APPENDIX TO THE THIRD REPORT OF THE COMMISSION APPOINTED TO INQUIRE INTO THE BEST MODE OF DISTRIBUTING THE SEWAGE OF TOWNS AND APPLYING IT TO BENEFICIAL AND PROFITABLE USES.

ON THE CONTAMINATION

OF THE

WATER OF LEITH

BY THE

SEWAGE OF EDINBURGH AND LEITH,

BY

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I. *Introduction.*

The drainage of the city of Edinburgh is at present carried away by three main channels, and the boundaries of these are determined by the uneven nature of the ground on which Edinburgh stands, which necessitates that there shall be three distinct watersheds. The entire population of Edinburgh is about 168,121 persons, who inhabit 34,828 separate occupations, and the rental of the city in 1863–4 was 933,536*l.* sterling. The three drainage districts convey the sewage to separate waters or burns, and whilst a large proportion of the sewage is carried to the Water of Leith, much is taken away to the sea by the Craigentinny Burn and the Powburn or Jordanburn. The larger proportion of the drainage passes into the Water of Leith, and is thence carried down to Bonnington and Leith, receiving accessions of sewage as it passes on, and when it arrives at the harbour of Leith, the water is still further contaminated by the discharges from the sewers of Leith.

The Water of Leith drainage system, within the parliamentary boundary of the city of Edinburgh, comprehends an area of 2,196 acres, on which there are 13,243 separate occupations, and the rental of which in 1863–4 was 456,108*l.*, whilst the population numbers about 69,000. Of the 13,243 dwellings there are 4,460 houses and shops which have no water-closets, but active measures are being taken by the municipal authorities to enforce the introduction of water-closets into those houses which are still devoid of such conveniences; and when these are carried out, the amount of sewage will probably be increased about one fourth. The majority of the houses which drain into the Water of Leith have cesspools in their immediate neighbourhood, and these tend to arrest much of the more solid parts of the sewage, but these cesspools are gradually being abolished, although it will take some time to remove the whole, as about 12,000 out of the 13,243 houses in this district are still connected with cesspools into which all the sewage from the houses passes and thereafter the liquid, with more or less solid matter, flows off into the drain and sewer. When these cesspools, which are a relic of a bygone system, are entirely done away with, the quantity of solid matter conveyed in the sewage of Edinburgh will necessarily increase. The population of Leith is about 35,000, of whom 22,000 reside south of the harbour, in that part of Leith known as South Leith, whilst the remainder occupy houses to the north of the harbour, in the district of North Leith.

During last session parliamentary powers were acquired for the construction of a main drainage pipe which would intercept the sewage of the large district of Edinburgh and Leith, which is now allowed to pass into the Water of Leith, and convey that sewage direct to the sea. The designs for this scheme of main drainage were made by Messrs.

Stevenson, M'Pherson, and Paterson, and the engineering details given in this paper are taken from the reports and evidence of Messrs. D. and T. Stevenson, under whom the works are being carried out. The drainage of North Leith is not proposed to be connected with the main drainage pipe, but is to be carried out independently by the Corporation of Leith, and the liquid is to be discharged into the sea by a special conduit. The drainage of South Leith, however, is to be intercepted by the main drainage pipe, and, along with the sewage of the Edinburgh district the whole is to be carried out to sea and discharged at the Black Rocks.

The cost of the main drainage works will be defrayed by an assessment for one year not exceeding 2*s.* 6*d.* per pound on the rental of those houses and premises which are within the drainage district and the parliamentary boundaries, and which contribute to the sewage ; and as the rental of the Water of Leith district in Edinburgh is 456,108*l.*, and of South Leith 80,600*l.*, the total rental to be taxed is 536,708*l.* An assessment of 2*s.* 6*d.* in the pound on this sum will yield 67,088*l.* 10*s.*, and deducting five per cent. for the cost of collection, there is left a net sum of 63,734*l.* 1*s.* 6*d.*, to which there has to be added a sum of 4,000*l.* which the Leith Docks Commission have agreed to give in support of the scheme, making in all the sum of nearly 68,000*l.* as the available funds for carrying out this important sanitary measure.

The Water of Leith, which is at present contaminated with the sewage matter to be diverted into the main drainage pipe, is comparatively a small stream, and whilst during the winter months and after rain there is a current of water passing down its bed, yet in summer and dry weather the whole of the natural water of the stream is diverted into mill-lades which traverse the whole course of Edinburgh, and there is little or no natural water in the bed of the river as it passes Edinburgh. Into this small stream of water there is discharged the sewage of 70,000 of the inhabitants of Edinburgh, and upwards of 30,000 of the people of Leith, and the result has been that the bed of the Water of Leith has become a foul polluted stream, conveying fæcal matter of the most disgusting and abominable character, and evolving fœtid emanations into the surrounding atmosphere. In many parts of its course through Edinburgh the bed of the Water of Leith is rocky and uneven, and in the pools thus formed much of the solid matter conveyed by the sewage stagnates, and, passing into a state of putrescence, evolves abundantly offensive gases. Larger accumulations of fæcal matter are arrested by the mill-dams, and, indeed, the numberless pools in the bed of the Water of Leith, and the various dams, form numerous cesspools open to the air, which are practically hot-beds of decomposing filth.

The Water of Leith, before it reaches Edinburgh, is essentially a mountain stream, the waters of which are originally of a mossy or peaty nature, and the faint brown tinge of colour which it exhibits at its sources, is much deepened as it passes several paper mills and other public works which discharge liquid matters into the stream. The run of water is always kept up from large compensating reservoirs, which retain much water during the wet seasons, and discharge it at a regular rate during the periods of drought. These compensating reservoirs owe their construction to the withdrawal of the spring water which previously flowed into the Water of Leith and which has been diverted into Edinburgh by the Water Company for the supply of the city, as well as of the towns of Leith and Portobello. The mill-

owners on the Water of Leith compelled the water company to provide storage-room sufficient to hold eight months' supply of the spring water abstracted, but in reality the compensation reservoirs hold more than the quantity rendered imperative by the various Acts. In 1849 the amount of spring water abstracted by the water company was from 150 to 200 cubic feet per minute, and in 1859 other 200 cubic feet per minute were taken, making altogether about 400 cubic feet per minute of spring water abstracted from the Water of Leith in its upper parts, and which, being transmitted through pipes to Edinburgh for service there, is returned back again, in good part, to the Water of Leith by the drains and sewers.

The compensation reservoirs constructed in lieu of the spring water, and which send down a regulated supply of water into the bed of the Water of Leith, are of large size. There are two reservoirs about eight miles distant from Edinburgh, at the base of the Pentland Hills, viz., those of Harelaw and Thricpmuir, which cost about 36,000*l.*, and a third reservoir, about 13 miles from Edinburgh, also at the base of the Pentland Hills which is called Harperrig reservoir, which cost about 25,000*l.* The latter reservoir is bound to store 85,000,000 cubic feet of water above the level of six feet from the top of the offlet-pipe, but it actually stores 90,000,000 cubic feet above that level. The total capacity of these compensation reservoirs is sufficient to store 150,000,000 cubic feet of water, and in dry weather they discharge into the Water of Leith, according to the state of the weather and the demands of the mills, from 1,000,000 to 1,500,000 cubic feet of water per day, which is at the rate of 700 to 1,050 cubic feet per minute. As only about 50 cubic feet per minute are allowed to escape from Saturday evening till Monday morning, there is a saving of the water to the extent of about one sixth of the available power.

The water supply of Edinburgh is necessarily connected directly with the sewage of the city. In 1681 certain springs were brought in by the town council from the lands of Comiston, and in 1762 a 4½-inch wooden pipe was employed for the conveyance of water from certain springs rising in the estate of Swanston on the northern side of the Pentlands. The supply of water from these sources, however, was very uncertain in quantity, and varied from 12 cubic feet to 60 cubic feet per minute. In 1822 a further supply of water was obtained from Glencorse, and the Crawley spring on the southern slope of the Pentland Hills, and the increase was sufficient to give an average flow of water of about 250 cubic feet per minute. In 1848, by the abstraction of a number of springs on the northern slope of the Pentlands, and which originally flowed into the Water of Leith, the average supply of town water was increased to 460 cubic feet per minute ; and in 1859 further springs on the northern side of the Pentland Hills were acquired, and the supply was increased to upwards of 700 cubic feet per minute. During the course of the last 20 years, therefore, schemes have been carried out whereby about 400 cubic feet of spring water per minute have been abstracted from the streamlets which feed the water of Leith, making altogether the large amount of 210,000,000 cubic feet per annum, and in lieu thereof compensating reservoirs have been constructed which can store 150,000,000 cubic feet, or more than eight months' supply of the springs. Besides the regular delivery from these reservoirs of sufficient water for the motive power of the mills, there is an additional supply of clear spring water conveyed in special pipes to the paper mills, glue works, and washing establishments to the extent of a constant run of 42 cubic feet per minute, and this extra amount of water, when used in the operations of paper making, &c.,

is also discharged into the Water of Leith. Considering the great expense connected with bringing in the spring water, and the cost of the compensation reservoirs, &c., which, altogether, entailed an expenditure on the part of the Water Company of 500,000*l*., it is calculated that the 750 cubic feet of water per minute at present delivered each day in Edinburgh, Leith, and Portobello has cost the Water Company at the rate of 666*l*. for each cubic foot of spring water rendered available for town use during each minute.

The special investigations relating to the contamination of the Water of Leith by the sewage of Edinburgh were commenced on the 14th March 1864, and were continued almost daily for five weeks, and they were resumed on the 20th May, and were carried on for other 10 days. The principal sewers and drains were examined in all conditions of weather, and at all hours of the day and night, and similar observations were made on the Water of Leith, above Edinburgh, during its transit through the city, and onwards till it passed out of the harbour of Leith to seawards.

The examination not only included the liquids with mechanically suspended organic matters, as collected from the sewers and the Water of Leith, but likewise took cognizance of the sedimentary matters which lodged in the drains and the bed of the streams down to and including the harbour of Leith ; as also the gases evolved from these decomposing sedimentary matters ; the gases dissolved in the various liquids ; and the state of the atmosphere immediately above the districts where the drains and the Water of Leith were conveying sewage. The numerous chemical analyses proved the foul condition of the matters carried by the sewers into the Water of Leith ; and the offensive state of the stream itself, and indeed the senses of sight and smell were sufficient to show that the sewage had converted the Water of Leith into a great public nuisance, which it was desirable to get rid of. Many of the inhabitants of the district immediately bordering on the stream complained bitterly of the offensive odours which rose from the water, and which gave rise to nausea and sickness, and compelled them to keep their doors and windows shut. Moreover, Professor Simpson showed from the statistics of the mortality in the streets bordering on the river, as compared with those away from its banks, that there was a greater death-rate in the immediate neighbourhood of the Water of Leith than at a short distance therefrom. Thus, taking a similar class of houses in the Edinburgh district, and judging by the mortality amongst children under five years of age, Professor Simpson found that in the streets away from the influence of the foul water the mortality was in the proportion of 100, whilst in the streets near the Water of Leith the mortality was as high as 160. In the Leith district also the death-rate was greater, as in the streets at some distance from the harbour the mortality was in the proportion of 100, with a death-rate among children under five years of age of 1 in 12 ; whilst in the same class of streets near the river and harbour the mortality was at the rate of 141, and the death-rate among children one in seven. These statistics are positive evidence of the effects of the foul, filthy, and offensive state of the Water of Leith conveying the sewage of Edinburgh and Leith, and the results are supported by the concurrent testimony of many persons who reside in the immediate neighbourhood of the Water of Leith, and who speak as to the nausea and sickness which are brought on by the inhalation of the gases and vapours evolved from the water, and to the general ill-health connected therewith.

II. *The liquid Discharges from the Sewers of Edinburgh and Leith.*

The sewage drainage area of Edinburgh and Leith which discharges into the Water of Leith is about 611 acres, of which Edinburgh contributes 514 acres and Leith 97 acres. This area does not include the gardens and open spaces, but merely that which is built upon and contributes to the quantity of sewage. The maximum discharge of sewage from this area is 574 cubic feet per minute, and whilst there are no less than 180 large and small sewers which empty their contents into the Water of Leith,—the majority of these are small,—and there are only six main sewers which convey the fæcal matters from Edinburgh, and two principal sewers which receive and discharge the sewage of South Leith into the river and harbour of Leith. The average amount of day discharge of sewage per acre of ground built upon ranges from $\frac{8}{10}$ths to $\frac{9}{10}$ths of a cubic foot per minute, but the proportion varies much from day to day and from hour to hour. The greatest daily discharge occurs on Mondays and Tuesdays, as on those days the majority of family washings takes place, and on these occasions the full amount of 574 cubic feet per minute is attained. On Wednesdays and Thursdays the proportion of sewage is less, and on Fridays and Saturdays it is still further diminished, and indeed, on those days it does not average more than four-fifths of the discharge of Monday and Tuesday. The quantity of sewage is greatest at 11 o'clock in the forenoon, after which it diminishes till about five o'clock in the morning, it falls to about one-half, after which it increases gradually till 11 o'clock forenoon, when the maximum is again attained. The sewage water is in the most filthy state in the forenoon, and during the evening it is comparatively clear of fæcal matter.

The main sewers which convey the fæcal matter from Edinburgh into the Water of Leith are the Lochrin Burn, which discharges itself into the stream at Coltbridge, a short distance west of Edinburgh; the South or Moray Place sewer, which flows into the bed of the Water of Leith at Stockbridge ; the North sewer, which also discharges at Stockbridge ; the Canonmills sewer, which joins the Water of Leith at Canonmills ; the Broughton Burn, which empties its contents into the stream above Junction Road Bridge, Leith ; and the Bulls Stank sewer, which flows into the harbour of Leith, immediately below the Junction Road Bridge at Leith. The two latter are mainly Edinburgh sewers, but as they traverse the outskirts of Leith before they join the Water of Leith, a small portion of the sewage of Leith is conveyed by them. The principal sewers which carry the fæcal matter from South Leith are the St. Andrew's Street drain, which enters the harbour as the Coal Hill sewer, and the Bernard Street drain, which empties its contents into the harbour by the Lower Drawbridge sewer. In the chemical examination of the contents of these sewers, portions of the discharges were collected at different periods of the day and night, and during the six days of the week, so as to ensure that the condition of the sewage at all times should be fairly represented. Moreover, during the earlier observations in the spring of the year, viz., during March and April, the weather was often boisterous and wet, whilst during the summer observations viz., in May, the weather was comparatively fine and dry, so that the average of the various samples collected at the different periods will fairly represent the mean composition of the sewage discharges during the year. The influence which these sewage matters can have upon the Water of Leith will be best considered by referring to the main

sewers individually, and observing especially the nature of their discharges at different times.

The Lochrin Burn, which is one of the main sewers of Edinburgh, has its rise in the house drains south of the castle, and thereafter travels in a westerly direction, collecting the sewage of many streets of houses in the west end of the city, and the drainage of the Edinburgh Abattoir and of the Caledonian Distillery. The total drainage area which falls into this burn is about 860 acres, but the built-on area or space is only about 100 acres, and taking the mean proportion of nine-tenths of a cubic foot per minute for each acre as the average amount of house sewage, the calculated quantity of domestic drainage-water would be 90 cubic feet per minute, which is really the full amount of the observed quantity. Thus, by actual measurement, it was found that at about eleven o'clock in the morning the discharge from the Lochrin Burn was 98 cubic feet per minute, and at a quarter past nine in the same evening the discharge fell to 51 cubic feet per minute, whilst in the succeeding morning at half past five the quantity rose to 69 cubic feet per minute, and at 11 o'clock in the forenoon to 92 cubic feet per minute. The average of all the measurements gave about 60 cubic feet per minute. During the summer in dry weather there is little if anything but sewage in the Lochrin Burn. There is a small drain which joins the Burn at Dalry, and which runs at the rate of about 3 cubic feet per minute, but this is the only accession which is worthy of note. During its course through the built-on area the Lochrin Burn is a covered drain or sewer, but when it emerges into the country districts on the west side of Edinburgh it becomes an open ditch or burn, and before it reaches the Water of Leith it is partially employed in the irrigation of a number of fields. The irrigation processes are carried out at intervals during the winter months, and somewhat regularly during the summer months, and tend to lessen not only the actual quantity of liquid which flows in the burn, but also to decrease the proportions of dissolved and suspended matters contained therein.

The sewage conveyed by the Lochrin Burn was collected at three different stations, one of which was immediately after the burn received the drainage of the Edinburgh Abattoir, a second station was immediately above the entrance of the liquids discharged from the Caledonian Distillery, and the third place of collection was immediately before the burn entered the Water of Leith at Coltbridge. 18 samples of sewage were collected at the first station in Lochrin Burn, and the details of the chemical analyses are given in Table A. The average composition of the 18 samples showed, that the liquid contained in one imperial gallon in a state of solution 12·36 grains of organic matter with 26·61 grains of saline matter, and in suspension 33·06 grains of organic matter with 24·66 grains of earthy matter, in all 45·42 grains of organic matter, and 51·27 grains of saline and earthy matter, making a total of 96·69 grains of organic and saline and earthy matters dissolved and suspended in one imperial gallon. 15 samples of sewage were collected at the second station, which was before the Lochrin Burn reached the Caledonian Distillery, and the details of the examination of these are given in Table B. The average of those samples gave of dissolved and suspended organic matter 44·38 grains, and of saline and earthy matters 34·49 grains, making 78·87 grains in one imperial gallon. Immediately after passing the second station, the Lochrin Burn receives the discharges from the Caledonian Distillery, and these consist mainly of dreg obtained from the stills. The analyses of three samples of dreg are given in Table B., and

the average composition of two samples of this substance in one imperial gallon gives 611 grains of organic matter, and 118 grains of saline and earthy matters. The discharge of this dreg is very irregular, but it must tend to increase materially the proportion of matters dissolved and suspended in the sewage matter of the Lochrin Burn, and as it is of a putrescible nature, it adds to the foul condition of the water. The third station on the Lochrin Burn, or that immediately preceding the discharge of the burn into the Water of Leith, is the principal one in regard to the contamination of the stream, as the liquids are collected just before they pass into the Water of Leith. At this station 20 samples of liquid were collected on different days, and at different hours, and the details of the analyses are given in Table C. The average of the 20 samples yielded in one imperial gallon in a state of solution, $31\frac{1}{4}$ grains of organic matter and $26\frac{1}{2}$ grains of saline matter; and in a state of mechanical suspension, $29\frac{1}{4}$ grains of organic matter and 9 grains of earthy matter: making $60\frac{1}{2}$ grains of organic and $35\frac{1}{2}$ grains of saline and earthy matters, and altogether 96 grains of dissolved and suspended matters in the imperial gallon. In every instance the liquid from the Lochrin Burn was in a foul and offensive condition, and evolved a fœtid disgusting odour. This was specially observable on those occasions, when there was an appearance of blood in the water coming from the abattoir; and during the times that dreg was issuing from the Caledonian Distillery a sour nauseous odour predominated.

The Lochrin Burn is the first Edinburgh sewer which discharges itself into the Water of Leith, and though the direction of the burn is westerly in its flow, yet, when it discharges into the stream, it is carried in an easterly direction back through Edinburgh and Leith, before it passes to the sea on the east coast. After the reception of the Lochrin Burn, the Water of Leith receives the discharges of numerous small sewers and drains as it flows through the Water of Leith village, and when it reaches the district of Edinburgh, known as Stockbridge, two large main sewers discharge their contents into the stream. These sewers are the South or Moray Place sewer, which collects the house-drainage of a built-on area of about 20 acres, though the total drainage area is about 30 acres. The discharge of sewage has never been gauged above 18 cubic feet per minute. The North sewer at Stockbridge likewise receives a large amount of house sewage from a built-on area of 23 acres. 22 samples of the liquid discharges from these sewers were analysed (see Table D). The average of 10 samples from the North sewer gave in solution and suspension in one imperial gallon $21\frac{1}{2}$ grains of organic matter and 33 grains of saline and earthy matter, in all $54\frac{1}{2}$ grains; whilst the average of 12 samples from the South or Moray Place sewer gave $31\frac{3}{4}$ grains of organic matter and 35 grains of saline and earthy matter, in all $66\frac{3}{4}$ grains of dissolved and suspended matters in the imperial gallon.

From Stockbridge the Water of Leith flows down in the direction of Canonmills and receives on its way the contents of numerous small drains, and at Canonmills a large sewer discharges itself into the stream. This sewer, which is known as the Canonmills sewer, collects the sewage from a drainage area of 171 acres, of which 116 acres are built upon. The analyses of 21 samples of the liquid conveyed by this sewer are given in Table E., and the average proportions in one imperial gallon are $23\frac{3}{4}$ grains of organic matter and 35 grains of saline and earthy matter in solution and suspension, making in all $58\frac{3}{4}$ grains. After this accession of sewage matter, the Water of Leith passes down to the outskirts of Leith where the Broughton Burn sewer, which

carries much Edinburgh sewage accompanied by the drainage of an outlying district of Leith, joins the stream. The average of two samples of the Broughton Burn sewage (Table F.) gives 48 grains of organic matter and $42\frac{3}{4}$ grains of saline and earthy matter in one imperial gallon, in all $90\frac{3}{4}$ grains. Flowing still further seaward, the stream passes into the harbour of Leith, and at the upper end of which the Bulls Stank sewer, which mainly flows from Edinburgh, discharges its contents. One analysis of the contents of this sewer was made at Lovers Loan immediately after the sewer leaves Edinburgh proper, and other four samples were collected from the sewer as it discharged into the harbour of Leith. The liquid of this sewer contained an average of $16\frac{3}{4}$ grains of organic matter and $36\frac{3}{4}$ grains of saline and earthy matter, in all $53\frac{1}{2}$ grains in the imperial gallon (Table F). Thereafter the Coal Hill sewer, which is very foul, conveying fæcal matter from Leith, discharges its contents into the harbour. The mean analysis of three samples of the discharge from the Coal Hill sewer (Table F.), which is also called the St. Andrew's Street drain, showed the large proportion of 145 grains of dissolved and suspended organic matter, and 182 grains of saline and earthy matter, making in all 327 grains of matter in one imperial gallon. And amongst others, another large Leith sewer, known as the Bernard Street drain, pours its contents into the harbour at the side of the Lower Drawbridge, and the liquid discharged therefrom contains $18\frac{1}{4}$ grains of organic matter and $51\frac{1}{4}$ grains of saline and earthy matter, in all $69\frac{1}{2}$ grains in the imperial gallon.

Whilst the Coal Hill sewer and the Lower Drawbridge sewer are the principal sewers which convey the house drainage of South Leith into the harbour, there are many smaller drains which discharge their contents into the water not only on the South-east side, but also on the North-west side of the harbour.

The general appearance of the matters discharged by the Edinburgh and Leith sewers into the water of Leith was foul, fæcal, and offensive. The night discharge, or that occuring between 11 P.M. and 5 A.M., was comparatively free from gross pollution, but at all times the contents contained sufficient organic matter in solution and suspension to cause putrefaction when retained in a vessel for a short time. Even when the liquids were filtered through bibulous paper, at the moment of their collection, the filtered liquid, though comparatively clear, yet contained much organic matter in solution, possessed a fœtid odour, gave a foul taste, destroyed the colour of a large amount of permanganate of potash, and when kept for a short time passed into a state of putrefaction. The number of samples of sewage liquids collected from the drains and sewers of Edinburgh and Leith, and analysed by me amounted to 107, and these were taken during all states of the weather, and at all times of the day and night. In every instance the water was more or less contaminated with floeculent matter, principally of organic origin, and on being allowed to settle, the suspended matter fell to the bottom of the vessel.

III. *Sedimentary Matters in the Sewers of Edinburgh and Leith.*

The more solid part of the sewage conveyed by the drains, tends to deposit whenever the rapidity of the current is lessened, and whilst in the ordinary sewers there is no great accumulation of sedimentary matter, yet the Lochrin Burn, the Bulls Stank sewer, and the Broughton Burn are somewhat sluggish in their movements, and hence at many parts of their course much foul deposit is found. This was spe-

cially observable at the parts of the course of these drains where they run as open ditches. At the Lochrin Burn sewer, west of the abattoir, a large amount of sedimentary matter was found, and the average of seven samples (Table G.) gave when dried 49⅔ per cent. of organic matter, which contained a considerable amount of nitrogen, and when lying in the bottom of the sewer was in an active state of putrescence, and evolving abundantly offensive and noxious gases. A similar observation was made at Lochrin Burn sewer immediately before it arrived at the Caledonian Distillery, where the bed of the sewer was more or less covered by decomposing and putrefying matters, and the average of three samples of sediment collected at this point (Table G.) gave 27⅔ per cent. of organic matter containing nitrogenous and putrescent elements. At the Lochrin Burn sewer, immediately before it discharged into the Water of Leith above Coltbridge, much sediment was also found, and whilst it was likewise of an active putrescent nature, it was mingled with more fine earthy matter. The average of three samples (Table G.) gave 17 per cent. of organic matter containing nitrogen. Sedimentary matter was also collected in quantity from the Bulls Stank sewer at Lovers Loan immediately after leaving Edinburgh (Table G.), and contained 50¾ per cent. of organic matter of a nitrogenous nature. And similar organic sediments were found in the Broughton Burn at the Bonnington Road, and just before the burn enters the Water of Leith (Table G).

The solid matters which form these sediments in the various sewers where the run of water is slow, are in a state of active putrescent fermentation, and are not only hurtful whilst present in the sewers by giving off abundantly fœtid exhalations of noxious gases, but whenever a shower of rain falls and the amount of water and the rapidity of the flow increases, these sedimentary matters are swept onwards and are discharged with the ordinary liquid sewage into the bed of the Water of Leith. The results are that when the rain is limited in quantity, much sedimentary matter is thus thrown into the stream and lodges in the uneven bed, though when the weather is broken and much rain falls, the sedimentary matters are swept onward by the current and discharged into the sea. The quantity of such sedimentary matter which is lodged in the bed of the Water of Leith throughout its course will be presently referred to, and the nature of the gaseous emanations from those putrefying sediments will also be described in detail.

IV. *The Water of Leith.*

The offensive state of the water and harbour of Leith, due to the discharge of the sewage of 70,000 of the inhabitants of Edinburgh and 30,000 of the inhabitants of Leith, has necessarily called forth public attention on several occasions for the purpose of adopting some means for the arrestment of the evil. Accordingly, in 1854, operations were commenced for the purpose of aiding to some extent in the removal of the fulsome discharges by providing a more rapid run of water at certain parts. The original and natural bed of the Water of Leith is of a very uneven and rocky nature, and being of some width, the small amount of water which accompanies the sewage, except in floods, is only sufficient to diffuse it over the bed of the stream and convey it down in a sluggish manner, which admits of a great deal of the solid matter being deposited in the rocky pools and cavities and on the banks of the stream. The measures adopted in 1854 were restricted to a part of the Edinburgh district, and were confined to the improvement of the bed of the river for only a mile

and a quarter in length, from St. Bernard's Bridge to St. Mark's Place, with a break of about 200 yards at the ford at Malta Green. The pools in the stream were filled in and the shallow and deep places were levelled, whilst the channel was narrowed by making a run in the centre of the bed of the river, by filling in the banks with stones, and keeping the run clear by wooden planks being placed along each side. Open iron conduits were also laid at the sides of the narrowed channel so as to convey the sewage from the drains into the central run. It was also proposed that when the matters had been conveyed down to St. Mark's Place, that the foul water should be there subjected to some deodorising process. The latter part of the scheme was never attempted, but the narrowing of the channel was carried out.

Arrangements were also made for the flushing of the central run by diverting water from the mill-lades for a few hours, once a fortnight, and for the liberty of using the water in this way the sum of 30*l.* a year was arranged to be paid to the mill owners.

The scheme for the levelling of the bed of the stream and the confining of the run of water and sewage was no doubt effectual in arresting the deposition of large quantities of decomposing filth at certain parts of the stream, but it was only a partial benefit. No improvement was effected in the bed of the river above where the run was restricted, and in those upper parts, as behind Ainslie and Moray Places, the numberless pools in the rocky bed still admitted of the deposition of large quantities of putrescent sediment. Moreover, the narrowed channel was not free from sedimentary organic matter, and in most places the slightest agitation of the bottom gave rise to the evolution of numberless bubbles of gas. And again, whenever the water rose a little, overflowed the narrow channel, and then subsided, it left on the banks much organic sediment which filled up the spaces between the stones, and being alternately moistened and dried, and acted on by the sun's rays, emitted much offensive effluvia. Whilst the nuisance was not entirely abated in those parts of the stream where the channel was narrowed, the working out of the scheme led to the more ready conveyance of large quantities of offensive material to St. Mark's Place, below which there is a mill-dam or caul, and the water being there kept back, became extremely sluggish in its movements and deposited much of the suspended matters. The result was the accumulation at this part of a foul deposit of considerable depth, and in a state of active putrescent fermentation. This place was essentially an enormous cesspool, near the upper end of which there were stepping stones (now a bridge), and on numerous occasions especially in summer weather, when there was occasion to use the stepping stones, the foul fæcal condition of the Water of Leith was plainly observable, and the highly offensive exhalations which emanated therefrom in the warmer seasons of the year were such as to produce an intolerable stench.

The improvements in the condition of part of the bed of the Water of Leith which were commenced in 1854 did not therefore provide for the abstraction of sewage from the Water of Leith, or for the arrestment of the discharge of impurities thereinto, but it merely arranged for a partial alleviation of the evil in one district of Edinburgh. Whilst much of the stream above the narrowed part was left in its ordinary foul state, there was much left also below, and indeed from Edinburgh to Leith there was no abatement of the nuisance, and the harbour of Leith, as previously, continued to receive the sewage of 100,000 people. Matters were in this position when the corporations of Edinburgh and Leith instructed me, in conjunction with Professor Penny of Glasgow, to institute a full series of experimental observa-

tions on the nature of the sewage discharged into the Water of Leith, and the effect which that sewage had upon the stream itself and the harbour of Leith. The chemical nature of the sewage as discharged by the drains and sewers of Edinburgh and Leith has been already fully adverted to in this paper, and the details of the analyses made by me of these sewage matters are given in the tables. I have now to refer to the chemical composition of the Water of Leith as contaminated by the sewage; and in order that the effect of such may be correctly observed, I will first refer to the nature and condition of the Water of Leith before it reaches Edinburgh, and thereafter to its state when it receives the various accessions of sewage.

V. *The Water of Leith above Coltbridge.*

The sources of the Water of Leith are mainly derived from the upland districts on the Pentland Hills, and the waters originally are of a peaty or mossy nature. The water is collected in large compensating ponds or reservoirs; two of which are situated about eight miles west from Edinburgh, and the outlet from which is known as the Bavelaw Burn, and the remaining reservoir is about 13 miles west from Edinburgh, and its water flows into the head stream of the Water of Leith. The Bavelaw Burn joins the Water of Leith above the village of Currie, about six miles west from Edinburgh, and the two streams then flow on to Edinburgh as the Water of Leith. There is a flax ropery work and a paper mill on the Bavelaw Burn, and six paper mills, a washing establishment, and a glue work on the Water of Leith before it arrives at Coltbridge and mingles with the sewage of Edinburgh. The ropery and the paper mills discharge considerable quantities of dark-coloured alkaline solutions from the boilers in which the flax, rags, and esparto fibre have been boiled, and these discharges tend to increase the quantity of saline and organic matters dissolved in the water, as may be seen from Table H., where the analyses are given of eleven samples of water from the Water of Leith before it reaches the neighbourhood of Edinburgh, and also the analyses of 23 samples collected immediately above Coltbridge and just before the contamination of the stream with the sewage conveyed by the Lochrin Burn From the latter analyses it will be observed that the average of these 23 samples gives 5 grains of organic matter and $15\frac{1}{4}$ grains of saline matter in one imperial gallon, in all $20\frac{1}{4}$ grains. The discharges from the ropery company and the paper mills contain much alkali, soluble silica, and some organic matter dissolved therein, accompanied by the washings of the boiled rags, and the water from the washing and beating engines and paper machines. These fluids tend to communicate more or less of a yellow brown colour and slight alkalinity to the Water of Leith, but they do not leave any deposit on the stones in the bed of the stream or on the banks thereof. So far as the chemical observations were carried out, there was no appearance of a putrefactive tendency in the contents of the water as it arrived at Coltbridge as a running stream, and though the water was not to be commended for dietetic use and ought not to be employed for such, yet there were no offensive gases escaping therefrom, and therefore there was no evidence of the contamination of the neighbouring atmosphere by exhalations which might be regarded as unwholesome. There are several villages situated on or near the banks of the Water of Leith before it arrives at Coltbridge, but these villages have no regular system of house drainage, and hence the water is not materially contaminated with sewage in its upper parts, and certainly, when it

arrives at Coltbridge, it does not contain an appreciable trace of house sewage.

VI. *The Water of Leith from Coltbridge to the Harbour of Leith.*

Whenever the Water of Leith arrives at Coltbridge and the Lochrin Burn mingles its sewage therewith, then the water begins to assume an offensive appearance, acquires a fœtid odour and taste, and when kept for a short time becomes putrescent. After receiving the sewage, the proportions of organic and saline matters increase in quantity. Samples of the water at all the principal points in its course through Edinburgh and Leith and passing out into the harbour, were collected at different times and subjected to analysis (Tables I., K., L., M., and N.) This part of the stream divides itself into five distinct portions :—

I. From Coltbridge down to the dam below Water of Leith village, where much of the water is at all seasons diverted into the lade which traverses the whole length of Edinburgh, and where, in ordinary dry summer weather, the whole of the liquid flows into the lade.

II. From the dam below Water of Leith village, where the lade diverges from the main stream, down to St. Mark's Place.

II. The lade which commences at the Water of Leith village, and, after traversing Edinburgh, is again united with the Water of Leith at St. Mark's Place.

IV. The Water of Leith at St. Mark's Place after the stream and lade with their Edinburgh impurities have commingled, and,

V. From St. Mark's Place down to and including the harbour of Leith.

The first part of the district comprehended from Coltbridge down to the dam below the Water of Leith village contains the natural flow of the stream, accompanied by the sewage of Lochrin Burn and numerous smaller sewers and drains. In dry or summer weather the amount of liquid which flows down this part of the stream is about 1,600 cubic feet per minute, and there are three mill-dams or eauls which retard the motion of the water and allow of sedimentary matter being deposited. These mill-dams also cause the whole of the water in the stream in dry or summer weather to be diverted into the lades, and necessarily at these parts there is no fall of water in the bed of the stream during such periods. The liquid of the stream or lade, however, still retains much organic matter in solution and suspension. Eleven samples of liquid were collected from this district and subjected to analysis (Table I.) and the average of these samples gave, in one imperial gallon, $9\frac{3}{4}$ grains of organic matter and $16\frac{1}{4}$ grains of saline matter, in all 26 grains.

The second district begins at the dam below the Water of Leith village and terminates at St. Mark's Place, and it is peculiar in this respect, that whilst during ordinary dry summer weather there is no flow of water over the dam, there is, at other times, a small portion passing over, and it is only during flood time that a decided flow of water is seen below the dam. The comparatively dry bed of the Water of Leith, however, very soon receives accessions of water, partly by leakage from the sides of the lade which flows for some distance alongside of the stream at a higher level, and in other part from numerous small drains conveying house-sewage. Six samples of liquid were examined from the Water of Leith under the Dean Bridge, six samples from the stream behind Moray Place and near St. Bernard's Well,

and six samples from the Water of Leith above Stockbridge (Table K.), and the mean of the analyses of these samples gave about 10 grains of organic matter and $16\frac{1}{4}$ grains of saline matter in the imperial gallon, in all $26\frac{1}{4}$ grains. At Stockbridge, however, the water receives the contents of two large sewers (the South or Moray Place sewer and the North sewer), and nine samples collected about 30 yards below the point of discharge of these sewers at Stockbridge (Table K.) gave an average, in one imperial gallon, of 9 grains of organic matter and $15\frac{1}{2}$ grains of saline matter in solution, and $14\frac{1}{4}$ grains of organic matter and $2\frac{1}{2}$ grains of earthy matter in suspension, in all $23\frac{1}{4}$ grains of organic matter and 18 grains of saline and earthy matter dissolved and suspended in the Water of Leith at this point. Another station behind Warriston Crescent and below the entrance of the Canonmills sewer gave similar evidence of the contamination of the water (Table K.)

The Edinburgh lade district commences at the dam below the Water of Leith village; it is one of six lades which receive the Water of Leith between Coltbridge and the sea, and each of which has its appropriate mill-dam. These lades take in all the river-water as well as the Lochrin Burn during the ordinary dry weather in summer, and the amount of water in the lades is about 1,600 cubic feet per minute. The principal lade is the one which traverses Edinburgh and which begins at the Water of Leith village. Generally it runs as an open ditch, occasionally washing the sides of the houses, passing through below houses and under the streets, and ultimately arrives once again at the Water of Leith at St. Mark's Place. The lade and its contents were specially examined behind Ainslie and Moray Places, and behind India Place, where the wall of the houses is actually the side of the lade, and where spouts standing out from the houses discharge the contents of household sinks and closets directly into the lade. At Clarence Street, where the lade passes below the houses; at Eyre Place, where it flows in front of the houses, as well as at Beaver Hall, and immediately before the junction of the lade with the stream, and indeed at all parts of the course of the lade, the liquid was foul and fæcal, and the average of eight samples collected at two different stations (Table L.) gave $10\frac{3}{4}$ grains of organic matter and $18\frac{1}{4}$ grains of saline and earthy matters, in all 29 grains, dissolved and suspended in one imperial gallon.

The district of St. Mark's Place is interesting as the spot, where the Water of Leith conveyed in the lade once again joins the stream, and at this point the effect of the greater part of the Edinburgh sewage upon the natural water of the river is best observed. The pool of water at St. Mark's Place is of considerable length and depth, and the flow of the water is retarded by a mill-dam at a little distance below. The liquid presents a most offensive appearance, and contains much organic matter in mechanical suspension as well as in solution. Much putrifying organic matter lies at the bottom of the pool, and indeed the district is an enormous cesspool. The decomposing sediment is constantly evolving numberless bubbles of noxious gases, the disengagement of which causes a constant commotion in this comparatively stagnant pool, and tends to keep much matter in a state of mechanical suspension in the water. The fulsome condition of the Water of Leith at this district, especially in a warm summer day, is highly disgusting and abominable. 18 samples of the liquid were collected from the Water of Leith at St. Mark's Place (Table M.), and the average of these samples gave in

one imperial gallon 8 grains of organic matter and $14\frac{3}{4}$ grains of saline matter in solution, and $18\frac{1}{2}$ grains of organic matter and $15\frac{1}{4}$ grains of earthy matter in suspension: in all $26\frac{1}{2}$ grains of organic matter and 30 grains of saline and earthy matter in solution and suspension. The foul appearance of the liquid at St. Mark's Place was increased during the warmer months by floating patches of organic matter bouyed up by the gases evolved during the putrefaction of the mass, and which not only served to keep such matter floating, but also were successful in raising from the bed of the pool a constant succession of new aggregations of decomposing matters.

The fifth district extends from St. Mark's Place down to the harbour of Leith, and 13 samples of water were collected at 10 different places (Table N.). One sample was from the dam above Bonnington, which is the lower end of the pool which extends up to St. Mark's Place; one sample was taken from the Water of Leith at the boundary of Edinburgh and Leith at Bonnington Bridge; another sample from the dam above Junction Road Bridge; one sample from the Water of Leith above the saw mills at Leith; two samples from the harbour of Leith below the Junction Road Bridge; three samples from the harbour above the Coal Hill; one sample from the harbour in front of the Coal Hill sewer; one sample from the harbour at the upper drawbridge; one sample from below the upper drawbridge; and one sample from the harbour off the Victoria Dock-head. Several of these samples were very foul from the large amount of suspended organic matter, and in all cases there was sufficient putrescible matter present to cause the liquid to exhibit a fœtid, nauseous odour, and a turbid and nasty appearance.

The special conclusions which are to be drawn from the observations on the water of the Water of Leith from Coltbridge down to the sea, and the relative analyses, are that whilst the water is comparatively free from impurity before being contaminated by the sewage, and is not liable to become putrescent, yet, the moment the sewage enters the stream the water is rendered foul, and as the drains increase in number and discharge their fæcal contents into the stream, the nuisance increases. At no time after the Lochrin Burn enters is the water free from the power of passing into a state of putrescence. Even when filtered on the spot at many different stations, the liquid which was obtained, though somewhat clear and transparent, yet contained more or less organic matter, had a foul taste and a fœtid odour, destroyed the colour of much permanganate of potash, and when allowed to stand for some days passed into putrefactive fermentation and evolved stinking gases.

VII. *The Sedimentary Matters in the Bed of the Water of Leith.*

The solid matters which the sewers of Edinburgh and Leith carry in mechanical suspension into the Water of Leith are deposited in large quantities in ordinary seasons in the pools or cavities in the rocky bed of the stream, and also at the bottom of the still water which is found above all the six mill dams or cauls.

Immediately below the entrance of the Lochrin Burn into the Water of Leith at Coltbridge a bank of deposit of decomposing solid sewage matter, several feet in depth, lies putrefying and exhaling foul gases, and from this point to the mill-dam at a short distance below, the fermenting sediment is more or less deep, and indeed from this station down to the harbour of Leith, the bed of the Water of Leith,

including the part where the channel is narrowed, and also the bottom of the lade, are covered more or less thickly with putrefying sediment (Table O.). This was specially observable—

1. At the dam below Water of Leith village, where the foul deposit consisted on the average of four samples, of 48 per cent. of organic matter, containing nitrogen, and was in a state of active putrescence (Table O).
2. In the numerous pools in the rocky bed of the Water of Leith behind Moray and Ainslie Places, where the putrefying stuff is often two feet in depth, and contains on the mean of two samples 45 per cent. of organic matter with nitrogen (Table O.)
3. In the bed of the Water of Leith, below the North and South sewers at Stockbridge, where the average of eight samples washed up upon the banks gave 43½ per cent. of organic matter; a sample taken from the sides of the narrowed channel gave 34½ per cent. of organic matter; a sample collected from the bottom of the narrowed run, 80 yards below Stockbridge, gave 25 per cent. of organic matter; and still further down, at Malta Terrace, the sediment in the bottom of the run gave 32½ per cent. of organic matter (Table O.). In all of these instances the organic matter was, as usual, of an offensive and putrescent nature, and contained a decided proportion of nitrogen.
4. In the bed of the Water of Leith, in front of the Canonmills sewer, which contained organic matter to the extent of 31¾ per cent. (Table O.).
5. In the narrowed channel behind Warriston Crescent, and in the bed of the Water of Leith at St. Mark's Place, after the junction of the Edinburgh lade, when the average of nine samples gave 36 per cent of organic matter containing nitrogen. From this point down to the dam above Bonnington there is a stretch of water of nearly half a mile nearly stagnant and overlying a foul deposit of from one to three, and even at its lower parts to four feet in depth. Indeed, this stretch of water is an enormous cesspool open to the air, and the sedimentary matter is in a state of active putrefaction. At the dam above Bonnington the sediment contained 49¾ per cent. of organic matter, accompanied by 1·4 of nitrogen (Table O.); and,
6. In the bed of the Water of Leith at the boundary of Edinburgh and Leith at Bonnington Bridge, where one sample gave 27 per cent. of organic matter; below the junction of the Broughton Burn where the dried sediment contained 13¾ per cent. of organic matter, and at the dam above Junction Road Bridge, where the deposit is from one to two feet in thickness, and contained 27¾ per cent. of organic matter, accompanied by 0·7 of nitrogen.

The lades also, which now and again convey the whole or the major part of the Water of Leith, are not exempt from these organic sedimentary deposits. The lade which commences at the Water of Leith village, and traversing Edinburgh, is again discharged into the stream at St. Mark's Place, has an average deposit of 6 to 8 inches of organic matter at many places, and seven samples taken from the lade behind Ainslie Place, Moray Place, and India Place, and above Canonmills, gave the mean proportion of 25¾ per cent. of organic matter with 0·69 of nitrogen (Table O.).

In the harbour of Leith the putrefying deposit is diffused through a depth of one to two feet, and is necessarily mingled with fine sand

brought in by each tide. Samples of the deposit were collected at all the principal points on both sides of the harbour, and they were taken at a little distance from the banks so as fairly to represent the condition of the mud or deposit in the harbour. When the tide was out, it was observed that the whole bed of the harbour was composed of a black-coloured slimy foul deposit. 12 samples of the sedimentary matter lying towards the south-east side of the harbour gave an average of $28\frac{1}{3}$ per cent. of organic matter containing nitrogen, and 6 samples collected towards the north-west side of the harbour gave an average of 20 per cent. of organic matter with fully 0·60 of nitrogen (Table P).

These sedimentary deposits found in the river of Leith, from Coltbridge downwards to the harbour of Leith, and in all the mill lades connected therewith, are undoubtedly due to the discharge of the sewage of Edinburgh and Leith into the Water of Leith and the lades, and are not only foul and unsightly in themselves, but are far more noxious as hotbeds for the disengagement of unwholesome gases. The rapidity with which the gas escapes from these organic muds is such that at the dam-heads and in the harbour, the water floating above the putrefying stuff is perforated every moment with bubbles of gas, and so abundant are these that in many places the water presents the appearance of being a state of ebullition.

VIII. *The Gases evolved from the Muds or Sedimentary Matters.*

The gaseous emanations from the putrefying deposits in the bed of the Water of Leith, the lades, and the harbour, have received special attention in their examination. These gases are evolved more or less rapidly according to the depth of the organic mud, and the temperature of the season, and hence, in summer weather, the putrefactive processes proceeding more quickly, give rise to the disengagement of much gas even when the sediments are kept at rest, and lead to the evolution of large quantities whenever the deposit is agitated by a rod. In the bed of the Water of Leith, especially at Coltbridge, behind Ainslie and Moray Places, at St. Mark's Place down to the dam above Bonnington, at Bonnington Bridge, at the dam above Junction Road Bridge, and in the harbour of Leith, the disengagement of bubbles of gas is incessant and resembles a shower of rain falling. In the part of the Water of Leith where the channel is narrowed, as also in the lades, the evolution of gas is not so readily observed owing to the rapidity of the run of the water, but the slightest agitation of the bottom of the confined channels of the stream or of the lades at once causes the rapid disengagement of gases, so that there is no difficulty at any part of the Water of Leith from Coltbridge downwards in obtaining a good supply of gas for the purpose of examination as to its chemical composition.

In the collection of the gases, a bottle was filled with the water which was flowing over the deposit, and being inverted under the water with a funnel attached to the mouth, the sediment was agitated, when the bubbles of gas rose and entering the bottle displaced the water. A glass stopper luted with lard was inserted into the mouth of the bottle whilst under the water, and within three hours of the collection of the gases, the per-centage composition was determined by analysis. The results of the chemical investigation showed, that the gaseous emanations mainly consisted of gases which were combustible with a blue-white flame accompanied by smaller proportions of carbonic acid and oxygen. The proportion of the latter gas was small,

and there is little doubt that some at least of this oxygen may be regarded as derived from the gases dissolved in the water used in the collection and examination of the samples of air under analysis. The carbonic acid was determined by absorption with potash, and the oxygen was ascertained by the use of pyrogallic acid and potash, whilst the remaining gases were merely brought into contact with a lighted taper and observed to burn with a blue-white flame. The combustible gases which are well known to be evolved from decomposing plant and animal substances during putrefactive decay are marsh gas or light carburetted hydrogen, hydrogen, and carbonic oxide, and from the fœtid odour of the residual gas in all of the experiments, I have no doubt that these were accompanied, in the gases collected by me from those deposits of mud, by smaller proportions of other gaseous substances of a foul and noxious nature. In the majority of instances no traces of sulphuretted hydrogen were obtained when lead paper was introduced or when the odour of the gas was tried, but in the gases evolved from the sediment in the Water of Leith behind Warriston Crescent in Edinburgh, and that between the upper and lower drawbridges in the harbour of Leith, as also in those evolved from the mud off the jetty head at the entrance to the Victoria Dock, decided traces of sulphuretted hydrogen were obtained.

Fourteen samples of gas collected from sedimentary matters were examined. One sample of gas was taken from the mud or deposit in the Lochrin Burn sewer ; two samples from the sediment in the bed of the Water of Leith at Coltbridge ; two samples from the bed of the Water of Leith behind Moray Place ; two samples from the sediment in the lade behind India Place ; one sample from the bed of the Water of Leith below Stockbridge ; one sample behind Warriston Crescent ; two samples from St. Mark's Place ; one sample from the dam at Junction Road Bridge ; one sample from between the upper and lower drawbridges, and one sample from off the jetty head at the entrance to Victoria Dock (Table Q.). The proportion of carbonic acid in the gases ranged from 1·56 to 25·60 per cent. ; of oxygen from 0·32 to 2·17 per cent. ; and of other gases which were combustible with a blueish-white flame from 72·60 to 97 per cent.

The experimental results on the composition of the gases evolved from sedimentary matters in foul burns and waters teach the important doctrine, that the escape of sulphuretted hydrogen may scarcely, if at at all, be recognized, and yet large quantities of combustible gases, undoubtedly of organic origin, may be disengaged into the surrounding atmosphere, and consequently that the contamination of the air may occur without sulphuretted hydrogen being observed.

During the progress of these experiments attention was directed to a green substance consisting mainly of *Euglena viridis*, one of the Phytozoa, which was observed on the surface of the stagnating mud at the side of the Lochrin Burn, and in shallow parts of the Water of Leith as at St. Mark's Place, and which was said to neutralise in great part the deleterious effects of the gaseous exhalations, and even to lead to the disengagement of oxygen gas in large volumes. A considerable quantity of the green slime was separated as well as practicable from the underlying filthy sediment, and having been placed in a bottle till it was filled, the bottle was then inverted in a basin, and immediately gases began to be evolved. On testing these gases in about three hours, there were found carbonic acid 13·40 per cent., oxygen 1·60 per cent., and other gases, which were combustible with a blueish-white flame, 85 per cent. (Table Q.) It was proved, therefore, that this green slime does not practically lead

to the disengagement of oxygen, and indeed the gases which are evolved therefrom are essentially identical with those obtained from any foul deposit in a sewer or in water conveying sewage.

Moreover, the green slime, when collected from the surface of the sedimentary matter, and placed in a bottle which it filled about one third, and the remaining two thirds being left as common air, it was found that in 40 hours the composition of the atmosphere had so materially changed that a lighted taper was immediately extinguished on being introduced. A chemical analysis proved that the atmosphere left in the bottle contained 11·56 per cent. of carbonic acid, only 2·01 per cent. of oxygen, and 86·43 per cent. of other gases, which in their mixed state were not combustible and did not support combustion (Table Q.). These two experiments, therefore, demonstrated that practically the evolution of oxygen gas from the green slime covering a mass of putrescent filth was at a minimum and was highly problematical, whilst the disengagement from the mass, of carbonic acid and of combustible gases was undoubtedly certain. The green slime on being examined microscopically was found to consist mainly of minute organisms belonging to the *Phytozoa*, and which are alternately regarded as animals and plants. At present, the *Euglena viridis*, which forms a part at least of the green matter of these deposits, is considered to be a plant by some naturalists, and an animal by other authorities.

IX. *The Gases dissolved in the Waters of the Sewers and of the Water of Leith, &c.*

In all good natural waters there is present in solution a greater or less proportion of gaseous matter which the water has in great part dissolved out of the atmosphere. The gases present in healthy waters are carbonic acid, oxygen, and nitrogen; the two latter being in largest quantity, and the relative proportions of these two gases are, that for one volume of oxygen there are two volumes of nitrogen. These are not the proportions in which oxygen and nitrogen are present in the atmosphere, where there are for one volume of oxygen four volumes of nitrogen; but the greater solubility of oxygen than of nitrogen in water admits of a larger proportion of oxygen dissolving in the water, relatively, to the amounts of these gases in the atmosphere.

Two important offices are fulfilled by the oxygen which is dissolved in natural water. In the first instance, it supplies the air which fish require for their respiration, and without a due supply of which the fish become asphixiated and die; and, in the second instance, it oxidises any organic matters which pass into the water, and thus tends to purify the stream. It may be at once stated, however, that there is a certain limit to the power which oxygen possesses to consume organic matters, as in the act of doing so the oxygen enters into union with the elements of the decaying organic matter, and therefore ceases to be free oxygen, and cannot be recognised as such in the water. Moreover, whenever the oxygen has been used up in the decomposition of the organic matter, and there is still some refuse plant or animal substance left in the water, then putrefaction must follow and consequently foul gases be evolved.

The manner in which the oxygen dissolved in water acts upon foul matters contained therein may be observed from this, that organic substances principally consist of carbon, hydrogen, and oxygen, accompanied by a smaller proportion of nitrogen and minute quantities of sulphur and phosphorus; and where there is

oxygen dissolved in the water sufficient to aet upon these, it oxidises the earbon into earbonie aeid, the hydrogen into water, the nitrogen into nitrie aeid, the sulphur into sulphuric acid, and the phosphorus into phosphoric aeid. Whenever the proportion of oxygen beeomes exhausted, then the organic substance still lying beneath as sedimentary matter, or still floating along with the water cannot be oxidised, and must seek the elements of change within itself, and give rise to the disengagement of those combustible and foul gases which are charaeteristic of the putrefaction of refuse animal and vegetable substances.

In the examination of the gases dissolved in the waters of the sewers of Edinburgh, and of the Water of Leith, &c., I analysed the gases from 25 samples of water, and the details of the analyses are given in Table R. The spring-water, which is conveyed to Edinburgh in pipes for the service of the city, gives, as the results of these separate analyses, from 9·33 to 10·01 eubie inches of gas dissolved in one imperial gallon, and the per-eentage eomposition of these gases is, earbonie acid 8·70 to 10·71, oxygen 28·77 to 29·47, and other gases (nitrogen) 59·82 to 61·90. The proportions of oxygen and nitrogen therefore are nearly 1 to 2, and the average amount of oxygen is fully 29 per cent. The two main feeders of the Water of Leith are the Harelaw reservoir, which flows into the Bavelaw Burn, and the Water of Leith, and, as the oxygen is the prineipal gaseous ingredient, and the details are given in Table R., I will simply mention here, that the per-eentage of oxygen in the gases dissolved in the water of the Harelaw reservoir is 29·23, whilst in the other feeder, viz., the upper part of the Water of Leith, the per-centage of oxygen is 28·87. A sample of water eollected at Currie Bridge, after the discharges from various works had passed into the stream, gave 22·06 per cent. of oxygen, and another sample of water eolleeted still further down, at Gorgie Bridge, on a different day, gave 25·20 per cent. of oxygen, whilst two samples taken at different times from the Water of Leith at Coltbridge, just before mingling with the sewage of Edinburgh, gave respectively 22·22 and 22·20 per cent. of oxygen. It is thus evident that all the discharges thrown into the river in its upper parts, from the paper mills and other public works, are sufficient only to reduee the per-centage of oxygen from 29 to 22, and there is praetieally enough of oxygen still left in the water to oxidise more organic matter. The aetual amount of oxygen taken up by the oxidation of the organie matters diseharged from the mills may, however, be relatively greater than what is represented by the proportional difference between 29 and 22, as, during its course down to Coltbridge, the Water of Leith is exposed to the air, is, moreover, at eertain parts, a rapid running stream, and oeeasionally flows over a roeky bed, and thus the water is liable to beeome aërated again, and will likely, as it loses oxygen in the oxidation of the organic matter present in the water, reeeive a fresh supply from the atmosphere. At all events, the Water of Leith arrives at the outskirts of Edinburgh, and at the point where the first portion of the sewage is discharged into it, as a stream which still retains enough of oxygen to keep all its other ingredients in a fresh condition.

Three samples of liquid were taken from the sewer known as the Lochrin Burn, one sample from the South or Moray Place sewer at Stoekbridge, and one from Canonmills sewer, and the amount of oxygen present in each of these respectively was 3·33, 2·70, 2·10, 2·80, and 2·60 per cent. In other words, the proportion of oxygen was at a minimum, and it is questionable how far the remaining traces could

have the power of oxidising organic matters. At all events it was plainly observable that the spring water which is conveyed into the houses of Edinburgh, with oxygen present in the gases dissolved therein to the extent of fully 29 per cent., is afterwards found escaping from the sewers with the proportion of oxygen less than 3 per cent. on the average of five samples. Moreover, the sewage liquids were highly charged with organic matters capable of being oxidised, and possessing the power of abstracting the oxygen dissolved in very large quantities of water.

The effect of the sewage matters on the gases disolved in the Water of Leith is very decided, for whilst the gases in the Water of Leith at Coltbridge contain fully 22 per cent. of oxygen, the sewage conveyed by the Lochrin Burn, and numerous smaller sewers discharging into the stream, has the effect of reducing the per-centage of free oxygen to 4·20 per cent. by the time the water passes down to the Water of Leith village, and much organic matter still remains dissolved and suspended in the water of the stream. The water then finds its way over a rocky bed, and, apparently, it becomes aërated anew to some extent, for under the Dean Bridge the per-centage of oxygen in the gases has increased to 5·70, and behind Moray Place, near St. Bernard's Well, to 6·10, whilst on another occasion the proportion rose to 10·20 per cent. As the stream flows on, the aëration process proceeds, counter-balanced, however, by the oxidation of the organic matters already present, and being received every here and there, the proportions of oxygen fluctuate from 6·60 to 4·10 near Stockbridge, and at St. Mark's Place, after the lade joins, from 6·98 to 4·10. The gases dissolved in the waters of the lade which traverses Edinburgh, gave at India Place, on two different occasions, 4·76 and 6·40 per cent. of oxygen, and the water of the lade, just before joining the Water of Leith at St. Mark's Place, gave 5·40 per cent. of oxygen.

These experimental data afford proof that whilst the water of the Water of Leith arrives at Coltbridge charged with oxygen, that immediately in mingling with the sewage of Edinburgh, conveyed by the Lochrin Burn, the proportion of oxygen is reduced to a minimum, and practically the Water of Leith and the lade traverse the streets of Edinburgh destitute of the power of oxidising the organic matter discharged into it by the numerous drains and sewers. The result is that true putrefaction proceeds, and noxious gaseous exhalations are evolved from the decomposing organic matters. Under no circumstances is oxygen evolved from the decomposition of animal and vegetable substances, and as there is practically no purifying agent left in the Water of Leith, the extensive deposits of organic muds, which are found here and there and everywhere in the bed of the stream and lade, have no oxygen to consume or burn them, and are left to putrefy and exhale fulsome emanations.

X. *The Atmosphere in the Neighbourhood of the Water of Leith, &c.*

The gases evolved from the decomposing matters were generally recognised in the immediate vicinity of the Water of Leith conveying the sewage, as also in close proximity to the main drains or sewers. The odour was not that of sulphuretted hydrogen, but a heavy fœtid nauseous odour, specially observable immediately over the stream, and was doubtless due to the escape of gases produced by the putrefaction of the organic deposits. The state of the atmosphere was not only judged of by the test of the nose, but special experiments were made with a standard solution of permanganate of potash, so as to determine

the relative purity or impurity of the atmosphere in the vicinity of the Water of Leith, and at some distance therefrom. The employment of the permanganate of potash for the detection of impurities in the air was first suggested by Dr. Angus Smith of Manchester. The standard solution which was used in making the analyses of the air in connection with this enquiry was of such a strength that 250 grains, by measure, of the permanganate of potash solution were decolorised by 0·027 of a grain of fruit sugar, and the same quantity of permanganate was decolorised by 0·0075 of a grain of metallic iron.

In the collection of the samples of the atmosphere at various localities, half gallon stoppered bottles were taken, and after being rinsed with sulphuric acid and nitric acid, were thoroughly washed with water, treated with a little permanganate of potash, re-washed with distilled water, and then filled with pure water and the stoppers inserted. When the bottle was intended to be filled with air a siphon was introduced to the bottom of the bottle, and the water being run off by the siphon, the air entered at the mouth of the bottle without being washed by the water. The bottle was re-stoppered and the contents were tested as quickly as possible.

In using the standard test solution of permanganate of potash for the examination of the air, an improvement in its mode of application was suggested by Dr. Penny, and carried out in these investigations. Instead of employing the coloured solution, little by little, so long as the colour was destroyed, which leads to great irregularity in the length of time of agitation, and is, moreover, tedious, a series of standard tubes were filled with solutions of the permanganate of potash of varying strength, so as to form a sliding scale, where the full or undiluted colour was No. 1, and the succeeding numbers contained more and more water till No. 11 was nothing but water. The following short table will exhibit the scale which was adopted as the test standard :

Test tube.							Degree in scale.
No. 1	contained	250 grains	of the solution of permanganate of potash, and	no water			100
„ 2	„	225	„	„	25 grs.	water	90
„ 3	„	200	„	„	50	„	80
„ 4	„	175	„	„	75	„	70
„ 5	„	150	„	„	100	„	60
„ 6	„	125	„	„	125	„	50
„ 7	„	100	„	„	150	„	40
„ 8	„	75	„	„	175	„	30
„ 9	„	50	„	„	200	„	20
„ 10	„	25	„	„	225	„	10
„ 11	„	0	„	„	250	„	0

The mode of testing the air in the bottles consisted in adding 250 grains by measure of the standard solution of permanganate of potash, and agitating the test solution with the air for five minutes, when the solution was poured into a test tube, and the depth of colour still remaining observed, and contrasted with that of the solutions in the standard test tubes. If one half of the colour was lost, the liquid from the bottle would resemble in depth of tint that in test tube No. 6, which contains 125 grains of the permanganate of potash solution, along with 125 grains of water, and the degree in the scale of purity would be 50 ; absolute purity being 100, and the complete decolorisation of the liquid being 0.

31 samples of air were collected at various parts on different occasions and were tested (Table S.). On the 7th April, nine samples were tested, and whilst the degrees of purity of the air at three stations in Edinburgh away from the influence of the Water of Leith were respectively (100 being absolute purity) 85, 70, and 67, and the air at the Water of Leith at Coltbridge, before being mingled with sewage was 75, the atmosphere in the immediate vicinity of the sewers and of the Water of Leith conveying sewage had its degree of purity reduced to 63, 58, 55, and 55, and in one instance, as below the dam under the Water of Leith village, the 100 of standard colour was totally destroyed, a second 100 was similarly bleached, and of a third 100 only 20 remained. The reason of the very impure state of the air at this point lies in the fact that the water conveying the sewage, in falling over the dam, is dashed into foam, and the impure gases tend more quickly to escape, and thus contaminate the surrounding atmosphere to an extent more than in ordinary circumstances.

On the 9th April, 16 samples of air were collected and examined. Three samples taken in Edinburgh in places away from the Water of Leith, and one sample collected in Leith at a distance from the polluted stream, gave respectively the degrees of purity of 80, 75, 80, and 80, and one sample taken from the harbour at the Victoria Dock head gave 70 ; whilst the air collected under the immediate influence of the Water of Leith, conveying the sewage of Edinburgh and Leith, gave respectively 60, 60, 50, 60, 60, 55, 55, 55, 60, 50, and 55. On the 14th April six samples of air were collected and examined, when it was found that over the Water of Leith above Coltbridge, and before mixture with sewage, the degree of purity was 80, whilst over the sewers, and the Water of Leith conveying sewage, the degrees of purity were 68, 66, 70, 64, and 70 respectively.

These experimental results demonstrated that the atmosphere in the immediate neighbourhood of the Edinburgh and Leith sewers and the Water and Harbour of Leith contains more impurity than what is present in those parts of Edinburgh and Leith which are away from the influence of the foul gases emanating from the putrefying substances in the Water of Leith.

XI. *The Vegetable and Animal Life in the Water of Leith, &c.*

In the bed of the Water of Leith above the influence of sewage as at Gorgie dam, which is about a mile above Coltbridge, the stones over which the water flows have plants, such as moss, attached to them, and these plants are found on the stones in the bed of the streams conveying water practically free from putrescent matter ; but from the entrance of the Edinburgh sewage at Coltbridge downwards to the harbour of Leith, the stones in the bed of the stream are covered with offensive organic growths, which are characteristic of waters conveying sewage and capable of decomposing and evolving unwholesome gases. Indeed, not only are the stones covered with such vegetable growths, but everything in the bed of the river, such as arrested portions of trees, become thickly coated. They are also seen in the sewers called the Lochrin Burn sewer, the Broughton Burn, and the Bulls Stank sewer at Lovers Loan as it leaves Edinburgh, in all of which the bottom and sides are more or less covered with the growths. Even in the narrowed part of the channel of the Water of Leith, where the run of water is great, these organic matters are abundant, and likewise in the bottom and sides of the lade which traverses Edinburgh. All the twigs and branches of trees which hang

down into the Lochrin Burn sewer, and into the water of the lade, as from the gardens behind Ainslie Place and Moray Place, have these growths adhering in long streamers, rendered bulky and doubly foul by the accumulation of entangled filth. These growths principally consist of those low forms of vegetable life which are regarded by some naturalists as *Fungi*, and by others as *Algae*, and they are accompanied by masses of animals belonging to the family of *Vorticellidæ*, including the genera *Vorticella*, *Carchesium*, *Zoothamnium*, and *Epistylis*. Much of the organic matters which are found entangled in the branches of trees hanging into the lades and open sewers, as also of the organic deposits which are found in the beds of the Water of Leith and of the lades, are composed of the decaying remains of such growths.

The chemical analyses of these organic growths (Table T.) demonstrated, that even when examined with all the adhering entangled filth, when dried, they contained on the average of seven samples, 50·61 per cent. of organic matter, of which 0·84 consisted of nitrogen. These organic matters are being constantly detached from the stones, &c., on which they grow, and the torn off fragments float down the stream or lade and form part of some deposit in a rocky pool or in the still water above a dam. A considerable proportion of the deposits observed in the bed of the Water of Leith behind Ainslie Place and Moray Place and in the large cesspool at St. Mark's Place, consisted of those organic growths passing into an active state of putrescence. During the spring months the growths are apparently stronger and form longer streamers than during the summer months. The temperature of the latter is higher and facilitates changes such as the disintegration of the mass. These growths appear to be the last stage of organic life which will inhabit foul water, but in places where in the spring many patches of the growth were observed, in summer hardly any was to be noticed. This disappearance, in part at least, of the growth is to be attributed to the more foul state of the sewers and Water of Leith in summer, which leads in some places to such a rapid putrefaction as even to arrest the development of this comparatively simple form of organic life.

In the whole course of the Water of Leith from Coltbridge downwards not a single fish could be seen. The animal life which were specially visible to the naked eye consisted of colonies of small red worms, which were very abundant in many places, and are regarded as the last remnant of animal life which will exist in water contaminated by sewage. These minute red worms are a kind of *Nais*, belonging to the family of *Naidina*, and are named *Tubifex rivulorum*. They are found in greater abundance in the Water of Leith during spring than in summer, apparently from the more active putrescence of the sedimentary matter leading in the summer to the disengagement of a more full supply of noxious gases which even these minute worms cannot survive. In many places, where in spring the bed of the stream or of the lade harboured myriads of even this inferior type of animal life, there was hardly a specimen to be had, and this was doubtless due to the more rapid putrescence of the deposits. Abundance of animalculæ, including the *Paramaccia*, were found in the Water of Leith at all seasons of the year.

One curious effect of sewage upon animal life was observed by me in the harbour of Leith. Two wooden piers stretch some distance into the sea ; they are constructed of the same kind of timber and are of the same age. The West pier is not liable to be influenced by sewage passing down the harbour as the tide sweeps the sewage from it, and

the wood of this pier is nearly eaten through in some parts by the *Teredo*, a bivalve (Lamellibranchiate) mollusc, which is well known to be destructive to wooden erections in the sea. But the East pier is washed by the sewage water, and apparently from the disengagement of sulphuretted hydrogen, which is specially formed when sewage meets sea water, there is not a single *Teredo* to be seen at its work of drilling holes in the wood. The sewage in such circumstances therefore appears to be beneficial in retarding the ravages of this troublesome mollusc.

Independently of the putrefaction of the sedimentary deposits fish might live in water which contained nearly the proper proportion of oxygen, but the water of the Water of Leith from Coltbridge downwards is almost devoid of oxygen, and fish can no more live in water containing no oxygen than land animals could live in an apartment destitute of air.

It it worthy of note, as evidence of the state of the water of Leith and its incapacity to support the life of fish, that during the summer of 1864 a shoal of young herrings attempted to enter the harbour of Leith, and those herrings turned over on account of the foulness of the water and the majority died upon the spot.

XII. *The Purification of the Water of Leith.*

The foul and abominable condition of the Water of Leith when polluted by the sewage of about 100,000 of the inhabitants of Edinburgh and Leith, and the consequent danger to health of the communities of both towns who inhabit houses in the vicinity of the stream, led to strenuous efforts being made to remove the cause of the evil and provide for the purification of the water of Leith, which at the present time is practically an open sewer, by the interception of the sewage and its conveyance by a main drain to the sea. The scheme which was suggested and approved of by both corporations, and which, having received the sanction of Parliament, is now in course of being carried out, provides for a main drain from Coltbridge down to Leith, and then out to sea to the Black Rocks. The whole length of the pipe and culvert will be about $5\frac{1}{4}$ miles for the main work, and 2 miles for branches, and the gradients will be from 1 in 40 to 1 in 600: the latter being the gradient at the outlet. The length of main pipe and branches in the Edinburgh district is from 4 to 5 miles, and the estimated cost of that part of the work, viz., from Coltbridge down to the boundary of Edinburgh and Leith is 29,314*l.*; whilst the length of the main pipe and branches from the boundary of Edinburgh and Leith at Bonnington to the Black Rocks at sea is 9,600 feet, and the estimated cost of that part of the work is 25,686*l.* The whole estimated expense of the work is 55,000*l.* which is a small sum in comparison with the 5,000,000*l*, now being expended by London in a similar measure, and the cost of the works is to be defrayed by a rate limited to 2*s.* 6*d.* per pound rental for one year, on all the property, within the parliamentary boundaries of Edinburgh and Leith, draining into the water of Leith, and contributing to the sewage, with the addition of a grant of 4,000*l.* from the Leith Docks Commission.

The main drain is to be an iron pipe throughout the greater part of its length, though at a portion of its course it will be a brick culvert. At the Lochrin Burn sewer and the Broughton Burn sewer there will be cesspools for the arrestment of dead cats and dogs and other materials thrown into these sewers where they run as open ditches, but all the other drains and sewers will be directly connected with the main drain,

leaving overflow pipes for the discharge of the comparatively pure water of high floods. The main drain will intercept all the ordinary sewage of Edinburgh and Leith, which naturally drains into the water of Leith and the lades. The apertures of the different branches and connections with the sewers will be considerably larger than the size required for the present flow of sewage, so that a reasonable fall of rain will also be received in the main drain.

The diameter of the entrance to the main drain or iron pipe at its commencement at Coltbridge and where the Lochrin Burn sewer enters will be 18 inches, and it will convey away 360 cubic feet of sewage per minute ; at Stockbridge, where the large North and South (Moray Place) sewers enter, the iron pipe will be 30 inches in diameter and be capable of carrying 1,616 cubic feet of sewage per minute. At Canonmills, where another large Edinburgh sewer joins, the diameter of the main drain will be increased to 33 inches. At the boundary of Edinburgh and Leith, at Bonnington, the drain will be a brick culvert 4 feet 6 inches by 3 feet ; and at Leith, and passing out to sea at the Black Rocks, the iron pipe of the main drain will be 3 feet 6 inches in diameter, and be capable of discharging at low water 2,200 cubic feet of sewage per minute. As the pipe is carried past the south-east side of the harbour of Leith it will have five or six overflow pipes at the level of high water, so that should there be a flood in the pipes, and very high tides at the same time, there will be a certain overflow into the harbour ; but this will only occur in exceptional cases, and then only into the harbour during high water, and when there is abundance of water to dilute the sewage and carry it off during the receding of the tidal water. The main drain only intercepts the sewage of South Leith, but simultaneously with this measure being carried out, the Corporation of Leith is bound to intercept the sewage of North Leith and carry it by an independent pipe to the sea.

The maximum amount of ordinary sewage from Edinburgh and Leith, which is discharged into the Water of Leith and will be received in the main drain, is 574 cubic feet per minute ; but this amount will be increased in the course of time by building operations, and the increase in the number of dwelling-houses and possibly of manufactories. The main pipe will certainly carry double the amount of the sewage water, and at ordinary times it may carry three times and even four times the amount of sewage water. During a flood of rain-water, the first portions of the rain will serve, from the extra force of the run, to clean out the sewers into the main drainage pipe, and when all the sediment in the sewers has been swept into the pipe, and the rain-water increases till the sewers convey more than four times their ordinary discharge, then, whilst much will still be carried away by the main drain, all the excess which will be in the upper part, and will merely, at the worst, be sewage mingled with three or four times its own volume of rain-water, will be discharged into the Water of Leith. Not only will the sewage be largely diluted when it flows from the drain into the stream, but the river itself will generally be in flood at those times, and the sewage will thus pass into the Water of Leith so much diluted with water that it will be comparatively innocuous, and will be immediately swept onwards with the flood-water.

That a flood of rain in the sewers is generally accompanied by a flood of water in the river has been placed beyond doubt by the accurate observations and measurements made by the Engineers of

the Drainage Bill, and the following Table gives the results of the simultaneous gaugings of the river and of the Lochrin Burn sewer :—

	Water of Leith. Water going over the waste wiers at the dams, and over and above the 1,600 cubic feet per minute passing down the lades. Surplus water at dams in cubic feet, per minute.	*Lochrin Burn Sewer.* As it discharges into the Water of Leith at Coltbridge. Flow of water in cubic ft., per minute.
15 March 1864 -	13,850	309
16 „ -	8,250	237
17 „ -	8,255	221
18 „ -	4,900	194
19 „ -	3,950	194
21 „ -	2,355	203
22 „ -	3,300	213
23 „ -	1,530	178

During the winter season water is always going to waste over the wiers, but in summer weather the flow of any water over the dams is exceptional.

The average rain-fall in Edinburgh is 24 inches annually, and judging from the observations of several years it is found that a rain-fall of ·64 in. per day, which is required to produce a flow of one cubic foot a minute per acre into the sewers, and would consequently increase the usual flow of water twofold, can only be exceeded ten times in the course of a year ; so that if the main-drainage pipe has the capacity to convey double the quantity of the ordinary sewage, the pipe will only refuse to take in the whole contents of the sewers in 10 days of every year. If the main drain can carry triple the amount of the ordinary sewage, the quantity of rain required to produce more than this quantity occurs so seldom that the junction pipes will only overflow $1\frac{1}{2}$ days in the year ; and if the main drain can carry four times the quantity of the ordinary sewage, then it will only permit of the discharge of part of the flood water into the Water of Leith in seven days in every eleven years.

XIII. *The Condition of the Water of Leith as contrasted with the State of the Thames.*

In drawing this paper to a conclusion it may be interesting and instructive to contrast the present state of the Water of Leith with the condition of the Thames, and then to sum up the principal results of the investigations undertaken by me in connection with the contamination of the Water of Leith by the sewage of Edinburgh and Leith.

The condition of the Thames, as it courses through London, is much less foul than the Water of Leith as it traverses Edinburgh. The experiments made by Graham, Miller, and Hofmann show there is very little increase in the amount of organic matter in the Thames at London than there is at Thames Ditton, which is above the tidal influence, and therefore not liable to be contaminated by the sewage of London. The proportion of organic matter in the water at Thames Ditton is 2·29 grains per gallon, and in the water supplied by the Lambeth Company and derived from the Thames, London, the organic matter is only 2·59 grains per gallon. Practically, therefore, the Thames water does not materially increase in the proportion of organic matter as it flows down to London, and this statement will be more decidedly borne out by the experimental results obtained by Hofmann and Witt

on the water of the Thames from Kew Bridge down to the Victoria Dock. The following Table gives the experimental results :—

	Solid constituents in grains per gallon.		
	Organic.	Mineral.	Total.
Water at Kew Bridge - -	1·844	23·067	24·911
„ at Crab Tree Slip, near Fulham -	1·992	20·124	22·116
„ opposite lock at Wandsworth -	2·359	23·672	26·031
„ at Westminster Bridge - -	1·937	23·496	25·433
„ at London Bridge - -	2·194	23·676	25·870
„ at Victoria Dock - -	2·032	25·649	27·681
Mean - -	2·059	23·281	25·340

The mean proportion of organic matter in the Thames water, therefore, is only two grains, which in one imperial gallon is only about $\frac{1}{35000}$ th of the weight of the water, and there is hardly any increase from Kew down to London Bridge. This extraordinary result is to be fairly attributed in part at least to the quantity of oxygen in the water, which acts readily on the organic matter and consumes it. The tide appears to have some effect upon the proportion of organic matter as well as saline matter in the Thames, doubtless due to the forcing back of the sewage water, and the disturbance of the sediment in the bed of the Thames. Thus Letheby found that at Woolwich at high tide the proportion of saline matter in the imperial gallon was 453·6 grains and at low tide was 60·6 grains, and at London Bridge the saline matter at high tide was 26·5 grains and at low tide 24·9 grains ; whilst the organic matter in the water at London Bridge, at high and low water, was respectively 3 grains and 2·7 grains : of the latter 1·6 grains were in solution and 1·1 in supension. The sea, therefore, penetrates to London Bridge. Odling, in experiments made on the Thames water at Greenwich, found that on the average of many experiments, the amount of matter dissolved in the water at high tide was 191·23 grains, of which 16·28 grains were organic matter, and at low tide the proportion of matter was 45·91 grains, of which 6·13 grains were organic. It would thus appear that the average amount of organic matter in the Thames at Greenwich is nearly three times more at high water (16·28 grains) than at low water (6·13 grains). Experiments made by Odling at Greenwich at neap tide showed that at high water the matter carried by the water was 58·87 grains, of which 4·69 grains were organic matter, and at low water 27·87 grains, of which 2·64 grains were organic matter.

The mean proportion of organic matter dissolved and suspended in the Water of Leith, after receiving the successive quantities of the sewage of Edinburgh, and as the stream flows past the city and onwards to the harbour of Leith, is much greater than what is found in the water of the Thames. Indeed, as the Water of Leith at certain parts of its course, in summer or dry weather, only conveys the discharges of the common sewers, it follows that the water in the bed of the stream is almost pure sewage. During the winter and spring months, however, the whole of the natural water of the stream is not diverted into the lades, and at those times, the sewage is mingled with more or less ordinary water flowing down the bed of the river.

The *average* proportions of organic, saline, and earthy matters dissolved and suspended in the drainage liquids from Edinburgh and Leith, and which are discharged into the Water of Leith, may be observed from Table U., whilst the amount of organic matter in the imperial gallon of the liquids conveyed by the principal sewers may be more clearly observed from the following table :—

Number of Samples.	Place of Collection.	Mean Proportion of organic matter dissolved and suspended in one imperial gallon.
18	Lochrin Burn Sewer, west of Abattoir or Slaughter-houses	45·42 grs. equal to $\frac{1}{1350}$th of weight of water.
15	Lochrin Burn Sewer, above Caledonian Distillery	44·38 „ $\frac{1}{1600}$th „
20	Lochrin Burn Sewer, above Coltbridge	60·54 „ $\frac{1}{1150}$th „
10	North Sewer, at Stockbridge	21·56 „ $\frac{1}{3200}$th „
12	South (Moray Place) Sewer, at Stockbridge	31·79 „ $\frac{1}{2150}$th „
21	Canonmills Sewer	23·70 „ $\frac{1}{2900}$th „
11	Broughton Burn Sewer, Bulls Stank Sewer, Coal Hill Sewer, Drawbridge Sewer — Discharging near and at Leith.	57·58 „ $\frac{1}{1200}$th „

When the contents of the above sewers are discharged into the Water of Leith they necessarily raise the relative amount of organic, saline, and earthy matters in the water of the stream, as may be specially observed from Table V., which gives the *average* proportions of such substances dissolved and suspended in the Water of Leith, from immediately above Coltbridge, where the sewage begins to enter, down to the Harbour of Leith ; and the following table gives the various quantities of the organic matter dissolved and suspended in the Water of Leith at the principal stations, from its sources down to the sea.

Number of Samples.	Place of Collection.	Mean Proportion of organic matter dissolved and suspended in one imperial gallon.
1	Water of Leith above Balerno Bridge (source)	2·00 grs. equal to $\frac{1}{35000}$th of weight of water.
1	Water of Leith, Harelaw Reservoir (source)	2·56 „ $\frac{1}{35000}$th „
23	Water of Leith, above Coltbridge, after receiving discharges from Works and before being mingled with the Sewage of Edinburgh and Leith	5·07 „ $\frac{1}{14000}$th „
	Water of Leith, from Coltbridge downwards, and whilst receiving successive quantities of Sewage.	
1	Water of Leith, down to Water of Leith Village	9·72 „ $\frac{1}{7000}$th „

Number of Samples.	Place of Collection.	Mean proportion of organic matter dissolved and suspended in one imperial gallon.
6	Water of Leith, under Dean Bridge	10·15 „ $\frac{1}{7000}$th „
6	Water of Leith, behind Moray Place	9·61 „ $\frac{1}{7000}$th „
6	Water of Leith, above Stockbridge	9·91 „ $\frac{1}{7000}$th „
9	Water of Leith, below Stockbridge	23·16 „ $\frac{1}{3000}$th „
1	Water of Leith, at Warriston Crescent	17·72 „ $\frac{1}{3000}$th „
8	Water of Leith, from lade behind India Place, and at Beaver Hall	10·82 „ $\frac{1}{3000}$th „
18	Water of Leith, St. Mark's Place	26·45 „ $\frac{1}{3000}$th „

It will thus be observed that the Water of Leith, as it leaves Edinburgh, contains fully ten times the quantity of organic matter which is found in the Thames at London Bridge, and necessarily the offensiveness of the water must be correspondingly greater.

The solid matter discharged by the sewage of London in one day is calculated to amount to 250 tons, and as 50 days elapse before it is capable of reaching Gravesend, it must by that time have mingled with 250 millions of tons of water, and the oxygen contained therein is no doubt sufficient to aid in the decay or combustion of the organic matter, and thus consume it, without putrefaction (in the true sense of the term) setting in. Indeed, before it reaches Gravesend, the greater part of the organic matter must be decomposed, and even at the worst, the water can only have present 12,500 tons distributed amongst 250,000,000 tons of water, which is only 2 ozs. of solid matter in a ton of the water, or $\frac{1}{20000}$th part of the weight of the water. In the investigations relating to the sewage of London and its effects on the Thames, and the injury to health inflicted thereby, it is conclusively shown that the greatest part of the nuisance lies in the sedimentary matter which lines the banks and is in an active state of putrefaction; and the same conclusion has been come to by me in regard to the foul deposits in the bottom of the lades and in the bed of the water and harbour of Leith. The *average* composition of these sedimentary matters collected from the bottom of the open sewers discharging into the Water of Leith, and from the bed of the Water of Leith, of the lades, and of the harbour, is given in Table W. in a condensed form.

The mixture of sea water with the sewage in the harbour of Leith causes, besides the ordinary putrefaction, the production of sulphuretted hydrogen in quantity, and this was specially observable in the mud which was brought up from mid-channel of the harbour by a dredging machine during one of my visits to the Water of Leith. A similar disengagement of sulphuretted hydrogen under like circumstances has been observed previously, especially where organic matter meets with sea water in hot climates, such as on the coasts of Africa, and it has also been observed in part to occur in the Thames, and give rise at least to an increase in the amount of sulphuric acid in combination with Thames water at high tide as

compared with low tide. The disengagement of sulphuretted hydrogen in tropical regions when organic matter and sea water meet is so decided that the odour and other effects of sulphuretted hydrogen have sometimes been observed 27 miles at sea from the mouths of rivers.

The gases evolved during the decomposition of the sedimentary matters lying in the open sewers, the lades, and in the bed of the Water of Leith do not, however, contain much sulphuretted hydrogen (hydrosulphuric acid), but mainly consist of carburetted hydrogen and other combustible gases and vapours which are known to be evolved during the putrefaction of organic matters. The *average* composition of twelve samples of these gases, collected from five stations, is given in Table X.

The gases dissolved in the waters of the sewers, the lades, and the Water of Leith are equally characterized by the minute proportion of sulphuretted hydrogen which is present at any time in these waters, and the amount of which is so slight, that, in many instances, it cannot be recognised. The *average* composition of twenty-five samples, collected from six stations, is given in Table Y. The gases evolved from the decomposing and putrefying deposits rise up through the water which flows above, and pass into the atmosphere, and the liquids also tend to interchange their foul gases with the gaseous constituents of the air, and hence the neighbouring atmosphere becomes contaminated by the evolution of those fœtid gases. The *average* relative purity of thirty samples of the atmosphere collected in districts away from and near the open sewers, lades, and the Water of Leith is given in Table Z.

XIV. *General Conclusions.*

In considering the whole subject of this paper, and contrasting the results of the investigation made by me relative to the Water of Leith with those made in London on the Thames, and knowing the great benefits derivable from improved drainage in the lessening of the rate of sickness and of death in all localities where effective and judicious sanitary measures have been carried out, I beg to submit the following conclusions on the contamination of the Water of Leith by the sewage of Edinburgh and Leith :—

I. That the Water of Leith, above the influence of the sewage of Edinburgh, is a small stream of water of a peaty or mossy nature, which has its original amount of organic and saline matters increased by discharges from paper mills and other public works, but arrives at Edinburgh in a condition not liable to putrefaction and containing a good proportion of free oxygen gas.

II. That the Water of Leith, immediately above Coltbridge, and before admixture with the Edinburgh sewage, is comparatively free from foul deposits and from unsightly organic growths, and does not evolve unwholesome gases into the surrounding atmosphere, and thus contaminate the air of the vicinity.

III. That the Lochrin Burn and other sewers and drains of Edinburgh convey large quantities of offensive liquids with decomposing organic matter in solution and mechanical suspension, and discharge such into the Water of Leith at many points from Coltbridge downwards.

IV. That the organic matters so conveyed into the Water of Leith principally consist of the decomposing effete matters of the

animal system, including the solid excrements or fæces, and even in comparatively cold weather evolve abundantly offensive odours.

V. That the sides and bottom of the open sewers, of the lades which traverse Edinburgh, and the bed of the Water of Leith from Coltbridge downwards, are more or less covered with offensive organic growths characteristic of streams and open drains which convey sewage matters.

VI. That the bottom of the open sewers, the bottom of the Edinburgh lades, the bed of the Water of Leith from Coltbridge downwards, and the harbour of Leith, are more or less thickly covered with organic matter in an advanced stage of putrefaction, which fills up the rocky pools at certain parts and renders the dams vast open cesspools.

VII. That the signs of animal life visible to the naked eye in the Water of Leith, after commencing to receive the sewage of Edinburgh, consist mainly of multitudes of minute worms, which are characteristic of waters conveying sewage, and may be regarded as the last remnant of animal life which will survive in such a locality, and even these die off in many places during the summer weather, and when the putrescence of the organic matter proceeds more rapidly.

VIII. That the organic sedimentary matters which are deposited in the bed of the Water of Leith from Coltbridge downwards, in the harbour of Leith, and in the various lades below Coltbridge, are in a state of active putrefactive fermentation, and the slightest agitation of the deposit gives rise to the abundant evolution into the surrounding atmosphere of those gases which are well known to be evolved from decomposing vegetable and animal matters.

IX. That whilst all healthy water contains a considerable proportion of oxygen gas dissolved therein, which can act in consuming any organic impurities which may pass thereinto, the Water of Leith, after mixing with the sewage matters, is found to be practically devoid of oxygen gas, and the contents of the sewers are found equally devoid of oxygen gas, so the waters of the sewers and of the Water of Leith from Coltbridge downwards are practically devoid of any purifier, and must allow their contents to become putrescent.

X. That the putrescence of the organic liquids and deposits in the open sewers, the bottom of the lades, and the bed of the Water of Leith, in all weathers, but especially in summer, and the evolution of noxious gases therefrom, lead to the sensible contamination of the surrounding atmosphere, and consequently decrease the purity and healthiness of the air.

XI. That, taking all these circumstances into consideration, I am decidedly of opinion that the discharge of sewage-matters into the Water of Leith in any weather, but especially in the warmer months, leads to the accumulation of organic matter of a most offensive nature, and that the consequent putrefaction of this organic matter gives rise to the evolution of gases which are highly offensive and pernicious, and must render the neighbouring localities more or less unwholesome.

XII. That the condition of the Water and Harbour of Leith is much more noxious than any part of the Thames, as the proportion of organic matter is much greater, and the rocky pools and dams afford more obstacles to the flow of the sewage, and that the time had certainly arrived when a main-drainage scheme was absolutely required for the purification of the Water of Leith.

The lengthened investigation into the condition of the Water of Leith, and the contamination of the stream with the sewage of Edinburgh and Leith, has brought prominently before me the great injury done to rivers by the sewage of populous places. The full effect of such contamination cannot be observed by the simple inspection or even the analysis of the water, so as to determine merely the proportion of organic matter which may be present therein, but can only be learned by a thorough examination of:—

1. The liquids conveyed by the sewers and rivers:
2. The sedimentary matters lying in the bottom of the open sewers and the bed of the rivers:
3. The gases evolved during the decomposition of these sedimentary matters:
4. The gases dissolved in the waters; and
5. The atmosphere in the neighbourhood of the open sewers and rivers conveying sewage.

The injury done by sewage in the contamination of the waters of streams and rivers is not the only grievance which is sustained by the improper discharge of the drainage of houses. In the smaller towns and villages where no drainage system is carried out, and where no regular water supply is introduced, a plan of receiving water and discharging drainage is adopted which is positively unwholsome and detrimental.

In the better class of dwellings in non-drainage localities, each house, when built, is provided immediately underneath or in a small front or back plot, with two holes, one of which is a well with a pipe leading to the house and the second is a cesspool with a pipe coming from the house, so that the water is drawn from the one hole and is returned to the other. The well is in most instances dependent for its supply on the percolation of water from the sides and bottom, and thus it draws water from the neighbouring ground; whilst the cesspool of the house is not many yards away, and the liquid discharged from the water-closets and kitchen sinks, is run into the cesspool, oozes through the soil and enters the well. That cesspools are related to wells in this manner is abundantly evident from the examination of the ground, and the analysis of the water from the well. The ground around the cesspool is more or less impregnated with organic matter, and whilst the more solid parts of the impurities are left in the ground, the more liquid portions enter the well. Occasionally the sides of the well are stained with an offensive slime, and in many instances, when the wells are cleared out, they are found to contain a large quantity of decomposing organic sediment. The sewage when discharged from a house in a fresh state is comparatively harmless; but when putrefaction sets in, and especially if the matter is arrested in cesspools in the immediate neighbouring ground, there is much danger from the contamination of the wells, and the escape of noxious gases into the surrounding atmosphere. During the process of putrefaction, a portion of the offensive matters become liquid and are dissolved in the water, and whilst, in some instances, the organic matter permeates the

soil and communicates a greenish yellow colour, and an offensive odour and taste to the water; yet in most cases the water does not betray from its colour, odour, or taste, the slightest evidence of being contaminated by the products of offensive animal and vegetable matters which have undergone putrefaction and decay. For some years my attention has been specially directed to the influence of cesspools and other accumulations of organic matter on waters intended to be employed for household use, and I have repeatedly examined waters of pleasing appearance which were regularly used for drinking and for culinary purposes, and were even famed as first class waters for general dietetic use, and which, on chemical examination, proved themselves to contain in one imperial gallon from two to thirty grains of organic matter and the products derived from its decomposition.

The results of the many experiments and observations which I have made on the pollution of the Water of Leith and other streams and rivers, as also on the contamination of wells, by the sewage of houses and towns, have demonstrated the following general conclusions on the important question of the influence of drainage materials on natural waters :—

I. That the discharge of the sewage of towns and cities into streams and rivers pollutes the water by the admixture of much organic matter in a state of active putrescence.

II. That the more solid part of the sewage discharged by drains into streams and rivers, accumulates in all pools, and above all dams, cauls, or other obstructions, and forms a deposit of decomposing filth.

III. That the organic matter conveyed by the sewers into natural waters, is more or less acted upon by the oxygen dissolved in the water, and is in part consumed thereby.

IV. That the combustion of part of the organic matter necessitates that the oxygen gas dissolved in the water, and which is the natural purifier, should be abstracted therefrom, and subsequently the remainder of the organic matter must pass into a state of putrefaction.

V. That the sedimentary matter which is conveyed by sewage, and which lodges in the pools and above obstructions, as well as on the banks of the streams and rivers, is of a nature to be actively putrescent.

VI. That the organic matter dissolved in the water, and the organic deposits, are constantly evolving considerable volumes of gases which mainly consist of combustible gases, or those which are known to be given off during the putrefaction and decomposition of animal and vegetable matters.

VII. That the gases evolved during the putrefaction of the organic substances contaminate the atmosphere of the neighbourhood, and necessarily decrease the healthy nature of the air.

VIII. That when the proportion of sewage is comparatively little, the waters of streams and rivers may contain enough of oxygen to consume much of the organic matter, but this necessitates that the proportion of oxygen be diminished, and the water be rendered more or less irrespirable for fish.

IX. That natural waters conveying relatively a large proportion of sewage matter are totally unfit for the sustenance of the life of fish, as the oxygen, for their respiration, has been

abstraeted, and the water has beeome praetieally devoid of that gas.

X. That, in distriets where defeetive or no drainage is earried out the well waters are liable to be eontaminated by the deeomposing organic matter which is discharged into the neighbouring eesspools, and impurities derived therefrom may be present in well waters whieh are devoid of colour and odour, have no unpleasant taste and may be popularly known as good waters.

XI. That water contaminated by sewage beeomes more or less unfit for household purposes, and even when the proportion of sewage is small, and the water may be eomparatively elear, it is unwholesome as a beverage, and is unfit for culinary purposes.

XII. That it behoves all parliamentary and munieipal authorities to pass and enforee measures for the suppression of the eauses of the pollution of wells, streams, and rivers, and thus arrest the evils which are neeessarily attendant on the eontamination of streams, rivers, and other waters by the sewage of eities, towns, villages, and other populous plaees.

(Signed) Stevenson Macadam.

Table A.

Liquids collected from the Drains and Sewers discharging into the Water of Leith.

Temperature.		Place and Time of Collection.	In solution.			In suspension.			One imperial gallon contains in solution and suspension.		
Air.	Liquid.		Organic matter in grains.	Saline matter in grains.	Total matter in solution in grains.	Organic matter in grains.	Earthy matter in grains.	Total matter in suspension in grains.	Organic matter in grains.	Saline and earthy matter in grains.	Grand total in matter grains.
		Loehrin Burn, West of Abattoir or Slaughter-houses.									
Fahr.	Fahr.	Day. Hour.									
46°	48°	14th March 1864 at 2.16 p.m.									
52°	45°	17th „ „ 1.45 p.m.									
51°	45°	18th „ „ 11.35 a.m.	11·68	31·20	42·88	28·80	52·00	80·80	40·48	83·20	123·68
50°	44°	19th „ „ 10.32 a.m.									
50°	45°	21st „ „ 4.7 p.m.									
48°	45°	22d „ „ 3.8 p.m.									
47°	46°	23d „ „ 12.25 p.m.	16·00	24·00	40·00	19·68	13·12	32·80	35·68	37·12	72·80
47°	45°	24th „ „ 9.40 a.m.	18·60	16·56	35·16	13·88	10·12	24·00	32·48	26·68	59·16
44°	45°	26th „ „ 10.46 a.m.	8·80	24·48	33·28	28·96	8·32	37·28	37·76	32·80	70·56
44°	44°	28th „ „ 5.2 p.m.	5·60	22·56	28·16	12·48	6·40	18·88	18·08	28·96	47·04
45°	44°	29th „ „ 2.10 p.m.	17·28	27·20	44·48	16·80	16·00	32·80	34·08	43·20	77·28
44°	43°	30th „ „ 7.20 a.m.	6·24	19·20	25·44	16·60	5·28	21·88	22·84	24·48	47·32
49°	47°	31st „ „ 1.5 p.m.	10·88	25·60	36·48	14·08	9·12	23·20	24·96	34·72	59·68
48°	46°	1st April 1864 „ 1.55 p.m.	7·20	25·92	33·12	24·48	18·72	43·20	31·68	44·64	76·32
44°	44°	2d „ „ 9.45 a.m.	6·72	18·24	24·96	22·88	8·32	31·20	29·60	26·56	56·16
56°	48°	7th „ „ 9.10 a.m.	21·12	35·20	56·32	89·44	10·72	100·16	110·56	45·92	156·48
69°	57°	20th May 1864 „ 12.20 p.m.	18·40	24·00	42·40	135·36	15·04	150·40	153·76	39·04	192·80
64°	54°	25th „ „ 10.25 a.m.	15·60	28·88	44·48	27·68	10·72	38·40	43·28	39·60	82·88
		Average of 18 samples -	12·36	26·61	38·97	33·06	24·66	57·72	45·42	51·27	96·69

Table B.

Liquids collected from the Drains and Sewers discharging into the Water of Leith.

Temperature.		Place and Time of Collection.	In solution.			In suspension.			One imperial gallon contains in solution and suspension.		
Air.	Liquid.		Organic matter in grains.	Saline matter in grains.	Total matter in solution in grains.	Organic matter in grains.	Earthy matter in grains.	Total matter in suspension in grains.	Organic matter in grains.	Saline and earthy matter in grains.	Grand total in matter grains.
		Lochrin Burn above Caledonian Railway.									
Fahr.	Fahr.	Day. Hour.									
46°	43°	14th March 1864 at 1.56 p.m.									
47°	50°	17th „ „ 2 p.m.									
47°	53°	18th „ „ 11.52 a.m.									
50°	52°	19th „ „ 10.50 a.m.	16·08	31·60	47·68	32·96	9·12	42·08	49·04	40·72	89·76
47°	53°	21st „ „ 4.30 p.m.									
48°	52°	22d „ „ 3.30 p.m.									
47°	53°	23d „ „ 12.48 p.m.	30·68	26·24	56·92	98·48	10·40	108·88	129·16	36·64	165·80
56°	57°	27th April 1864 „ 9.25 a.m.	12·00	24·00	36·00	45·16	11·72	56·88	57·16	35·72	92·88
64°	65°	20th May 1864 „ 12.40 p.m.	18·80	22·88	41·68	18·08	9·12	27·20	36·88	32·00	68·88
51°	61°	26th „ „ 9.25 a.m.	18·80	24·32	43·12	16·88	6·64	23·52	35·68	30·96	66·64
53°	57°	27th „ „ 12.20 a.m.	13·20	23·20	36·40	12·40	4·80	17·20	25·60	28·00	53·60
52°	56°	27th „ „ 2.30 a.m.	10·84	18·40	29·24	8·20	3·80	12·00	19·04	22·20	41·24
51°	55°	27th „ „ 4.30 a.m.	8·20	16·52	24·52	5·88	2·72	8·60	14·08	19·04	33·12
60°	59°	27th „ „ 12.25 p.m.	14·16	29·84	44·00	12·72	6·80	19·52	26·88	36·64	63·52
63°	58°	28th „ „ 1 p.m.	13·36	25·76	39·12	13·68	6·12	19·80	27·04	31·88	58·92
		Average of 15 samples -	15·77	26·70	42·47	28·61	7·79	36·40	44·38	34·49	78·87
		Dreg running from Caledonian Distillery.									
46°	51°	14th March 1864 at 2.1 p.m.	78·40	25·60	104·00	19·68	2·72	22·40	98·08	28·32	126·40
54°	187°	5th April 1864 „ 2.25 p.m.	880·64	193·60	1074·24	242·88	13·92	256·80	1123·52	207·52	1331·04
		Average of 2 samples of dreg	479·52	109·60	589·12	131·28	8·32	139·60	610·80	117·92	728·72
47°	199°	21st March 1864 at 4.35 p.m.	Dreg allowed to settle and sediment dried at 212° yielded - - - -						Organic. 93·32	Saline. 6·68	Total per ct. 100·00

Table C.

Liquids collected from the Drains and Sewers discharging into the Water of Leith.

Temperature.		Place and Time of Collection.	In solution.			In suspension.			One imperial gallon contains in solution and suspension.		
Air.	Liquid.		Organic matter in grains.	Saline matter in grains.	Total matter in solution in grains.	Organic matter in grains.	Earthy matter in grains.	Total matter in suspension in grains.	Organic matter in grains.	Saline and earthy matter in grains.	Grand total matter
		Lochrin Burn above Coltbridge.									
Fahr.	Fahr.	Day. Hour.									
45°	44°	14th March 1864 at 1.38 p.m.									
48°	48°	17th „ „ 2.23 p.m.									
48°	47°	18th „ „ 12.10 a.m.	23·01	27·20	50·24	39·68	16·32	56·00	62·72	43·52	106·2
50°	44°	19th „ „ 11.10 a.m.									
47°	45°	21st „ „ 4.50 p.m.									
48°	43°	22d „ „ 3.50 p.m.									
50°	51°	23d „ „ 1.25 p.m.	11·52	23·04	34·56	17·92	8·00	25·92	29·44	31·04	60·4
44°	47°	28th „ „ 5.20 p.m.	16·24	31·20	47·44	93·68	7·52	101·20	109·92	38·72	148·6
44°	60°	30th „ „ 7.50 a.m.	174·88	40·64	215·52	15·04	4·00	19·04	189·92	44·64	234·5
48°	54°	1st April 1864 „ 2.15 p.m.	33·92	27·04	60·96	27·52	9·12	36·64	61·44	36·16	97·6
44°	48°	2d „ „ 10.5 a.m.	13·68	21·92	35·60	12·72	8·00	20·72	26·40	29·92	56·3
56°	54°	7th „ „ 9.35 a.m.	11·52	24·80	36·32	79·84	4·32	84·16	91·36	29·12	120·4
64°	63°	20th May 1864 „ 1 p.m.	16·40	25·44	41·84	8·32	8·32	16·64	24·72	33·76	58·4
54°	57°	26th „ „ 9.35 p.m.	12·16	25·60	37·76	4·00	6·80	10·80	16·16	32·40	48·5
53°	57°	27th „ „ 12.35 a.m.	11·36	27·20	38·56	3·56	3·64	7·20	14·92	30·84	45·7
52°	60°	27th „ „ 2.45 a.m.	8·60	19·20	27·80	4·12	3·48	7·60	12·72	22·68	35·4
51°	56°	27th „ „ 4.40 a.m.	22·40	19·20	41·60	3·60	4·16	7·76	26·00	23·36	49·3
62°	59°	27th „ „ 1.15 p.m.	12·40	23·04	35·44	6·92	6·16	13·08	19·32	29·20	48·5
63°	59°	28th „ „ 1.10 p.m.	12·36	20·64	33·00	8·44	6·16	14.60	20·80	26·80	47·6
47°	68°	30th „ „ 7.10 p.m.	130·56	38·40	168·96	60·80	5·92	66·72	191·36	44·32	235·6
		Average of 20 samples -	31·31	26·53	57·84	29·23	9·17	38·40	60·54	35·70	96·2

Table D.

Liquids collected from the Drains and Sewers discharging into the Water of Leith.

Temperature.		Place and Time of Collection.	In solution.			In suspension.			One imperial gallon contains in solution and suspension.		
Air.	Liquid.		Organic matter in grains.	Saline matter in grains.	Total matter in solution in grains.	Organic matter in grains.	Earthy matter in grains.	Total matter in suspension in grains.	Organic matter in grains.	Saline and earthy matter in grains.	Grand total matter
		North Sewer at Stockbridge.									
Fahr.	Fahr.	Day. Hour.									
45°	43°	18th March 1864 at 12.50 p.m.									
50°	46°	19th „ „ 11.40 a.m.	9·60	23·68	33·28	13·28	9·12	22·40	22·88	32·80	55·6
48°	44°	21st „ „ 5.15 p.m.									
48°	45°	22d „ „ 4.30 p.m.									
45°	46°	23d „ „ 3.35 p.m.	11·68	28·48	40·16	13·28	7·84	21·12	24·96	36·32	61·2
45°	45°	29th „ „ 1.30 p.m.	8·00	27·84	35·84	20·00	9·92	29·92	28·00	37·76	65·7
44°	43°	30th „ „ 8.10 a.m.	6·40	18·08	24·48	10·72	4·00	14·72	17 12	22·08	39·2
48°	44°	1st April 1864 „ 2.45 p.m.	5·44	24·32	29·76	10·72	11·68	22·40	16·16	36·00	52·1
44°	44°	2d „ „ 11.35 a.m.	8·88	23·24	32·12	13·20	9·12	22·32	22·08	32·36	54·4
56°	48°	9th „ „ 4.5 p.m.	4·16	23·68	27·84	11·68	9·12	20·80	15·84	32·80	48·6
		Average of 10 samples -	8·29	24·01	32·33	13·27	8·81	22·08	21·56	32·85	54·4
		South (Moray Place) Sewer at Stockbridge.									
48°	45°	22d March 1864 at 4.35 p.m.	5·08	26·88	31·96	11·88	6·72	18·60	16·96	33·60	50·5
45°	47°	23d „ „ 3.30 p.m.	6·80	22·24	29·04	15·60	7·52	23·12	22·40	29·76	52·1
45°	45°	29th „ „ 1.30 p.m.	5·20	24·64	29·84	16·52	10·72	27·24	21·72	35·36	57·0
48°	45°	1st April 1864 „ 2.45 p.m.	4·00	23·20	27·20	20·48	7·52	28·00	24·48	30·72	55·2
44°	45°	2d „ „ 11.44 p.m.	9·44	29·60	39·04	101·60	48·00	149·60	111·04	77·60	188·6
44°	45°	2d „ „ 11.44 p.m.	9·60	29·60	39·20	80·96	42·72	123·68	90·56	72·32	162·8
64°	54°	25th May 1864 „ 10.55 a.m.	10·16	27·44	37·60	12·32	7·52	19·84	22·48	34·96	57·4
54°	54°	26th „ „ 10.25 p.m.	8·20	17·76	25·96	10·00	7·60	17·60	18·20	25·36	43·5
53°	52°	27th „ „ 1.30 a.m.	6·52	12·80	19·32	6·80	1·80	8·60	13·32	14·60	27·9
52°	50°	27th „ „ 3.33 a.m.	5·08	12·80	17·88	4·20	1·60	5·80	9·28	14·40	23·6
51°	50°	27th „ „ 5.25 a.m.	4·80	14·84	19·64	3·28	0·80	4·08	8·08	15·64	23·7
63°	52°	27th „ „ 2.3 p.m.	9·92	27·60	37·52	13·04	6·96	20·00	22·96	34·56	57·5
		Average of 12 samples -	7·07	22·45	29·52	24·72	12·45	37·17	31·79	34·90	66·6

Table E.

Liquids collected from the Drains and Sewers discharging into the Water of Leith.

Temperature.		Place and Time of Collection.	In solution.			In suspension.			One imperial gallon contains in solution and suspension.		
Air.	Liquid.		Organic matter in grains.	Saline matter in grains.	Total matter in solution in grains.	Organic matter in grains.	Earthy matter in grains.	Total matter in suspension in grains.	Organic matter in grains.	Saline and Earthy matter in grains.	Grand total matter in grains.
		Canonmills Sewer.									
Fahr.	Fahr.	Day. Hour.									
46°	44°	14th March 1864 at 12.59 p.m.									
50°	45°	17th „ „ 2.55 p.m.									
50°	45°	18th „ „ 1.3 p.m.	8·60	23·20	31·80	16·80	13·60	30·40	25·40	36·80	62·20
50°	44°	19th „ „ 11.54 a.m.									
48°	45°	21st „ „ 5.27 p.m.									
48°	45°	22d „ „ 4.54 p.m.									
45°	46°	23d „ „ 3.50 p.m.	8·96	57·76	66·72	47·68	49·92	97·60	56·64	107·68	164·32
46°	46°	26th „ „ 11.32 a.m.	7·68	24·48	32·16	28·32	8·48	36·80	36·00	32·96	68·96
44°	45°	28th „ „ 5.40 p.m.	7·06	23·52	30·58	9·28	5·12	14·40	16·34	28·64	44·98
45°	45°	29th „ „ 1.22 p.m.	8·00	28·80	36·80	20·80	10·72	31·52	28·80	39·52	68·32
44°	44°	30th „ „ 8.18 a.m.	6·08	18·40	24·48	14·40	15·20	29·60	20·48	33·60	54·08
49°	46°	31st „ „ 2.20 p.m.	23·84	24·96	48·80	6·08	8·32	14·40	29·92	38·28	63·20
48°	46°	1st April 1864 „ 2.55 p.m.	8·00	27·20	35·20	8·08	9·92	18·00	16·08	37·12	53·20
44°	45°	2d „ „ 12 noon.	4·00	15·20	19·20	18·72	11·52	30·24	22·72	26·72	49·44
62°	55°	25th May 1864 „ 5.20 p.m.	9·52	23·20	32·72	9·12	7·52	16·64	18·64	30·72	49·36
54°	53°	26th „ „ 10.35 p.m.	8·00	23·20	31·20	8·40	2·40	10·80	16·40	25·60	42·00
53°	51°	27th „ „ 1.45 a.m.	5·24	18·36	23·60	4·28	0·80	5·08	9·52	19·16	28·68
52°	50°	27th „ „ 3.38 a.m.	4·20	15·80	20·00	1·92	0·48	2·40	6·12	16·28	22·40
51°	50°	27th „ „ 5.40 a.m.	3·60	18·40	22·00	2·72	0·48	3·20	6·32	18·88	26·20
56°	50°	27th „ „ 2.18 p.m.	8·60	25·92	34·52	10·64	8·16	18·80	19·24	34·08	53·32
59°	51°	28th „ „ 5.25 p.m.	7·76	21·44	29·20	34·88	9·92	44·80	42·64	31·36	74·00
		Average of 21 samples -	8·20	24·10	32·30	15·50	11·00	26·50	23·70	35·10	58·80

Table F.

Liquids collected from the Drains and Sewers discharging into the Water of Leith.

Temperature.		Place and Time of Collection.	In solution.			In suspension.			One imperial gallon contains in solution and suspension.		
Air.	Liquid.		Organic matter in grains.	Saline matter in grains.	Total matter in solution in grains.	Organic matter in grains.	Earthy matter in grains.	Total matter in suspension in grains.	Organic matter in grains.	Saline and earthy matter in grains.	Grand total matter in grains.
		Broughton Burn Sewer at Bonnington Road, and immediately above junction with Water of Leith.									
Fahr.	Fahr.	Day. Hour.									
65°	57°	9th April 1864 at 11.50 a.m.	9·12	22·24	31·36	14·40	10·88	25·28	23·52	33·12	56·64
64°	61°	25th May 1864 „ 3.20 p.m.	12·00	28·80	40·80	60·48	23·52	84·00	72·48	52·32	124·80
		Average of 2 samples -	10·56	25·52	36·08	37·44	17·20	54·64	48·00	42·72	90·72
		Bulls Stank Sewer at Lovers Loan.									
47°	45°	21st March 1864 at 6.5 p.m.	5·44	31·04	36·48	14·08	5·92	20·00	19·52	36·96	56·48
		Bulls Stank Sewer at Junction Road Bridge, Leith.									
45°	42°	14th March 1864 at 12.37 p.m.									
49°	45°	17th „ „ 4.8 p.m.	5·28	31·04	36·32	10·88	5·92	16·80	16·16	36·96	53·12
36°	40°	19th „ „ 8.5 a.m.									
64°	57°	25th May 1864 „ 1.1 p.m.	8·32	32·96	41·28	7·68	2·72	10·40	16·00	35·68	51·68
		Average of 5 samples -	5·92	31·42	37·34	10·88	5·28	16·16	16·80	36·70	53·50
		Coal Hill Sewer at Leith.									
45°	43°	18th March 1864 at 5.7 p.m.									
36°	49°	19th „ „ 7.50 a.m.	64·64	145·76	210·40	80·48	36·32	116·80	145·12	182·08	327·20
36°	41°	19th „ „ 7.55 a.m.									
		Sewer below Drawbridge at Leith.									
44°	46°	23d March 1864 at 6.50 p.m.	7·84	46·56	54·40	10·40	4·80	15·20	18·24	51·36	69·60

Table G.

Sedimentary Matters collected from the bottom of the open Sewers discharging into the Water of Leith.

Dried at 212° Fahr.

Temperature.		Place and time of collection.	Per-centage composition.			
Air.	Sediment.		Organic matter.	Earthy matter.	Total.	Nitrogen.
						Average Amount.
Fahr. 51°	Fahr. 45°	Edinburgh Sewers, Lochrin Burn, west of Slaughter-houses, collected on 18th March 1864 at 11.35 a.m.	44·92	55·08	100·00	
50°	44°	Edinburgh Sewers, Lochrin Burn, west of Slaughter-houses, collected on 19th March 1864 at 10.35 a.m.	46·12	53·88	100·00	
50°	45°	Edinburgh Sewers, Lochrin Burn, west of Slaughter-houses, collected on 21st March 1864 at 4.10 p.m.	67·72	32·28	100·00	1·30
48°	45°	Edinburgh Sewers, Lochrin Burn, west of Slaughter-houses, collected on 22d March 1864 at 3.12 p.m.	52·44	47·56	100·00	
47°	46°	Edinburgh Sewers, Lochrin Burn, west of Slaughter-houses, collected on 23d March 1864 at 12.30 p.m.	55·32	44·68	100·00	
69°	57°	Edinburgh Sewers, Lochrin Burn, west of Slaughter-houses, collected on 20th May 1864 at 12.20 p.m.	46·12	53·88	100·00	
64°	54°	Edinburgh Sewers, Lochrin Burn, west of Slaughter-houses, collected on 25th May 1864 at 10.25 a.m.	35·32	64·68	100·00	1·20
		Average of 7 samples	49·70	50·30	100·00	1·27
48°	52°	Edinburgh Sewers, Lochrin Burn above Caledonian Distillery, collected on 22d March 1864 at 3.35 p.m.	26·12	73·88	100·00	
47	53°	Edinburgh Sewers, Lochrin Burn, above Caledonian Distillery, collected on 23d March 1864 at 1 p.m.	36·44	63·56	100·00	0·57
64	65°	Edinburgh Sewers, Lochrin Burn, above Caledonian Distillery, collected on 20th May 1864 at 12.40 p.m.	20·52	79·48	100·00	0·42
		Average of 3 samples	27·70	72·30	100·00	0·52
50	44°	Edinburgh Sewers, Lochrin Burn, above Coltbridge, collected on 19th March 1864 at 11.12 a.m.	14·52	85·48	100·00	
48°	43°	Edinburgh Sewers, Lochrin Burn, above Coltbridge, collected on 22d March 1864 at 3.55 p.m.	17·20	82·80	100·00	0·77
64°	63°	Edinburgh Sewers, Lochrin Burn, above Coltbridge, collected on 20th May 1864 at 1 p.m.	19·32	80·68	100·00	0·58
		Average of 3 samples	17·02	82·98	100·00	0·71
47	45°	Edinburgh Sewers, Bulls Stank at Lovers Loan, collected on 21st March 1864 at 6.10 p.m.	50·72	49·28	100·00	0·76
65°	57°	Edinburgh Sewers, Broughton Burn, at Bonnington Road, collected on 9th April 1864 at 12 noon	20·52	79·48	100·00	0·82

Table H.

Liquids collected from the Water of Leith above Coltbridge.

Temperature.		Place and Time of Collection.	In solution.			In suspension.			One imperial gallon contains in solution and suspension.		
Air.	Liquid.		Organic matter in grains.	Saline matter in grains.	Total matter in solution in grains.	Organic matter in grains.	Earthy matter in grains.	Total matter in suspension in grains.	Organic matter in grains.	Saline and earthy matter in grains.	Grand total matter in grains.
Fahr. 44°	Fahr. 35°	Harelaw Reservoir on 24th March 1864 at 11.4 a.m.	2·32	3·88	6·20	0·24	2·72	2·96	2·56	6·60	9·16
44°	35°	Bavelaw Burn above Works, on 24th March 1864 at 11.22 a.m.	2·60	4·60	7·20	1·16	1·72	2·88	3·76	6·32	10·08
46°	41°	Bavelaw Burn, below Hill's Mill, on 24th March 1864 at 12.30 p.m.	2·60	5·60	8·20	1·83	1·12	2·95	4·43	6·72	11·15
47°	41°	Water of Leith above Balerno Bridge, on 24th March 1864 at 12.35 p.m.	1·64	8·80	10·44	0·36	2·72	3·08	2·00	11·52	13·52
47°	41°	Water of Leith above Kinleith Mill, on 24th March 1864 at 1.10 p.m.	3·36	7·04	10·40	0·96	2·02	2·98	4·32	9·06	13·38
47°	41°	Water of Leith below Kinleith Mill, on 24th March 1864 at 1.45 p.m.	4·32	8·08	12·40	1·12	3·36	4·48	5·44	11·44	16·88
47°	41°	Water of Leith above Katesmill, on 24th March 1864 at 2.30 p.m.	4·00	9·60	13·60	1·76	4·80	6·56	5·76	14·40	20·16
47°	41°	Water of Leith below Katesmill, on 24th March 1864 at 2.45 p.m.	7·20	16·80	24·00	1·28	2·64	3·92	8·48	19·44	27·92
47°	41°	Water of Leith below Katesmill, on 24th March 1864 at 2.45 p.m.	8·00	17·92	25·92	1·33	2·72	4·05	9·33	20·64	29·97
47°	42°	Water of Leith at Gorgie Dam, on 24th March 1864 at 3.40 p.m.	4·36	10·40	14·76	2·84	3·52	6·36	7·20	13·92	21·12
61°	52°	Water of Leith at Gorgio Dam, on 27th May 1864 at 12.45 p.m.	3·76	13·28	17·04	0·76	0·51	1·27	4·52	13·79	18·31
		Water of Leith immediatcly above Coltbridge.									
48°	42°	17th March 1864 at 2.18 p.m.									
47°	47°	18th " " 12.20 p.m.									
50°	42°	19th " " 11.20 a.m.	3·70	11·36	15·06	2·56	3·52	6·08	6·26	14·88	21·14
47°	41°	21st " " 4.57 p.m.									
48°	43°	22d " " 4.1 p.m.									
50°	43°	23d " " 1.35 p.m.	2·68	12·32	15·00	2·64	3·04	5·68	5·32	15·36	20·68
50°	43°	23d " " 1.40 p.m.	2·56	12·48	15·04	2·12	3·04	5·16	4·68	15·52	20·20
47°	41°	24th " " 4.0 p.m.	3·96	9·60	13·56	2·40	3·52	5·92	6·36	13·12	19·48
44°	41°	26th " " 11.10 a.m.	3·96	13·76	17·72	1·28	3·52	4·80	5·24	17·28	22·52
44°	41°	28th " " 5.15 p.m.	3·00	12·20	15·20	2·88	2·72	5·60	5·88	14·92	20·80
45°	42°	29th " " 1.55 p.m.	3·68	14·40	18·08	1·28	2·72	4·00	4·96	17·12	22·08
44°	41°	30th " " 7.45 a.m.	3·36	11·66	15·02	1·60	3·20	4·80	4·96	14·86	19·82
49°	43°	31st " " 1.55 p.m.	3·20	11·36	14·56	0·48	1·12	1·60	3·68	12·48	16·16
48°	43°	1st April 1864 " 2.22 p.m.	2·24	13·12	15·36	0·80	2·72	3·52	3·04	15·84	18·88
44°	40°	2nd " " 10.10 a.m.	1·80	10·08	11·88	2·20	3·20	5·40	4·00	13·28	17·28
56°	54°	7th " " 1.45 p.m.	3·32	16·00	19·32	2·00	3·00	5·00	5·32	19·00	24·32
64°	60°	20th May 1864 " 1.10 p.m.	3·60	15·60	19·20	1·28	1·12	2·40	4·88	16·72	21·60
62°	58°	25th " " 6.45 p.m.	3·40	16·64	20·04	0·98	0·36	1·34	4·38	17·00	21·38
54°	57°	26th " " 9.40 p.m	3·80	14·24	18·04	1·60	0·80	2·40	5·40	15·04	20·44
53°	55°	27th " " 12·40 a.m.	2·56	12·80	15·36	1·28	0·32	1·60	3·84	13·12	16·96
52°	56°	27th " " 2.50 a.m.	3·84	13·60	17·44	0·96	0·32	1·28	4·80	13·92	18·72
51°	54°	27th " " 4.49 a.m.	4·16	15·04	19·20	0·48	0·32	0·80	4·64	15·36	20·00
62°	53°	27th " " 1.0 p.m.	3·28	16·32	19·60	0·80	0·80	1·60	4·08	17·12	21·20
		Average of 23 samples	3·34	12·96	16·30	1·73	2·32	4·05	5·07	15·28	20·35

Table I.

Liquids collected from the Water of Leith from Coltbridge down to dam below Water of Leith Village.

Temperature.		Place and Time of Collection.	In solution.			In suspension.			One imperial gallon contains in solution and suspension.		
Air.	Liquid.		Organic matter in grains.	Saline matter in grains.	Total matter in solution in grains.	Organic matter in grains.	Saline matter in grains.	Total matter in suspension in grains.	Organic matter in grains.	Saline and earthy matter in grains.	Grand total in matter in grains.
		Water of Leith at dam below Coltbridge.									
Fahr. 62°	Fahr. 58°	Day. 25th May 1864 at Hour. 7.0 p.m.	6·40	16·80	23·20	2·96	1·32	4·28	9·36	18·12	27·48
		Water of Leith at dam above Water of Leith village.									
50°	43°	23d March 1864 at 2 35 p.m.	4·32	12·48	16·80	4·64	2·88	7·52	8·96	15·36	24·32
56°	54°	7th April 1864 „ 2.20 p.m.	4·88	11·20	16·08	6·54	3·20	9·74	11·42	14·40	25·82
		Average of 2 samples -	4·60	11·84	16·44	5·59	3·04	8·63	10·19	14·88	25·07
		Water of Leith at dam below Water of Leith village.									
44°	42°	2d April 1864 at 10.30 a.m.	4·64	14·56	19·20	14·40	4·32	18·72	19·04	18·88	37·92
56°	54°	7th „ „ 2.10 p.m.	4·48	11·20	15·68	4·00	1·12	5·12	8·48	12·32	20·80
64°	61°	20th May 1864 „ 1.52 p.m.	6·40	15·20	21·60	3·20	2·24	5·44	9·60	17·44	27·04
54°	56°	26th „ „ 9.55 p.m.	6·08	17·60	23·68	2·40	0·48	2·88	8·48	18·08	26·56
53°	55°	27th „ „ 1.0 a.m.	4·64	15·52	20·16	3·68	1·12	4·80	8·32	16·64	24·96
52°	54°	27th „ „ 3.5 a.m.	5·60	13·60	19·20	2·08	0·80	2·88	7·68	14·40	22·08
51°	54°	27th „ „ 5.5 a.m.	5·40	15·36	20·76	1·64	0·38	2·02	7·04	15·74	22·78
64°	53°	27th „ „ 1.35 p.m.	5·68	16·40	22·08	2·80	0·60	3·40	8·48	17·00	25·48
		Average of 8 samples -	5·36	14·93	20·29	4·27	1·38	5·65	9·63	16·31	25·94

Table K.

Liquids collected from the Water of Leith from the dam below Water of Leith Village (where Edinburgh Lade begins) to St. Mark's Place (where Edinburgh Lade again joins the stream).

Temperature.		Place and Time of Collection.	In solution.			In suspension.			One imperial gallon contains in solution and suspension.		
Air.	Liquid.		Organic matter in grains.	Saline matter in grains.	Total matter in solution in grains.	Organic matter in grains.	Earthy matter in grains.	Total matter in suspension in grains.	Organic matter in grains.	Saline and earthy matter in grains.	Grand total in matter in grains.
		Water of Leith under Dean Bridge.									
Fahr. 62°	Fahr. 58°	Day. 25th May 1864 at Hour. 6.25 p.m.	14·40	14·24	28·64	3·08	1·12	4·20	17·48	15·36	32·84
54°	56°	26th „ „ 10.0 p.m.	7·52	14·56	22·08	2·96	0·64	3·60	10·48	15·20	25·68
53°	55°	27th „ „ 1.5 a.m.	5·20	19·20	24·40	2·40	0·80	3·20	7·60	20·00	27·60
52°	54°	27th „ „ 3.10 a.m.	5·36	15·60	20·96	2·96	0·64	3·60	8·32	16·24	24·56
51°	54°	27th „ „ 5.10 a.m.	4·80	14·80	19·60	2·36	0·46	2·82	7·16	15·26	22·42
64°	53°	27th „ „ 1.40 p.m.	7·08	16·00	23·08	2·80	0·50	3·30	9·88	16·50	26·38
		Average of 6 samples -	7·39	15·73	23·12	2·76	0·69	3·45	10·15	16·42	26·57

Table K.—*continued.*

Liquids collected from the Water of Leith from the dam below Water of Leith Village (where Edinburgh Lade begins) to St. Mark's Place (where Edinburgh Lade again joins the stream).

Temperature.		Place and Time of Collection.	In solution.			In suspension.			One imperial gallon contains in solution and suspension.		
Air.	Liquid.		Organic matter in grains.	Saline matter in grains.	Total matter in solution in grains.	Organic matter in grains.	Earthy matter in grains.	Total matter in suspension in grains.	Organic matter in grains.	Saline and earthy matter in grains.	Grand total matter in grains.
		Water of Leith behind Moray Place, near St. Bernard's Well.									
Fahr.	Fahr.	Day. Hour.									
62°	58°	25th May 1864 at 6.10 p.m.	11·68	18·40	30·08	3·43	0·82	4·30	15·16	19·22	34·38
54°	56°	26th „ „ 10.10 p.m.	7·60	15·20	22·80	2·86	0·64	3·50	10·46	15·84	26·30
53°	55°	27th „ „ 1.20 a.m.	6·40	19·20	25·60	2·76	0·64	3·40	9·16	19·84	29·00
52°	54°	27th „ „ 3.20 a.m.	5·48	16·80	22·28	2·12	0·48	2·60	7·60	17·28	24·88
51°	54°	27th „ „ 5.10 a.m.	3·52	14·40	17·92	1·96	0·56	2·52	5·48	14·96	20·44
64°	53°	27th „ „ 1.50 p.m.	6·48	11·52	18·00	3·32	1·06	4·38	9·80	12·58	22·38
		Average of 6 samples -	6·86	15·08	21·94	2·75	0·70	3·45	9·61	15·78	25·39
		Water of Leith immediately above Stockbridge.									
64°	58°	25th May 1864 at 10.55 a.m.	13·60	16·80	30·40	3·12	0·60	3·72	16·72	17·40	34·12
54°	55°	26th „ „ 10.27 p.m.	6·40	14·40	20·80	2·80	0·76	3·56	9·20	15·16	24·36
53°	55°	27th „ „ 1.34 a.m.	6·00	18·56	24·56	2·92	0·48	3·40	8·92	19·04	27·96
52°	54°	27th „ „ 3.30 a.m.	5·80	17·60	23·40	1·96	0·64	2·60	7·76	18·24	26·00
51°	54°	27th „ „ 5.28 a.m.	6·40	14·40	20·80	1·84	0·42	2·26	8·24	14·82	23·06
63°	52°	27th „ „ 2.6 p.m.	6·00	15·20	21·20	2·64	0·60	3·24	8·64	15·80	24·44
		Average of 6 samples -	7·36	16·16	23·52	2·55	0·58	3·13	9·91	16·74	26·65
		Water of Leith 30 yards below Stockbridge.									
61°	56°	25th May 1864 at 10.45 a.m.	13·76	14·40	28·16	41·12	5·72	46·84	54·88	20·12	75·00
64°	56°	25th „ „ 10.45 a.m.	16·00	16·00	32·00	32·88	4·92	37·80	48·88	20·92	69·80
62°	55°	25th „ „ 5.40 p.m.	10·40	20·96	31·36	11·44	1·12	12·56	21·84	22·08	43·92
54°	53°	26th „ „ 10.30 p.m.	6·76	15·36	22·12	4·48	3·24	7·72	11·24	18·60	29·84
53°	54°	27th „ „ 1.36 a.m.	7·20	14·12	21·32	4·64	1·16	5·80	11·84	15·28	27·12
52°	53°	27th „ „ 3.33 a.m.	5·44	14·80	20·24	4·80	0·83	5·63	10·24	15·63	25·87
51°	53°	27th „ „ 5.30 a.m.	5·00	13·28	18·28	3·28	2·32	5·60	8·28	15·60	23·88
63°	52°	27th „ „ 2.8 p.m.	6·96	13·60	20·56	12·64	1·32	13·96	19·60	14·92	34·52
59°	52°	28th „ „ 5.45 p.m.	8·80	16·00	24·80	12·88	1·92	14·80	21·68	17·92	39·60
		Average of 9 samples -	8·92	15·40	24·32	14·24	2·50	16·74	23·16	17·90	41·06
		Water of Leith behind Warriston Crescent.									
62°	60°	25th May 1864 at 5.10 p.m.	7·04	25·60	32·64	10·68	3·52	14·20	17·72	29·12	46·84

Table L.

Liquids collected from the Edinburgh Lade flowing from the Dam below Water of Leith Village to St. Mark's Place.

Temperature.		Place and Time of Collection.	In solution.			In suspension.			One imperial gallon contains in solution and suspension.		
Air.	Liquid.		Organic matter in grains.	Saline matter in grains.	Total matter in solution in grains.	Organic matter in grains.	Earthy matter in grains.	Total matter in suspension in grains.	Organic matter in grains.	Saline and earthy matter in grains.	Grand total matter in grains.
Fahr.	Fahr.	Water of Leith Lade behind India Place. Day. Hour.									
64°	61°	20th May 1864 at 2.30 p.m.	7·36	15·44	22·80	3·68	2·52	6·20	11·04	17·96	29·00
54°	56°	26th „ „ 10.12 p.m.	7·20	16·20	23·40	2·44	0·96	3·40	9·64	17·16	26·80
53°	55°	27th „ „ 1.25 a.m.	4·80	15·80	20·60	2·72	0·48	3·20	7·52	16·28	23·80
52°	54°	27th „ „ 3.25 a.m.	4·96	20·00	24·96	2·28	0·32	2·60	7·24	20·32	27·56
51°	54°	27th „ „ 5.22 a.m.	5·60	18·80	24·40	2·56	0·64	3·20	8·16	19·44	27·60
63°	53°	27th „ „ 1.55 p.m.	6·40	16·60	23·00	3·36	1·44	4·80	9·76	18·04	27·80
		Average of 6 samples -	6·05	17·14	23·19	2·84	1·06	3·90	8·89	18·20	27·09
		Water of Leith Lade below Beaver Hall.									
64°	60°	25th May 1864 at 4.35 p.m.	12·00	18·40	30·40	3·64	1·92	5·56	15·64	20·32	35·96
54°	51°	27th „ „ 2.35 p.m.	8·40	16·16	24·56	8·40	0·80	9·20	16·80	16·96	33·76
		Average of 2 samples -	10·20	17·28	27·48	6·02	1·36	7·38	16·22	18·64	34·86

Table M.

Liquids collected from the Water of Leith at St. Mark's Place after junction with the Edinburgh Lade.

Temperature.		Place and Time of Collection.	In solution.			In suspension.			One imperial gallon contains in solution and suspension.		
Air.	Liquid.		Organic matter in grains.	Saline matter in grains.	Total matter in solution in grains.	Organic matter in grains.	Earthy matter in grains.	Total matter in suspension in grains.	Organic matter in grains.	Saline and earthy matter in grains.	Grand total matter in grains.
Fahr.	Fahr.	St. Mark's Place below junction of Lade. Day. Hour.									
50°	43°	17th March 1864 at 3.3 p.m.	3·52	9·76	13·28	5·28	3·52	8·80	8·80	13·28	22·08
48°	44°	22d „ „ 5.2 p.m.									
48°	44°	22d „ „ 5.12 p.m.	3·20	15·52	18·72	4·80	8·00	12·80	8·00	23·52	31·52
44°	41°	23d „ „ 4.5 p.m.	7·20	14·72	21·92	6·88	5·12	12·00	14·08	19·84	33·92
46°	45°	26th „ „ 11.40 a.m.	7·52	14·72	22·24	11·68	5·12	16·80	19·20	19·84	39·04
41°	42°	28th „ „ 5.50 p.m.	6·72	11·52	18·24	5·28	5·92	11·20	12·00	17·44	29·44
45°	43°	29th „ „ 1.15 p.m.	9·76	16·00	25·76	14·10	5·92	20·32	24·16	21·92	46·08
44°	42°	30th „ „ 8.25 a.m.	9·60	14·56	24·16	3·12	2·00	5·12	12·72	16·56	29·28
49°	46°	31st „ „ 2.30 p.m.	6·40	10·40	16·80	4·16	5·12	9·28	10·56	15·52	26·08
48°	46°	1st April 1864 „ 3 p.m.	11·60	16·96	28·56	41·48	14·72	56·20	53·08	31·68	84·76
44°	43°	2d „ „ 12.8 p.m.	9·36	14·72	24·08	23·28	29·92	53·20	32·64	44·64	77·28
64°	62°	20th May 1864 „ 2.55 p.m.	8·80	16·00	24·80	26·88	29·12	56·00	35·68	45·12	80·80
64°	60°	25th „ „ 4.45 p.m.	21·44	18·00	39·44	143·36	145·12	288·48	164·80	163·12	327·92
54°	53°	26th „ „ 10.40 p.m.	6·68	19·20	25·88	4·92	2·48	7·40	11·60	21·68	33·28
53°	54°	27th „ „ 1.49 a.m.	6·00	16·80	22·80	4·76	2·32	7·08	10·76	19·12	29·88
52°	53°	27th „ „ 3.45 a.m.	7·60	16·80	24·40	3·20	1·80	5·00	10·80	18·60	29·40
51°	53°	27th „ „ 5.50 a.m.	6·40	13·60	20·00	5·44	1·96	7·40	11·84	15·56	27·40
62°	52°	27th „ „ 2.30 p.m.	8·32	15·20	23·52	18·24	3·16	21·40	26·56	18·36	44·92
		Average of 18 samples -	7·98	14·68	22·66	18·47	15·27	33·73	26·45	29·95	56·39

Table N.

Liquids collected from the Water of Leith from St. Mark's Place down to the Harbour of Leith.

Temperature.		Place and Time of Collection.	In solution.			In suspension.			One imperial gallon contains in solution and suspension.		
Air.	Liquid.		Organic matter in grains.	Saline matter in grains.	Total matter in solution in grains.	Organic matter in grains.	Earthy matter in grains.	Total matter in suspension in grains.	Organic matter in grains.	Saline and earthy matter in grains.	Grand total matter in grains.
Fahr.	Fahr.	Water of Leith from Dam above Bonnington. Day. Hour.									
64°	61°	25th May 1864 at 4.15 p.m.	12·80	17·80	30·60	115·68	153·12	268·80	128·48	170·92	299·40
		Water of Leith at Boundary of Edinburgh and Leith at Bonnington Bridge.									
64°	62°	25th May 1864 at 3.45 p.m.	10·24	17·60	27·84	30·88	33·12	64·00	41·12	50·72	91·84
		Water of Leith from Dam above Junction Road Bridge.									
64°	61°	25th May 1864 at 3 p.m.	16·96	21·92	38·88	500·96	369·12	870·08	517·92	391·04	908·96
		Water of Leith above Saw-mills.									
36°	40°	19th March 1864 at 8.22 a.m.	4·32	10·08	14·40	5·20	3·52	8·72	9·52	13·60	23·12
		Water of Leith below Junction Road Bridge and off Bulls Stank Sewer.									
49°	44°	17th March 1864 at 4.10 p.m.	4·32	12·32	16·64	3·36	4·64	8·00	7·68	16·96	24·64
64°	61°	25th May 1864 „ 1 p.m.	14·04	24·32	38·36	4·08	1·92	6·00	18·12	26·24	44·36
		Average of 2 samples -	9·18	18·32	27·50	3·72	3·28	7·00	12·90	21·60	34·50
		Water of Leith above Coal Hill.									
45°	43°	18th March 1864 at 5.13 p.m.	8·64	76·00	84·64	10·88	5·92	16·80	19·52	81·92	101·44
46°	43°	21st „ „ 5.45 p.m.									
45°	44°	29th „ „ 12.55 p.m.	9·76	44·80	54·56	21·12	5·92	27·04	30·88	50·72	81·60
		Average of 3 samples -	9·01	65·60	74·61	14·29	5·92	20·21	23·30	71·52	94·82
		Water of Leith from off Coal Hill Sewer.									
42°	42°	23d March 1864 at 6.35 p.m.	35·20	170·08	205·28	8·32	6·72	15·04	43·52	176·80	220·32
		Water of Leith from harbour at Upper Drawbridge.									
54°	56°	26th May 1864 at 11 p.m.	27·36	157·76	185·12	4·16	3·84	8·00	31·52	161·60	193·12
		Water of Leith below Upper Drawbridge.									
42°	42°	25th March 1864 at 6.45 p.m.	31·84	609·60	641·44	10·72	10·40	21·12	42·56	620·00	662·56
		Water of Leith in harbour off Victoria Dock Head.									
64°	52°	25th May 1864 at 12.20 p.m. Low Water.	3·92	1208·80	1212·72	1·32	1·12	2·44	5·24	1209·92	1215·16

Table O.

Sedimentary Matters collected from the Bed of the Water of Leith, and from the Bottom of the Edinburgh Lade.

Dried at 212° Fahr.

Temperature.		Place and Time of Collection.	Per-centage composition.			
Air.	Sediment.		Organic matter.	Earthy matter.	Total.	Nitrogen.
		Bed of Water of Leith.				
Fahr. 56°	Fahr. 43°	Underneath dam below Water of Leith Village, collected on 23d March 1864 at 2.10 p.m.	82·12	17·88	100·00	2·04
44°	42°	From dam below Water of Leith Village, collected on 2d April 1864 at 10.40 a.m.	35·32	64·68	100·00	
64°	61°	From dam below Water of Leith Village, collected on 20th May 1864 at 1.32 p.m.	35·72	64·28	100·00	1·12
64°	61°	Below Dean Bridge, collected on 20th May 1864 at 1.40 p.m.	39·32	60·68	100·00	1·31
		Average of 4 samples	48·12	51·88	100·00	1·63
44°	42°	Behind Ainslie and Moray Place, collected on 2d April 1864 at 11.25 a.m.	49·72	50·28	100·00	0·98
64°	61°	Behind Ainslie and Moray Place, collected on 20th May 1864 at 2 p.m.	40·12	59·88	100·00	
		Average of 2 samples	44·92	55·08	100·00	0·98
45°	43°	Sediment lying in bed of Water of Leith, 4 to 6 yards below North Sewer at Stockbridge, collected on 18th March 1864 at 12.55 p.m.	41·52	58·48	100·00	
50°	46°	Sediment lying in bed of Water of Leith, 4 to 6 yards below North Sewer at Stockbridge, collected on 19th March at 11.40 a.m.	23·92	76·08	100·00	
48°	44°	Sediment lying in bed of Water of Leith, 4 to 6 yards below North Sewer at Stockbridge, collected on 21st March 1864 at 5.20 p.m.	48·32	51·68	100·00	
48°	45°	Sediment lying in bed of Water of Leith, 4 to 6 yards below North Sewer at Stockbridge, collected on 22d March 1864 at 4.35 p.m.	66·52	33·48	100·00	
48°	45°	Sediment lying in bed of Water of Leith, below South Sewer at Stockbridge, collected on 22d March 1864 at 4.45 p.m.	37·12	62·88	100·00	1·14
45°	46°	Sediment lying in bed of Water of Leith, below North and South Sewers at Stockbridge, collected on 23d March 1864 at 3.35 p.m.	28·56	71·44	100·00	
48	41°	Sediment lying in bed of Water of Leith below North and South Sewers at Stockbridge, collected on 1st April 1864 at 2.45 p.m.	54·56	45·44	100·00	
41°	45°	Sediment lying in bed of Water of Leith below North and South Sewers at Stockbridge, collected on 2d April 1864 at 11.45 a.m.	48·80	51·20	100·00	
		Average of 8 samples	43·67	56·33	100·00	1·14
61°	61°	Sides of narrowed channel of Water of Leith at Stockbridge below sewers, collected on 20th May 1864 at 2.40 p.m.	34·52	65·48	100·00	0·50
62°	59°	Eighty yards below Stockbridge, collected on 25th May 1864 at 2.55 p.m.	25·12	74·88	100·00	1·08
62°	59°	Behind Malta Terrace, collected on 25th May 1864 at 5.30 p.m.	32·52	67·48	100·00	

Table O.—*continued.*

Sedimentary Matters collected from the Bed of the Water of Leith, and from the Bottom of the Edinburgh Lade.

Dried at 212° Fahr.

Temperature.		Place and Time of Collection.	Per-centage composition.			
Air.	Sediment.		Organic matter.	Earthy matter.	Total.	Nitrogen.
Fahr.	Fahr.	Bed of Water of Leith—*cont.*				
50°	45°	Sediment in bed of Water of Leith in front of sewer at Canonmills, collected on 18th March 1864 at 1.5 p.m.	31·72	68·28	100·00	0·57
62°	60°	Behind Warriston Crescent, collected on 25th May 1864 at 5.10 p.m.	13·32	86·68	100·00	0·55
48°	44°	At St. Mark's Place, collected on 22d March 1864 at 5.12 p.m.	40·72	59·28	100·00	
44°	44°	At St. Mark's Place, collected on 23d March 1864 at 4.5 p.m.	41·24	58·76	100·00	
44°	43°	At St. Mark's Place, collected on 2d April 1864 at 12.10 p.m.	24·40	75·60	100·00	1·14
62°	50°	At St. Mark's Place, collected on 9th April 1864 at 3.45 p.m.	40·52	59·48	100·00	
64°	62°	At St. Mark's Place, collected on 20th May 1864 at 2.55 p.m.	40·52	59·48	100·00	
62°	60°	At St. Mark's Place, collected on 25th May 1864 at 4.50 p.m.	30·92	69·08	100·00	
54°	53°	At St. Mark's Place, collected on 27th May 1864 at 5.55 p.m.	44·70	55·30	100·00	1·08
62°	60°	At St. Mark's Place, collected on 25th May 1864 (green matter) at 5 p.m.	48·12	51·88	100·00	
		Average of 9 samples	36·05	63·95	100·00	1·05
64°	61°	At dam above Bonnington, collected on 25th May 1864 at 4.15 p.m.	49·72	50·28	100·00	1·40
64°	62°	At Boundary of Edinburgh and Leith at Bonnington Bridge, collected on 25th May 1864 at 3.45 p.m.	26·92	73·08	100·00	0·70
64°	61°	Immediately below the junction of the Broughton Burn, collected on 9th April 1864 at 12.5 p.m.	13·72	86·28	100·00	0·52
64°	61°	Dam above Junction Road Bridge, collected on 25th May 1864 at 3.5 p.m.	27·72	72·28	100·00	0·70
		Water of Leith Lade which traverses Edinburgh.				
44°	42°	Mud taken from lade behind Ainslie Place, collected on 2d April 1864 at 10.45 a.m.	12·52	87·48	100·00	0·34
44°	42°	Mud taken from lade behind Moray Place, collected on 2d April 1864 at 11.0 a.m.	21·48	78·52	100·00	0·62
64°	61°	Mud taken from lade behind Moray and Ainslie Places, collected on 20th May 1864 at 2.10 p.m.	11·32	88·68	100·00	0·46
50°	43°	Mud taken from lade behind India Place, collected on 23d March 1864 at 3.20 p.m.	21·12	78·88	100·00	0·59
56°	42°	Mud taken from lade behind India Place, collected on 7th April 1864 at 3.15 p.m.	37·00	63·00	100·00	0·84
64°	61°	Mud taken from lade behind India Place, collected on 20th May 1864 at 2.25 p.m.	20·92	79·08	100·00	0·62
44°	42°	Mud taken from lade above Canonmills, collected on 2d April 1864 at 12.3 p.m.	55·52	44·48	100·00	1·34
		Average of 7 samples	25·70	74·30	100·00	0·69

Table P.

Sedimentary Matters collected from the bed of the Harbour of Leith.

Dried at 212° Fahrenheit.

Temperature.		Place and Time of Collection.	Per-centage composition.			
Air.	Sediment.		Organic matter.	Earthy matter.	Total.	Nitrogen.
Fahr. 36°	Fahr. 41°	South-east side of harbour of Leith, bank below Junction Road Bridge, and off Bulls Stank Sewer, collected on 19th March 1864 at 8.10 p.m.	31·40	68·60	100·00	
42°	42°	South-east side of harbour of Leith, bank above Coalhill, collected on 23d March 1864 at 7.15 p.m.	47·72	52·28	100·00	
46°	45°	South-east side of harbour of Leith, 10 yards above Coalhill, collected on 21st March 1864 at 5.48 p.m.	21·92	78·08	100·00	
45°	45°	South-east side of harbour of Leith, 10 yards above Coalhill, collected on 29th March 1864 at 12.55 p.m.	52·50	47·50	100·00	0·84
36°	41°	South-east side of harbour of Leith, 3 yards in front of Coalhill, collected on 19th March 1864 at 7.52 a.m.	60·28	39·72	100·00	
42°	42°	South-east side of harbour of Leith, alongside Coalhill, collected on 23d March 1864 at 6.30 p.m.	27·72	72·28	100·00	
64°	56°	South-east side of harbour of Leith, between drawbridges, collected on 25th May 1864 at 11.40 a.m.	10·52	89·48	100·00	0·41
42°	42°	South-east side of harbour of Leith, below second drawbridge, collected on 23d March 1864 at 6.55 p.m.	10·36	89·64	100·00	0·43
64°	54°	South-east side of harbour of Leith, below second drawbridge, collected on 25th May 1864 at 12.15 p.m.	16·92	83·08	100·00	0·57
42°	42°	South-east side of harbour of Leith, off Ferry Boat Stairs, collected on 23d March 1864 at 7.0 p.m.	18·72	81·28	100·00	0·61
64°	52°	South-east side of harbour of Leith, at entrance to Prince of Wales Graving Dock, collected on 25th May 1864 at 12.30 p.m.	15·72	84·28	100·00	
60°	50°	South-east side of harbour of Leith, at entrance to Prince of Wales Graving Dock, collected on 28th May 1864 (Dredger) at 2.45 p.m.	26·20	73·80	100·00	0·58
		Average of 12 samples	28·33	71·67	100·00	0·64
36°	41°	North-west side of harbour of Leith, opposite Coalhill, collected on 19th March 1864 at 7.45 a.m.	25·32	74·68	100·00	
42°	42°	North-west side of harbour of Leith, at upper drawbridge, collected on 23d March 1864 at 6.25 p.m.	22·05	77·95	100·00	
42°	42°	North-west side of harbour of Leith, opposite Fishmarket, collected on 23d March 1864 at 6.40 p.m.	32·20	67·80	100·00	0·63
42°	42°	North-west side of harbour of Leith, below Second Drawbridge, collected on 23d March 1864 at 6.50 p.m.	16·84	83·16	100·00	
64°	54°	North-west side of harbour of Leith, at side of Custom-house, collected on 25th May 1864 at 11.35 a.m.	12·52	87·48	100·00	
64°	52°	North-west side of harbour of Leith, off bank at west side of Jetty Head, entrance to Victoria Dock, collected on 25th May 1864 at 12.10 p.m.	12·12	87·88	100·00	0·41
		Average of 6 samples	20·18	79·82	100·00	0·62

Table Q.

Gases evolved during the decomposition of the Sedimentary Matters lying in the Edinburgh Sewers and in the Bed of the Water of Leith.

Temperature of Sediment.	Places and Time of Collection.	Per-centage composition of the gases by volume.		
		Carbonic acid.	Oxygen.	Other gases.
Fahr.				
45°	Gases evolved from sediment in Lochrin Burn, west of Slaughter-houses, collected on 14th April 1864 - -	14·63	0·81	84·56, combustible with blue-white flame.
46°	Gases evolved from sediment in bed of Water of Leith at Coltbridge, collected on 14th April 1864 - - -	6·21	0·69	93·10 „ „
	Gases evolved from sediment in bed of Water of Leith at Coltbridge, collected on 30th May 1864 at 7 p.m. - -	12·00	1·20	86·80 „ „
47°	Gases evolved from sediment in bed of Water of Leith, behind Moray Place near St. Bernard's Well, collected on 14th April 1864 - - - - -	14·65	0·32	85·03 „ „
54°	Gases evolved from sediment in bed of Water of Leith, behind Moray Place near St. Bernard's Well, collected on 30th May 1864 at 6·35 p.m. - -	3·60	1·80	94·60 „ „
47°	Gases evolved from sediment in lade behind India Place, collected on 14th April 1864 - - - - - -	1·56	1·56	96·88 „ „
54°	Gases evolved from sediment in lade behind India Place, collected on 30th May 1864 at 6·20 p.m. - - -	1·60	1·40	97·00 „ „
54°	Gases evolved from sediment in bed of Water of Leith, below Stockbridge, on 30th May 1864 at 6·5 p.m. - -	4·30	0·50	95·20 „ „
54°	Gases evolved from sediment in bed of Water of Leith, behind Warriston Crescent, collected on 30th May 1864 at 5·50 p.m. - - - - - -	4·90*	1·60	93·50 „ „
47°	Gases evolved from sediment in bed of Water of Leith, at St. Mark's Place, collected on 14th April 1864 - -	3·63	2·17	94·20 „ „
54°	Gases evolved from sediment in bed of Water of Leith, at St. Mark's Place, collected on 30th May 1864 at 5·30 p.m. - - - - - -	4·80	1·90	93·30 „ „
54°	Gases evolved from sediment in bed of Water of Leith, at dam above Junction Road Bridge, collected on 30th May 1864 at 5 p.m. - - - -	9·50	1·40	89·10 „ „
55°	Gases evolved from sediment in bed of Harbour of Leith between Upper and Lower Drawbridges, collected on 30th May 1864 at 4·40 p.m. - - -	25·60*	1·80	72·60 „ „
55°	Gases evolved from sediment in bed of Harbour of Leith off Jetty Head at entrance to Victoria Dock, collected on 30th May 1864 at 4·30 p.m. - -	7·70*	1·40	90·90 „ „
60°	Gases evolved from green slime collected at St. Mark's Place on 4th June at 9·30 a.m. and placed in inverted bottle. In three hours the gas which had been evolved was examined and found to consist of - - - - - -	13·40	1·60	85·00 „ „
60°	Gases evolved from green slime or matter collected at St. Mark's Place on 4th June at 9·30 a.m. and placed in bottle containing one-third of green slime, and the remaining two-thirds of common air. The atmosphere in forty hours extinguished a lighted taper and was found to consist of - - -	11·56	2·01	86·43 not combustible and not capable of supporting combustion.

* Containing hydro-sulphuric acid in small quantities.

Table R.

Gases dissolved in the Water of the Water of Leith, &c.

Temperature of Matter.	Place and Time of Collection.	Cubic inches of gas per gallon of water.	Per-centage composition of the gases by volume.		
			Carbonic acid.	Oxygen.	Other gases.
44°	Spring water, as supplied to Edinburgh, taken from main leading into the cistern at Surgeons' Hall, on the 16th April 1864 at 10 a.m.	10·01	9·59	28·77	61·64
51°	Spring water, as supplied to Edinburgh, taken from the cistern at Surgeons' Hall after standing a night in the cistern, on 18th April 1864 at 10.5 a.m.	9·96	10·71	29·47	59·82
47°	Spring water, as supplied to Edinburgh, on 27th May 1864 at 3 p.m.	9·33	8·70	29·40	61·90
45°	Water from Harelaw Reservoir, taken on 15th April 1864 at 11 a.m.	9·24	1·92	29·23	68·85
46°	Water from Water of Leith, taken from above Balerno Bridge on 15th April 1864 at 12 noon	9·69	1·89	28·87	69·24
47°	Water from Water of Leith, taken from above Currie on 15th April 1864 at 12.35 p.m.	9·30	5·88	22·06	72·06
52°	Water from Water of Leith, taken from Gorgie Dam on 27th May 1864 at 12.45 p.m.	9·21	6·10	25·20	68·70
46°	Water from Water of Leith, taken above Coltbridge on 14th May 1864	9·60	7·41	22·22	70·37
53°	Water from Water of Leith taken from above Coltbridge on 27th May 1864 at 1 p.m.	9·29	6·60	22·20	71·20
45°	Water from Lochrin Burn, west of slaughter-houses, collected on 14th April 1864	13·71	52·67	3·33	44·00
59°	Water from Lochrin Burn, above Caledonian Distillery, collected on 27th May 1864 at 12.25 p.m.	9·77	50·00	2·70	47·30
59°	Water from Lochrin Burn above Coltbridge, collected on 27th May 1864 at 1.15 p.m.	12·67	54·70	2·10	43·20
52°	Water from Moray Place Sewer, collected on 27th May 1864 at 2.3 p.m.	10·74	42·30	2·80	54·90
50°	Water from sewer at Canonmills, collected on 27th May 1864 at 2.18 p.m.	13·87	59·60	2·60	37·80
53°	Water of Leith from dam below Water of Leith Village, collected on 27th May 1864 at 1.35 p.m.	6·31	6·30	4·20	89·50
53°	Water of Leith below Dean Bridge, collected on 27th May 1864 at 1.40 p.m.	7·22	14·30	5·70	80·00
47°	Water from Water of Leith, behind Moray Place, near St. Bernard's Well, collected on 14th April 1864	6·90	14·29	10·20	75·51
53°	Water from Water of Leith, behind Moray Place, near St. Bernard's Well, on 27th May 1864 at 1.50 p.m.	7·29	22·00	6·10	71·90
52°	Water from Water of Leith, above Stockbridge, collected on 27th May 1864 at 2.6 p.m.	6·95	19·70	6·60	73·70
52°	Water from Water of Leith, 30 yards below Stockbridge, collected on 27th May 1864 at 2.8 p.m.	5·60	24·60	4·10	71·30
47°	Water from Water of Leith at St. Mark's Place, collected on 14th April 1864	7·64	18·60	6·98	74·42
52°	Water from Water of Leith at St. Mark's Place, collected on 27th May 1864 at 2.30 p.m.	8·87	25·80	4·10	70·10
47°	Water from lade behind India Place, collected on 14th April 1864	6·47	9·52	4·76	85·72
53°	Water from lade behind India Place, collected on 27th May 1864 at 1.55 p.m.	7·13	12·80	6·40	80·80
53°	Water from lade before joining Water of Leith at St. Mark's Place, collected on 27th May 1864 at 2.35 p.m.	7·64	14·20	5·40	80·40

Table S.

Examination of the Atmosphere in the neighbourhood of the Water of Leith, &c. determined by standard solution of permanganate of potash.

Degree of absolute purity of air, 100°.

Place and Time of Collection.	Temperature of air.	Degree of purity.
Air collected at west side of St. Andrew's Square, Edinburgh, on 7th April 1864 at 6.35 p.m.	57°	85°
Air collected at the Scott Monument, Princes Street, Edinburgh, on 7th April 1864 at 6.25 p.m.	57°	70°
Air collected on the Calton Hill in Edinburgh on 7th April 1864 at 5.40 p.m.	57°	67°
Air collected over the Lochrin Burn Sewer west of slaughter-houses on 7th April 1864 at 1 p.m.	56°	55°
Air collected in the vicinity of the Canonmills Sewer in the Water of Leith on 7th April 1864 at 5 p.m.	55°	58°
Air collected over the Water of Leith above Coltbridge, and before mingling with sewage, on 7th April 1864 at 1.40 p.m.	56°	75°
Air collected over the Water of Leith below the dam under Water of Leith Village on 7th April 1864 at 2.10 p.m.	58°	(1) 100° destroyed. (2) 100° destroyed. (3) 100°, and only 20° left.
Air collected over the lade behind Moray Place on 7th April 1864 at 2.55 p.m.	56°	55°
Air collected over the Water of Leith at St. Mark's Place on 7th April 1864 at 5.15 p.m.	54°	63°
Air collected at west side of St. Andrew's Square, Edinburgh, on 9th April 1864 at 10.24 a.m.	59°	80°
Air collected on the Calton Hill, Edinburgh (S. of Observatory) on 9th April 1864 at 10.34 a.m.	63°	75°
Air collected in Windsor Street, Edinburgh, on 9th April 1864 at 10.43 a.m.	64°	80°
Air collected at the south-west corners of Constitution and Charlotte Streets, Leith, on 9th April 1864 at 1.20 p.m.	64°	80°
Air collected in harbour of Leith at Victoria Dock Head on 9th April 1864 at 2.50 p.m.	59°	70°
Air collected in harbour of Leith off Ferry Boat Stairs on 9th April 1864 at 3 p.m.	61°	60°
Air collected at foot of Fishmarket Stairs, harbour of Leith, on 9th April 1864 at 11.10 a.m.	59°	60°
Air collected off side of vessel near Coalhill Sewer, Leith, on 9th April 1864 at 11.25 a.m.	63°	50°
Air collected over the Water of Leith, midway between Coalhill and Bulls Stank Sewers on 9th April 1864 at 2.40 p.m.	64°	60°
Air collected at east side of Junction Road Bridge over Water of Leith on 9th April 1864 at 11.33 a.m.	66°	60°
Air collected in the vicinity of the Broughton Burn, near Leith, on 9th April 1864 at 12.15 p.m.	65°	55°
Air collected over the Water of Leith at St. Mark's Place, Edinburgh, on 9th April 1864 at 3.35 p.m.	62°	55
Air collected in the vicinity of the North Sewer at Stockbridge, Edinburgh, on 9th April 1864 at 4 p.m.	56°	55°
Air collected over the lade behind India Place, Edinburgh, on 9th April 1864 at 4.10 p.m.	61°	60°
Air collected under dam below Water of Leith Village, Edinburgh, on 9th April 1864 at 4.30 p.m.	68°	50°
Air collected under dam above Water of Leith Village, Edinburgh, on 9th April 1864 at 4.40 p.m.	61°	55°
Air collected over the Lochrin Burn, west of slaughter-houses, on 14th April 1864 at 11.20 a.m.	60°	68°
Air collected over Water of Leith above Coltbridge, and before mingling with sewage, on 14th April 1864 at 12.20 p.m.	60°	80°
Air collected over Water of Leith behind Moray Place, Edinburgh, on 14th April 1864 at 1 p.m.	63°	66°
Air collected over Water of Leith behind India Place, Edinburgh, on 14th April 1864 at 1.49 p.m.	63°	70°
Air collected in the vicinity of the North Sewer at Stockbridge, Edinburgh, on 14th April 1864 at 1.50 p.m.	62°	64°
Air collected over the Water of Leith at St. Mark's Place, Edinburgh, on 14th April 1864 at 2.30 p.m.	64°	70°

Table T.

Organic growths found in the open sewers and in the Water of Leith conveying sewage.

Dried at 212° Fahrenheit.

Place and Time of Collection.	Per-centage composition.			
	Organic matter.	Earthy matter.	Total.	Nitrogen.
Edinburgh sewers, organic growth collected from Lochrin Burn, west of slaughter-houses, on 23d March 1864 at 1.5 p.m.	64·32	35·68	100·00	0·96
Edinburgh sewers, organic growth collected from Lochrin Burn, west of slaughter-houses, on 20th May 1864 at 12.40 p.m.	40·52	59·48	100·00	0·68
Water of Leith lade, organic growth collected from twigs of trees hanging into the lade behind Moray Place on 23d March 1864 at 3 p.m.	34·60	65·40	100·00	0·52
Water of Leith lade, organic growth collected from the stones of the sides of the lade behind Moray Place on 23d March 1864 at 3.10 p.m.	38·84	61·16	100·00	0·56
Water of Leith lade, organic growth collected from the stones of the sides of the lade behind Moray and Ainslie Place on 28th May 1864 at 2.15 p.m.	57·87	42·13	100·00	1·42
Bed of Water of Leith, organic growth collected off stones in bed of river behind Moray and Ainslie Places on 11th April 1864 at 11.30 a.m.	66·00	34·00	100·00	0·79
Bed of Water of Leith, organic growth collected off sides of run of Water of Leith, 30 yards below Stockbridge, on 20th May 1864 at 2.40 p.m.	52·12	47·88	100·00	0·92
Average of 7 samples	50·61	49·39	100·00	0·84

Table U.

Average Analyses.

Liquids collected from the Drains and Sewers discharging into the Water of Leith. One Imperial Gallon contains

Place of Collection.	In solution.			In suspension.			In solution and suspension.		
	Organic matter in grains.	Saline matter in grains.	Total matter in solution in grains.	Organic matter in grains.	Earthy matter in grains.	Total matter in suspension in grains.	Organic matter in grains.	Saline and earthy matter in grains.	Grand total matter in grains.
Average of 18 samples from Lochrin Burn sewer, west of abbatoir or slaughter-houses	12·36	26·61	38·97	33·06	24·66	57·72	45·42	51·27	96·69
Average of 15 samples from Lochrin Burn sewer, above Caledonian Distillery	15·77	26·70	42·47	28·61	7·79	36·40	44·38	34·49	78·87
Average of 20 samples from Lochrin Burn sewer, above Coltbridge and just before entering the Water of Leith, west of Edinburgh	31·31	26·53	57·84	29·23	9·17	38·40	60·54	35·70	96·24
Average of 10 samples from North sewer at Stockbridge, Edinburgh	8·29	24·04	32·33	13·27	8·81	22·08	21·56	32·85	54·41
Average of 12 samples from South (Moray Place) sewer at Stockbridge	7·07	22·45	29·52	24·72	12·45	37·17	31·79	34·90	66·69
Average of 21 samples from Canonmills sewer	8·20	24·10	32·30	15·50	11·00	26·50	23·70	35·10	58·80
Average of 2 samples from Broughton Burn sewer at Bonnington Road	10·56	25·52	36·08	37·44	17·20	54·64	48·00	42·72	90·72
Average of 5 samples from Bulls Stank sewer	5·92	31·42	37·34	10·88	5·28	16·16	16·80	36·70	53·50
Average of 3 samples from Coal Hill sewer at Leith	64·64	145·76	210·40	80·48	36·32	116·80	145·12	182·08	327·20
Average of 1 sample from sewer below lower drawbridge at Leith	7·84	46·56	54·40	10·40	4·80	15·20	18·24	51·36	69·60

Table V.

Average Analyses.

Liquids collected from the Water of Leith, from immediately above Coltbridge down to the Harbour of Leith. One Imperial Gallon contains

Place of Collection.	In solution.			In suspension.			In solution and suspension.		
	Organic matter in grains.	Saline matter in grains.	Total matter in solution in grains.	Organic matter in grains.	Earthy matter in grains.	Total matter in suspension in grains.	Organic matter in grains.	Saline and earthy matter in grains.	Grand total matter in grains.
Average of 23 samples from the Water of Leith immediately above Coltbridge	3·34	12·96	16·30	1·73	2·32	4·05	5·07	15·28	20·35
Average of 1 sample from the Water of Leith at dam below Coltbridge	6·40	16·80	23·20	2·96	1·32	4·28	9·36	18·12	27·48
Average of 2 samples from the Water of Leith at dam above Water of Leith Village	4·60	11·84	16·44	5·59	3·04	8·63	10·19	14·88	25·07
Average of 8 samples from the Water of Leith at dam below Water of Leith Village	5·36	14·93	20·29	4·27	1·38	5·65	9·63	16·31	25·94
Average of 6 samples from the Water of Leith under Dean Bridge	7·39	15·73	23·12	2·76	0·69	3·45	10·15	16·42	26·57
Average of 6 samples from the Water of Leith behind Moray Place, near St. Bernard's Well	6·86	15·08	21·94	2·75	0·70	3·45	9·61	15·78	25·39
Average of 6 samples from the Water of Leith above Stockbridge	7·36	16·16	23·52	2·55	0·58	3·13	9·91	16·74	26·65
Average of 9 samples from the Water of of Leith, 30 yards below Stockbridge	8·92	15·40	24·32	14·24	2·50	16·74	23·16	17·90	41·06
Average of 1 sample from the Water of Leith behind Warriston Crescent	7·04	25·60	32·64	10·68	3·52	14·20	17·72	29·12	46·84
Average of 6 samples from the Water of Leith lade behind India Place	6·05	17·14	23·19	2·84	1·06	3·90	8·89	18·20	27·09
Average of 2 samples from the Water of Leith lade below Beaver Hall	10·20	17·28	27·48	6·02	1·36	7·38	16·22	18·64	34·86
Average of 18 samples from the Water of Leith at St. Mark's Place below junction of lade	7·98	14·68	22·66	18·47	15·27	33·73	26·45	29·95	56·39
Average of 1 sample from the Water of Leith from dam above Bonnington	12·80	17·80	30·60	115·68	153·12	268·80	128·48	170·92	299·40
Average of 1 sample from the Water of Leith at boundary of Edinburgh and Leith at Bonnington Bridge	10·24	17·60	27·84	30·88	33·12	64·00	41·12	50·72	91·84
Average of 1 sample from the Water of Leith from dam above Junction Road Bridge	16·96	21·92	38·88	500·96	369·12	870·08	517·92	391·04	908·96
Average of 1 sample from the Water of Leith above the Saw Mills at Leith	4·32	10·08	14·40	5·20	3·52	8·72	9·52	13·60	23·12
Average of 2 samples from the Water of Leith below Junction Road Bridge	9·18	18·32	27·50	3·72	3·28	7·00	12·90	21·60	34·50
Average of 3 samples from the Water of Leith above Coal Hill at Leith	9·01	65·60	74·61	14·29	5·92	20·21	23·30	71·52	94·82
Average of 1 sample from the Water of Leith from off Coal Hill Sewer at Leith	35·20	170·08	205·28	8·32	6·72	15·04	43·52	176·80	220·32
Average of 1 sample from the Water of Leith from harbour at Upper Drawbridge	27·36	157·76	185·12	4·16	3·84	8·00	31·52	161·60	193·12
Average of 1 sample from the Water of Leith from harbour below Upper Drawbridge	31·84	609·60	641·44	10·72	10·40	21·12	42·56	620·00	662·56
Average of 1 sample from the Water of Leith from harbour off Victoria Dockhead	3·92	1208·80	1212·72	1·32	1·12	2·44	5·24	1209·92	1215·1

Table W.

Average Analyses.

Sedimentary Matters collected from the open Sewers discharging into the Water of Leith, from the bed of the Water of Leith, and from the bottom of the Edinburgh lade.

Dried at 212° Fahr.

Place of Collection.	Per-centage composition.			
	Organic matter.	Earthy matter.	Total.	Nitrogen.
Average of 7 samples collected from Edinburgh sewers, Lochrin Burn sewer, west of abbatoir or slaughter-houses	49·70	50·30	100·00	1·27
Average of 3 samples collected from Edinburgh sewers, Lochrin Burn sewer, above Caledonian Distillery	27·70	72·30	100·00	0·52
Average of 3 samples collected from Edinburgh sewers, Lochrin Burn sewer, immediately above Coltbridge	17·02	82·98	100·00	0·71
Average of 1 sample collected from Edinburgh sewers, Bulls Stank sewer, at Lovers Loan	50·72	49·28	100·00	0·76
Average of 1 sample collected from Edinburgh sewers, Broughton Burn sewer, at Bonnington Road	20·52	79·48	100·00	0·82
Average of 4 samples collected from bed of Water of Leith, between Water of Leith Village and the Dean Bridge	48·12	51·88	100·00	1·63
Average of 2 samples collected from bed of Water of Leith, behind Ainslie and Moray Places	44·92	55·08	100·00	0·98
Average of 8 samples collected from bed of Water of Leith, below North and South sewers at Stockbridge	43·67	56·33	100·00	1·14
Average of 1 sample collected from bed of Water of Leith, from sides of narrowed channel at Stockbridge	34·52	65·48	100·00	0·50
Average of 1 sample collected from bed of Water of Leith, 80 yards below Stockbridge	25·12	74·88	100·00	1·08
Average of 1 sample collected from bed of Water of Leith, behind Malta Terrace	32·52	67·48	100·00	1·08
Average of 1 sample collected from bed of Water of Leith, in front of sewer at Canonmills	31·72	68·28	100·00	0·57
Average of 9 samples collected from bed of Water of Leith, behind Warriston Crescent and at St. Mark's Place	36·05	63·95	100·00	1·05
Average of 1 sample collected from bed of Water of Leith at dam above Bonnington	49·72	50·28	100·00	1·49
Average of 1 sample collected from bed of Water of Leith at boundary of Edinburgh and Leith at Bonnington Bridge	26·92	73·08	100·00	0·70
Average of 1 sample collected from bed of Water of Leith, immediately below the junction of the Broughton Burn	13·72	86·28	100·00	0·52
Average of 1 sample collected from bed of Water of Leith, at dam above Junction Road Bridge	27·72	72·28	100·00	0·70
Average of 7 samples collected from bed of Water of Leith lade which traverses Edinburgh	25·70	74·30	100·00	0·69
Average of 12 samples collected from the bottom of the harbour of Leith, south-east side	28·33	71·67	100·00	0·64
Average of 6 samples collected from the bottom of the harbour of Leith, north-west side	20·18	79·82	100·00	0·62

Table X.

Average Analyses.

Gases evolved during the decomposition of the Sedimentary Matters lying in the open Sewers, the Lades, and in the Bed of the Water of Leith.

Place of Collection.	Per-centage composition of the gases by volume.		
	Carbonic acid.	Oxygen.	Other gases.
Average of 1 sample of gases evolved from sediment in Lochrin Burn	14·63	0·81	84·56, combustible with blue white flame.
Average of 4 samples of gases evolved from sediment in bed of Water of Leith from Coltbridge down to St. Bernard's Well	9·12	1·00	89·88 „ „
Average of 2 samples of gases evolved from sediment in lade of Water of Leith which traverses Edinburgh	1·58	1·48	96·94 „ „
Average of 5 samples of gases evolved from sediment in bed of Water of Leith, from Stockbridge down to Junction Road Bridge	5·43*	1·51	93·06 „ „
Average of 2 samples of gases evolved from sediment in Harbour of Leith	16·65*	1·60	81·75 „ „

* Containing hydrosulphuric acid (sulphuretted hydrogen).

Table Y.

Average Analyses.

Gases dissolved in the Water of the Water of Leith, &c.

Place of Collection.	Cubic inches of gas per gallon of water.	Per-centage composition of the gases by volume.		
		Carbonic acid.	Oxygen.	Other gases.
Average of 3 samples of spring-water as supplied to Edinburgh	9·77	9·67	29·21	61·12
Average of 2 samples of water from the sources of the Water of Leith	9·47	1·91	29·05	69·04
Average of 4 samples of water from the Water of Leith as it flows down to Coltbridge	9·35	6·50	22·92	70·58
Average of 5 samples of water from the sewers of Edinburgh	12·15	51·85	2·71	45·44
Average of 8 samples of water from the Water of Leith, from Coltbridge down to St. Mark's Place	7·10	18·20	6·00	75·80
Average of 3 samples of water from the lade of the Water of Leith which traverses Edinburgh	7·08	12·17	5·52	82·31

Table Z.

Average Analyses.

Examination of the Atmosphere in the Neighbourhood of the Water of Leith, &c.

Degree of absolute Purity of Air, 100°·00.

Place of Collection.	Degree of Purity.
Average of 7 samples of air collected from five stations in Edinburgh and Leith away from the influence of open sewers and of the Water of Leith - -	76°·71
Average of 2 samples of air collected over the Water of Leith above Coltbridge and before mingling with sewage - - - - - - - -	77°·50
Average of 3 samples of air collected from above the open sewers of Edinburgh and Leith - - -	59°·33
Average of 16 samples of air collected over the Water of Leith from Coltbridge down to the Harbour of Leith, and after being mingled with sewage* -	60°·37
Average of 2 samples of air collected over the lade of the Water of Leith which traverses Edinburgh and conveys sewage - - - - -	57°·50

* One sample of air collected over the Water of Leith, below the dam under Water of Leith Village, has not been included in the above average, as its degree of impurity is unusually high (Table S.) owing to the more rapid escape of the impure gases from the water as it falls over the dam and is dashed into foam.

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