7 to 10 feet above the ground, to carry off and deodorize any offensive gaseous matter rising from the liquids, the receiver being always open to the access of air through this pipe or chimney. To the lower extremity is fixed the large pipe, say of 4 to 6 inches in diameter, through which the contents are withdrawn by the pumps. But as it is of essential importance that the receiver should not be in constant communication with the pumps, but only be emptied at intervals of say 24 or 48 hours, the outlet main must be furnished with a stop valve which can be opened periodically by a turnkey, or it may be arranged with a valve and float in the interior of receiver, which will be self-acting, and only permit the discharge of the contents when it is full, the valve being opened by the rising of the float, and closed by the return of the float when the vessel is emptied. By either method the discharge and closing of receiver can be easily accomplished, but I believe it will be the safest, but not the most economical, to do this by a turnkey. From fifty to one hundred turnkeys would be sufficient for the whole metropolis, the number depending of course upon the number of receivers and of valves to be attended to.

Third. The collection of the excreta from the receivers, and delivery into reservoirs or tanks at the works.

The arrangements just described depend upon gravitation for their efficiency and operation, so that the only care required is in the proper placing of the receivers, that they receive freely and by natural fall the liquids of the district to be drained. The collection from the receivers must depend now, however, upon the pumping-machinery placed at the works at the extremity of the main. Four-inch to six-inch pipes will be sufficient to convey from the receiver to the main, and the size of the main must be regulated by the requirements of the district, by the number of receivers, and should increase in diameter and capacity as they approach the pumps until the extreme size required is attained. In this way 4-inch pipes will be followed by 6-inch, 6-inch by 8-inch, and 8-inch by 10-inch and 12-inch if required. Care only should be taken to employ as large a pipe in all cases as the wants of say the next twenty years can require. The main pipes may be laid through *and along* the secondary principal streets, and need not pass through any leading thoroughfare—crossing these occasionally being all that will be required of them. This will avoid disturbing or interrupting the traffic of the principal streets and roads—a great source of loss and annoyance to the citizens at all times, and one to which the attention of the city authorities is now being urgently called, from the frequent tearing up and destruction of the streets by the several gas and water companies. In the side or bye streets this is a matter of minor importance; and the rapidity with which the ground may be opened, the pipes laid in and fastened, and the road replaced, may be such that very little inconvenience will be suffered at any point. It will be unnecessary to lay them at a greater depth than from 15 to 18 inches from the surface; they may follow the general inclination of the surface, and need not differ any from the laying of the gas or water pipes. It is important only that the joints be made as tightly as possible to avoid leakage or access of air; and I would suggest for this purpose the use of marine glue with sawdust melted together by heat, or the use of Jamaica bitumen with hemp, as a cement, instead of the usual lead-joint, which is both expensive and imperfect. Until the position of the works is determined it will be impossible to give an estimate of the expense of laying down all the different-sized piping required; but the following scale will give an idea of the cost of each size of cast-iron pipe, including the opening of ground, laying, jointing with lead, and replacing of road.* The costs are those required for a water-company's pipes:—

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* I may remark that the whole of the urinals placed throughout London may easily be connected with the tubular arrangements, and furnished with draught vents containing charcoal which will entirely carry off the urinous odours, and avoid the necessity of using *water*. These useful arrangements ought to be multiplied and placed in every available corner, especially in the busy parts of the city, so as to afford ample accommodation and avoid what would otherwise be a great source of loss of the most valuable excreta. All manufactories also should be carefully furnished with abundant accommodation of this kind.

3 inch pipe	will cost	about	4s.	per yard.
4 ,,	,,	,,	5s.	,,
6 ,,	,,	,,	6s.	,,
8 ,,	,,	,,	7s. 6d.	,,
10 ,,	,,	,,	12s.	,,
12 ,,	,,	,,	16s.	,,
15 ,,	,,	,,	23s.	,,
18 ,,	,,	,,	27s.	,,

But the pipes for the excreta need not be so stout as for water, and will of course be cheaper than this scale. This will serve as a guide.

The arrangements for the size and power of the pumping-machinery will also depend upon the extent and position of the works, and upon the amount of liquids to be conveyed; these, of course, I cannot determine here. By a reference to the figures at page 19 it will be seen that the produce from 100 houses amounts to about 245½ gallons; and if we assume the present number of houses in London to be 350,000, this will yield a total of about 857,675 gallons, or say, in round numbers, 1,000,000 gallons of excreta per day, to be withdrawn by the pumps. It will be seen by a reference to the daily quantities of water pumped and supplied to the metropolis that this quantity is very trifling indeed; and we may judge—from a statement in the Report of the General Board of Health on the water supply of the metropolis—that the cost of pumping the above quantity of excreta per day will be very trifling indeed. The Report states, "The daily cost of raising 44,000,000 gallons of water daily by engine power 100 *feet* high would be about 25*l.* per day, or about 9000*l.* per annum."

The reservoirs at the works for the receipt of the excreta must now be considered. These vessels may be excavations in the ground, lined with brickwork in cement, and plastered over with hot Jamaica bitumen to render the whole perfectly water-tight and *acid-proof*. The sides and ends should be made as perpendicular as practicable, to avoid the precipitating matter collecting on the sides as it falls, and the bottom should have a considerable inclination towards one extremity, or better towards the centre, where a shallow pit is to be made from which to pump the slimy and more solid matters which deposit from the liquor by subsidence. These reservoirs should be sufficient in size for collecting the utmost produce of 24 hours, which, as we have just seen, is, for the whole of London, about 1,000,000 gallons, equal to 160,000 cubic feet. A vessel to hold this quantity would require to be 200 feet long by 40 feet wide, and 20 feet deep; and three such vessels would be sufficient for the purpose, using them alternately, and allowing abundance of time for fully cleaning out each after use, and for making any necessary repairs or adjustments. Each reservoir should be covered over with a light building, to prevent access of rain, and to confine the urinous odour of the liquids. A space of, say 100 feet to 120 feet, should separate each reservoir, which is also to be covered in from the weather by similar roofing arrangements. On this ground the evaporating apparatus, to be immediately described, is to be placed, and complete arrangements made for supplying the necessary fuel and removing the products, by trucks on lines of rails laid wherever requisite. It will be, of course, of great importance for the economy of conveyance of products, and for the fuel, that the works be placed as near the river-bank as possible. Plaistow marshes, in the vicinity of the Victoria Dock, would be admirably suited for these facilities, and from the low-lying position of the ground. On the south side of the river, the ground at Greenwich marsh is equally well adapted. There are also other positions lower down the river on both sides equally well adapted for the purpose, and the addition of a few miles' distance will add but very triflingly to the expense of the whole undertaking.

Fourth. The treatment of the liquors with sulphuric acid, and the preparation for evaporation.

We have now to examine the nature and the quantity of the liquid matter to be dealt with, and the most economical means of fixing and obtaining the valuable constituents contained. If the whole excreta of the whole population is collected, and by means of the quantity of water I have described, the liquid matter in the reservoirs will consist of about the following proportions:—

Urine about	36 ounces,	or in 1 gallon	113	ounces.
Water ,,	12 ,,	,,	38	,,
Fæces ,,	3 ,,	,,	9	,,

Of these, the first and chief constituent is urine, both in quantity and in value. We find, by a comparison of the results of the analyses of the most eminent chemists, that urine is very variable in its composition, its quantity, and its features. Thus, according to the following chemists, 1000 grains of urine yield of dry solid matter:—

			Urea, per cent.	Uric Acid, per cent.
Berzelius ..	67 grains	containing in the dry matter	44·91	1·50
Thomson ..	52½ ,,		45·03	0·46
Becquérel ..	30 ,,		45·90	1·66
		Average	44·98	

According to Becquérel the composition of urine is, in 1000 parts:—

Water	970·0	
Urea	13·5	= 45 per cent. in the dry matter.
Uric Acid	0·5	
Fixed salts	7·5	
Organic salts	8·5	
	1000·0	

The *dry matter* of urine appears, according to the analyses of these and of other chemists, to contain of

Urea about	45	per cent.
Uric acid "	1	"
Fixed salts	25	"
Organic salts	29	"
	100	

Of these matters the urea is by far the most valuable in an agricultural point of view, and demands from us a close examination. It is this constituent of urine which yields the ammonia by standing. The urea, by the fermentative process, is after a few days, on standing, *entirely* changed into carbonate of ammonia; the same result is obtained more speedily by the action of an acid, and by heat, so that by adding to the fresh urine sulphuric acid the urea is entirely decomposed into carbonate of ammonia, the ammonia becomes sulphate of ammonia, and the carbonic acid escapes. On boiling down—on evaporation—the sulphate of ammonia with the fixed salts, and organic matters more or less changed, which the urine originally contained, may all be obtained in the crystalline form. The resulting saline mass is chiefly sulphate of ammonia, but is accompanied with the phosphates, sulphates, and muriates of potassa, soda, and lime, originally contained in the urine. It is a most valuable manure, as it contains not only a high percentage of ammonia, a rare stimulant to the growth of plants, but also every other constituent required in the food of plants. The analysis of this product I will give further on. In the mean time we have to inquire into the amount of sulphuric acid required to effect this change, and fix the ammonia that it may not escape during the evaporation of the liquid.

According to Lecanu, who has experimented upon the urine of 120 persons of all ages and both sexes, the average amount of urea contained in the urine per 24 hours is 226·21 grains: now, if this quantity is divided by 15·859, the number of grains contained in 36¼ ounces—the average amount of urine per individual of the population per day—we obtain 14·26 grains of urea as the average content per 1000 grains, a result which approaches very nearly to that of Becquérel already stated, and which agrees very accurately with results I have obtained on the large scale by the evaporation of many thousand gallons of urine, and the production of many tons of the urine salts. Each gallon of urine, therefore, will contain 998·2 grains of urea; but inasmuch as one gallon of the liquid matter collected in the reservoir only contains say 113 ounces of urine, it follows that it only contains nearly 705 grains of urea.

Now, 60 grains of urea require, for conversion into sulphate of ammonia, 122½ grains of brown oil of vitriol, containing 80 per cent. of real oil of vitriol, and such as the manure-makers employ, and this will produce 150 grains of sulphate of ammonia.

Each gallon, therefore, of the dilute urine in the reservoir will require 1439 grains, equal to 3¼ ounces and 17 grains, of 80 per cent. oil of vitriol, to prepare it for evaporation. We have now ascertained the contents in urea of the reservoir liquid, and prepared it by a sufficient dose of acid for evaporation. The acid may be added to the liquors continuously as they are being pumped into the reservoir, so that when the charge for the day is received it only remains to add so much powdered chalk, or powdered bone ash, or carbonated alkali, as will neutralize any free acid in excess. It is better still to add rather *less acid* than is just sufficient, and so avoid the necessity of neutralising any free acid, and lessen the liability to corrosion of the evaporating vessels. Finely powdered wood, or peat charcoal, is added to remove a part of the urinous smell from the liquid, and assist the subsidence of the more solid matters. The reservoir is then allowed to stand a few hours, until the suspended matters have deposited, or until the liquor becomes clear enough for evaporation.

Fifth. The evaporation and concentration of the liquid, and the obtaining the sulphate of ammonia and the other salts.

When the liquor has become clear from the deposition of the suspended matters it is ready for final operation, and is now to be pumped into the boilers for evaporation. The boiler I would propose to employ may be, say 40 ft. long by 8 ft. in diameter, cylindrical, and having a 5 ft. tube traversing its entire length; or better still, with two large tubes the whole length and each having a fireplace. It is furnished with a fire or coal-burning surface of 7 ft. long by 5 ft. wide; built in brickwork and surrounded with a flue, in the usual manner, to carry off the products of combustion and obtain the greatest advantage from the heat. Each boiler is provided with a blow-off pipe, having a stopcock or valve through which the liquor is frequently drawn for the supply of the evaporating vessels which are placed alongside, and is also furnished with a capacious steam chest and pipe to carry off the steam, and for distribution amongst the evaporating vessels. Each boiler has contiguous to it a set of eight evaporating tanks or pans, arranged in pairs of two, traversed with lengths of cast-iron condensing pipes, and so connected that the steam from the boiler in passing through is thoroughly exhausted of its heat. The steam is directed into each set of pans by means of valves which adjust the exact amount of steam required, and the condensed steam only is allowed to escape by the exit valves at the extreme ends of the condensing coils. These tanks or pans to have a number of coils of 6-inch cast-iron pipes placed in series lengthways about midway down, so as to allow the condensed water to flow off continuously towards the exit end. The tanks being filled with liquor from the boiler or from the reservoir, the steam is admitted from the boiler into the coils of piping, and the evaporation proceeds. As the evaporation goes on fresh liquor is pumped into the boiler, and hot liquor drawn from the boiler into the evaporators. In this way the liquor in the boiler can never become so increased in strength, or specific gravity, as to endanger its safety by deposition or incrustation. The concentration taking place entirely in the evaporation tanks not only avoids danger to the boiler, but the condensed water from the coils will remove a considerable proportion of the disagreeable urinous odour which the liquid possesses, and the saline products are readily obtained and removed, when sufficiently accumulated, without in any way stopping the work. With similar apparatus I have evaporated *many thousands of tons* of very dirty and impure liquors during the last few years at Millwall.*

We have now to ascertain how much evaporation can be obtained from each boiler and set of evaporating pans, so as to find how many such arrangements will be required for the evaporation of the whole excretage—if I may use the term—of London collected in our reservoirs. The fire-grate surface of each boiler is 7 feet by 5 feet, or 35 square feet. If the draught of the boiler is good we may with ease consume from 15 lbs. to 25 lbs. of coal per square foot per hour; but we will take 15 lbs., the lowest quantity.† This will amount to 525 lbs. per hour, or for the 24 hours—one day—to 12,600 lbs. of coal.

* The following is my estimate of the cost of *one set* of the boiler and evaporating pans placed ready for working :—

1 Boiler (weight 11½ tons) complete	£280
Building and materials for ditto	40
8 Pans, with steam piping, valves, &c., complete, each about £160	1280
	1600

† Messrs. Richardson and Armstrong, in their recent trials on the Newcastle coals, burned in one experiment at the rate of 37·4 lbs. of coal per square foot of grate per hour; the least quantity used in any of the experiments is

In the 'Three Reports on the Use of the Steam Coal,' &c., already alluded to, it is stated, as the result of numerous trials, that a practical calorific value of 12·91 was obtained by the use of these coals in a *multitubular* or marine boiler; and that if the whole of the heat produced had been economised a value of 14·71 would have been obtained; that is to say, 1 ton of coals will evaporate 14·71 tons of water, if the *whole* of the heat is absorbed; but this is very difficult to obtain in practice. Dr. Ure, who has made many experiments on this subject, has stated in his 'Dict. of Arts and Manufactures,' p. 824, that nine varieties of the Newcastle coal were capable of evaporating from 15·1 to 16·6 times their own weight of water. I have obtained in daily practice, during the past six years, with large single and double tubed boilers from 26 feet to 28 feet long and 6 feet in diameter, and in which the fuel was consumed at the rate of about 18 lbs. per square foot per hour, a result varying from 12 lbs. to 13 lbs. of water from 1 lb. of coal. I think, therefore, if we assume that from the large boiler I propose to employ we can evaporate 10 tons of water with 1 ton of coal, we shall be quite below the quantity I have shown can be obtained. Now according to this assumption we should obtain the evaporation of 126,000 lbs. of water for each 24 hours, from *each boiler alone*. To this, however, we have to add the amount of evaporation we obtain in the evaporating-tanks from the steam of the boiler passing through the coils; theoretically, if no heat were lost in the intervening steam-pipes and from the boiler, &c., by radiation, we should obtain an equal amount of evaporation from the condensation of the steam in the coil of pipes, but in practice three-fourths of the heat may readily be economised. Let us, however, assume—and we shall in doing so be very considerably within the mark—that only *one-half* is obtainable, then we have an addition of 63,000 lbs. to make to the first quantity, or equal to 189,000 lbs. in all. Each boiler and set of tanks, therefore, will consume per day of 24 hours coals amounting to 5 tons 12½ cwt., and will evaporate 84 tons 7½ cwt. of water or liquor. We can now readily find how many *sets of boilers and tanks* will be required.

The total liquid matter to be evaporated amounts for the whole of London to 814,218 gallons (resulting from the amounts of urine and water together for a population of 2,700,000), equal to nearly 3635 tons; but to this is to be added the total weight of sulphuric acid employed for the neutralization of the liquor (to be added at the rate of 1439 grains of brown oil of vitriol per gallon), equal to nearly 75 tons, making the total liquid matter as nearly as possible 3710 tons, which will require very nearly

14·25 lbs. See Three Reports on the Use of the Steam-coal of the Hartley District, pp. 20 and 21.

44 *boilers and sets of evaporating tanks* just described. To this should be added say 6 extra boilers, &c., to enable repairs and cleaning out to be regularly undertaken in rotation.

I further add, for completeness of information, the quantities and cost of the fuel and sulphuric acid required per day. The fuel for 44 boilers will amount to about 227½ tons, and if to this we add the fuel required for steam-engine, boiler, and other purposes, say 22½ tons, the total fuel and coal will be, say—

250 tons at 15*s*. .. .. .. £187. 10*s*. per day.

This amount may be reduced 75*l*. by the use of small coal or screenings, instead of ordinary ship coal. The price per ton named is upon the supposition of *buying* them from the London coal-merchants by the barge-load, and so delivered. If the ship were brought alongside the works, and discharged direct upon the wharf, the price per ton would be lower than that named. At 9*s*. per ton for screenings, the charge for coal would be only 112*l*. 10*s*.

The quantity of sulphuric acid required will, of course, vary according to the richness of the liquid in urea, but the above may be taken as the average quantity required; this will cost, for—

75 tons at 5 .. .. £375 per day.

The only other materials required will be the powdered bone-ash, powdered charcoal, and carbonated alkali, which will not exceed 20*l*. per day; or for the whole of the raw or extraneous materials the sum of 582*l*. 10*s*.

It only remains under this head of the subject to describe the treatment by which the fæces or solid portion of the excretage is to be obtained. This matter, as it deposits in the reservoirs, after a few hours' subsidence, is drawn up by pumps, through small (say 3-inch) cast-iron pipes, communicating with the shallow well in the lowest part of the bottom, and is forced into patent-filter presses, same as are, or were, so successfully employed by the Leicester Solid Sewage Manure Company. Of these, Mr. W. Fothergill Cooke, in his paper 'On the Utilization of the Sewage of Towns,' &c., read at the Society of Arts, 10th December, 1856, says:—

"For the interior of towns, where it is desirable that the operation should be closed in, a new patent filter, manufacturing about two tons of solid matter at one operation, is preferable to the centrifugal machines. The filter-system admits of *no communication whatever with the atmosphere* at any stage of the operation until the deposit is withdrawn from it in the form of flat, firm slabs, forty inches square and three inches thick, to be dropped from the press into a barge for daily removal. A full-sized filter would manufacture *about eight tons daily*, and *three men and a boy* could manage twenty to twenty-four filters."

Such filtering apparatus is the best adapted for our purpose, because there need be no communication with the air until the operation is completed, and the material withdrawn; and because, only the solid matter contained is retained by the cloth, and the result is an almost dry and inodorous, compact, and portable mass. According to the above evidence—and that was the then daily experience at Leicester—eight full-sized filters would be amply sufficient for the excretage of London. Two additional may be kept ready in case of accident by bursting or otherwise. I have seen numerous such filters in operation applied to other purposes, and can speak of their perfect efficiency and practicability. Not the least merit is the very small amount of labour they require in attending them. I have not been able to ascertain the cost of such filter arrangements, nor who is the *present* possessor of the right.

Sixth. Under this head we have now to ascertain the amount, probable composition, and value of the products to be thus obtained.

1st. The sulphate of ammonia, and saline matters from the urine. By a reference to page 24, it will be seen that 1 gallon of the dilute urine liquor requires for exact decomposition of the *average* amount of urea contained, 1439 grains of brown oil of vitriol. When evaporated this will yield about 2624 grains of saline matter, consisting—

Of about 1762½ grains of sulphate of ammonia,
And ,, 861½ ,, of other salts and organic matter;

or, as nearly as possible, 6 ounces of solid dry matter from each gallon of liquor. It will also be seen, by reference to page 26, that I have estimated the total amount of liquor (that is urine and water) to be evaporated at 814,218 gallons, which, at a yield of 6 ounces per gallon, will produce about 305,332 lbs., equal to 136¼ tons. This corresponds as nearly as possible with those I obtained on the large scale—operating on undiluted urine by itself, at Messrs. Turnbull's chemical works at Glasgow, in the years 1845 and 1846—on some hundreds of tons of urine, which required an average quantity of 4 ounces of brown oil of vitriol per gallon, and yielded about 8 ounces of sulphate of ammonia and other salts. The composition of the saline matter will of course vary with the composition of the urine, &c., employed, but I append an analysis I made upon the dry saline matter obtained by the direct evaporation of urine and sulphuric acid:—

Sulphate of ammonia	59·30	per cent.
Organic matter	23·70	,,
Phosphoric acid	2·52	,,
Sulphuric acid	0·53	,,
Potassa, magnesia, lime, and iron ..	1·60	,,
Chlorides, sodium and potassium ..	12·10	,,
Siliceous matter	0·25	,,
	100·00	
Containing nitrogen	11·07	per cent.
Equal to ammonia	13·44	,,

Another analysis of another sample furnished 62·25 of sulphate of ammonia.

From other examples taken from parcels of several tons I have obtained varying percentages of sulphate of ammonia, from the amount stated up to 64 per cent.; the calculated amount from ordinary urine, and where the sulphuric acid is not added in any excess, is equal to a content of 67·15 per cent. of sulphate of ammonia. I have by preference selected an analysis which shows rather a low percentage, to avoid being accused of over-estimating the value of the article.

In 1842 and following years these urine salts were sold at 20*l.* per ton, whilst sulphate of ammonia from gas liquor was sold at about 10*l.* Since then the latter salt has fluctuated in price very much, and reached last year the very high price of 22*l.* and 23*l.* Its present value, however, is from 15*l.* to 16*l.* The urine salts do not contain so much ammonia as the gas liquor sulphate, but they contain valuable fertilising ingredients, as phosphoric acid, magnesia, potassa, besides uric acid and other organic matters, which are not present in the gas liquor salt, and render it a manure of greater agricultural value than the ordinary sulphate of ammonia. If compared with guano it is found to be equally rich in ammonia with very fine Peruvian, and to far exceed the Ichaboe and Chilian in that important ingredient:—

Peruvian guano contains from	12 to 16·5	per cent. ammonia.
Ichaboe	6 to 7·3	,,
Chilian	5·47	,,

As a manure, therefore, it must rank equal to fine Peruvian guano, and its price and value be determined by the market value of that importation, and by that of ordinary sulphate of ammonia. It is proper to remark here, however, that the ammonia in the urine salts is already *formed,* and *exists* in that condition without liability to loss by exposure to air, whilst only a small proportion, from 5 to 10 per cent., of the analytically stated quantity in all guanos is actually present, the remainder being in the form of azotised matter capable, under proper conditions, of yielding ammonia.

Estimating these urine salts as of the same present agricultural value as gas liquor sulphate of ammonia, we obtain the following result:—

136¼ tons at £15	£2,043 15*s.*	per day.
And equal to	£745,969 0*s.*	per annum.

2nd. The solid matter obtained by filtering, &c.—The solid excrement per individual amounts, as already shown, to a daily average of 2¾ ounces, which, for a population of 2,700,000, is equal to 464,062 lbs., or about 207 tons. As obtained from the filters, and only slightly dried, to render it portable in bulk or in bags, it would yield only about one-third of that weight, or equal to about 70 tons. The agricultural value of which, calculated by the usual method of valuation assumed by agricultural chemists, would be about as follows:—

70 tons at £4	£208	per day.
And equal to	£102,200	per annum.

Or for both manures a revenue of

£2,323 15*s.* per day.
£848,169 0*s.* per annum.

The practical agricultural value of both of these manures is well known, and requires little to be said on either head. For the results of a great many trials made in 1842 by some of the leading Scotch agriculturists of the day, to ascertain the comparative merits of all the then fabricated artificial manures, I would refer the reader to Professor Johnstone's 'Results of Experiments in Practical Agriculture made in 1842,' and appended to his well-known 'Lectures on Agriculture, Chemistry, and Geology.' The sulphate of ammonia used in all those experiments was the urine salts in question. In one instance, page 60 of the above, Professor Johnstone says, "These remarks lead me to notice the effect ascribed in Mr. Fleming's second table (page 56) to sulphate of ammonia, one hundredweight of which nearly doubled the crop (of turnips); thus:—

	Tons.	Cwt.
The unmanured soil gave	12	17
With 1 cwt. of sulphate of ammonia	24	11

This is exactly equal to the effect produced by 15 cwt. of rape-dust at a cost of 6*l.* 10*s.* But the sulphate of ammonia here employed was that prepared from urine by the Messrs. Turnbull in Glasgow, and is not merely sulphate of ammonia, but a variable and undetermined mixture." The analysis I have given will show what it is. Every farmer has tried, and knows the value of night-soil as a manure; it only remains for me to append Professor Way's analysis of *Dried* excrements or night-soil.

Organic matter	88·52	per cent.
Insoluble siliceous matter	1·48	,,
Oxide of iron	0·54	,,
Lime	1·72	,,
Magnesia	1·55	,,
Phosphoric acid	4·27	,,
Sulphuric ,, ...	0·24	,,
Potassa	1·19	,,
Soda	0·31	,,
Chloride of sodium	0·18	,,
	100·00	
Nitrogen	5·00	,,
Equal to ammonia	6·07	,,

Lastly. The cost of the plant and working expenses. Of this I can only at present offer an *approximate* estimate; it will be impossible to do more until the position of the works is chosen, and the nature of the ground and arrangements of pipes, reservoirs, &c., is fully settled. I believe the following, under ordinary circumstances of position and distance, will give a very fair idea:—

PLANT.

Pipes, cisterns, valves, &c., from town to works ..	£1,500,000
Engines, machinery, boilers, evaporating vessels, kilns for drying, filters, reservoirs, and buildings, to cover the whole. Rails and trucks for conveyance of raw materials and products.	250,000
	£1,750,000

PRODUCE.

Annual value of products as per estimates of quantity and values	£848,169

WORKING EXPENSES.

Wages of labour and superintendence per annum	£ 24,276
Cost of coals, oil of vitriol, &c.	212,612
	£236,888

CHARGES.

4 per cent. interest on ..	£1,750,000 ..	..	£70,000	
10 ,, tear and wear on	250,000 ..	..	25,000	
5 ,, ,,	1,500,000 ..	..	75,000	
			£170,000	£406,888
Profit per annum ..		.. ..		£441,281

It is unnecessary, at this moment, to trouble the reader with the *details* of the cost of plant, or of labour, which I have gone into. I merely offer the results, that they may draw some attention to the subject, and induce further inquiry and examination into the whole of the plan and details.

This is now the place to examine and inquire what effect the use of a larger quantity of water in the water-closets would have upon the above results? If we suppose that instead of 12 ounces of water it were thought desirable to employ double this bulk, that is 24 ounces or $1\frac{1}{4}$ imperial quart, this would increase the total quantity to be evaporated to 1,025,000 lbs., equal to $457\frac{1}{2}$ tons, a quantity which would require an addition of equal to $5\frac{1}{2}$ boilers and sets of evaporators. The result would thus be:—

For extra boilers and evaporators, addition to capital ..		£10,000
For cost of fuel for same	£1200	
For cost of labour	550	
14 per cent. tear and wear and interest on £10,000	1400	
	£3150	

For each addition of 12 oz. to the water used there would be thus an addition of about 10,000*l.* to the plant, and a reduction of about 3150*l.* on the profit. The addition of water up to the enormous and unnecessary amount of one gallon of water per individual would have the effect only of reducing the annual revenue, clear of charge, by about 35,000*l.* The very small influence, therefore, comparatively, which a very large quantity of water has upon the pecuniary results, induces me to hint that we may have simply to apply the regulator-valve, described, to the whole of the present water-closet arrangements of London, limit the amount of water to, say, one-fourth or one-third of a gallon per each discharge, and lay down the pipe and other cistern arrangements proposed in connection therewith. In this way the citizens would individually be saved an enormous outlay, and the whole plan could be put very speedily in execution—within the next twelve months, as every part could be done simultaneously—and in process of realisation of revenue. The revenue would be such as to render it unnecessary to put the citizens to any expense whatever in making the new arrangements and alterations, and induce the hope that it would be sufficient to remove or alleviate many of the heavy burdens with which they are now taxed, besides presenting a large fund annually for carrying out the Metropolitan Improvements so much wanted at this moment.

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