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PART I.

ORIGINAL COMMUNICATIONS.

ART. XVII.—*On the Water-supplies to Irish Towns.*^a By CHARLES A. CAMERON, M.D.; S. S. C. Camb. Univ.; M.K.Q.C.P.; Vice-President and Professor of Hygiene, R.C.S.I.; Vice-President, Institute of Chemistry of Great Britain; Examiner in Sanitary Science, Royal University; Medical Officer of Health for Dublin.

THE results of many years' experience in the examination of potable waters have convinced me that a very large proportion of those used in this country are below the standard of a fairly pure water. No doubt a similar state of things exists in other countries. The extent to which the health of communities is affected by the quality of their water-supplies has not been accurately determined; but there is evidence to prove that, in the case of many districts, the state of public health has been improved by the substitution of pure for impure supplies of water.

There is some difference of opinion as to what constitutes the purest potable water. The majority of chemists appear to consider such water as that which Glasgow obtains from Loch Katrine as the best for all domestic purposes. This water really differs but slightly from rain. One gallon (70,000 grains, or ten pounds in weight) of it evaporated to dryness, leaves only from 2 to 2½ grains weight of solid matter. If the latter be burned, about one half (the organic part) disappears, leaving the mineral, or inorganic part. Loch

^a Paper read October 3rd, 1884, at the Congress of the Sanitary Institute of Great Britain, held at Dublin.

Katrine water, therefore, contains only about one part of organic matter and one part of mineral matter in 70,000 parts. This kind of water is usually not very sparkling. Many persons do not like its "flat" flavour so much as that of water taken from springs or wells, and containing from 10 to 100 grains of solid matters per imperial gallon. There is generally less dissolved gas in the soft water of Loch Katrine, and its temperature is in summer higher as compared with spring and well waters.

Some persons believe that very soft waters are not so wholesome as moderately hard ones, owing to the absence of lime compounds from the former. No doubt this earth is an abundant constituent of animals; but there is no good physiological proof of the truth of the assertion that the lime of our bones is procured from the water we drink. By far the greater portion of the lime in the animal system is combined with phosphoric acid, whilst in water it is united with carbonic acid and sulphuric acid (in some waters there is chloride of calcium). It seems strange, therefore, that lime should be obtained from water and phosphoric acid from some other source. I am one of those who prefer soft water to hard water for a town supply; for although in many instances the flavour of hard water is pleasanter, yet for cooking and washing purposes the soft water possesses great advantages over the hard one. Beside, I do not believe that the lime in water contributes to the nutrition of animals.

The Dublin pipe-water is derived from the impounded drainage of a mountainous region. It contains $4\frac{1}{2}$ grains of solid matters—one-half of which consists of organic matter, nearly altogether derived from peat.

The water supplied to Irish towns contains, with very few exceptions, a larger amount of solid matters than is found in the Vartry water. The colour of the latter and of Loch Katrine water is a very faint yellow, whilst most of the high-pressure waters supplied to the Irish towns have a colour varying from a faint yellow to a brownish hue.

In selecting a water for a town supply, due regard should be had to colour—the lighter it is the better. The very brown waters are usually much objected to, even when it is known that the colouring matter is derived from peat, and is therefore comparatively innocuous. When water is impounded in reservoirs it often happens that its colour gradually becomes deeper; this change is due to the vegetable matter of the soil and of the reservoir becoming soluble

and entering into solution. After a time, which may be from one to three years, the water will lose much, perhaps nearly all, its colour—this has happened in the case of the Vartry and Knockaderry (Waterford) waters. The nearer the amount of solid matter approaches that contained in the Vartry water the better—it is undesirable that it should exceed 14 grains per gallon.

It is most important to ascertain carefully the extent of the drainage area proposed to be utilised for a water supply, and also the rainfall of the district where several sources are available; that which yields the clearest water should be selected, so as to avoid the expense of filtration. The greatest attention should be given to the nature of the industries carried out upon the drainage area. If there be no factories or arable farms so much the better. If there be villages or even isolated dwellings, the sewage from which would probably enter a projected reservoir, the means of diverting such objectionable matter should be considered before the commencement of operations. It sometimes happens that the sources of impurities on a catchment area are so numerous and serious that they cannot, economically, be satisfactorily dealt with.

As a rule, I do not like supplies of water taken from large rivers: I prefer the collection and impounding of springs and streams in hilly regions. In the former case the water has usually to be pumped up into "service reservoirs," which is more or less an objectionable process; in the latter case the water can be delivered, by its gravitating power, with any desirable pressure, to the points of consumption. Lakes, especially those of large size, afford in general better water than rivers. A little sewage entering the former has an inappreciable effect upon the composition, whilst upon a river its effect might for a time be very serious.

Springs in the limestone rocks often afford an abundant supply of water; it is usually hard, but this is generally its only bad point. The spring waters may be conveyed by means of small earthen or iron pipes (even gas pipes, as Sir Robert Rawlinson suggests, may answer) direct to small towns. In cases where there is a river ascertained to be free from pollution, its waters might be delivered under pressure, if pumped into tanks by means of turbines. These machines, so much used in America and other countries, are rarely employed in Ireland. It is not desirable to have the service tanks placed in or very close to a town, as its water is liable to become contaminated with soot and other matters.

For many small towns a good supply might often be procured

at a moderate cost. For example, Professor Townsend, C.E., has supplied Belmullet with high-pressure water at a cost of only £1,000, exclusive of the cost of land and legal expenses. The reservoir consists chiefly of concrete, with an iron main. The water flows by gravitation.

In collecting water for the purpose of having it analysed, care should be taken to secure a specimen likely to represent the average quality of the proposed supply. The centre of a river is the best part to take samples from. If the water of a river is proposed to be taken as a supply for a town, then that of every neighbouring stream entering it should be examined. In case the analysis of one or more of the tributary streams proved unfavourable, it might often be possible to either divert the streams or take water from the river at a point above the objectionable tributaries to it.

I have discovered the remarkable fact that good and bad water may co-exist in the one well—good hard water at the lower part, soft and bad water on the surface. Hence it is important that surface drainage, nearly always polluted, should be kept out of the openings of wells by having them covered, and the sides of the shafts cemented at least six feet downwards.

The organic matter in water may be wholly or partly derived from a vegetable source such as peat, the decomposing roots, &c., of plants in the soil, and their decaying leaves, &c., lying upon the surface of the ground. In countries where malarial fevers prevail, the presence of much vegetable matter in potable water is likely to produce disease in those who drink it; but in Ireland there is no evidence to show that organic matter altogether derived from peat, &c., is injurious to health. This question is of great interest in this country where peaty waters are so very common. Those waters have a yellowish or even brown hue, and are more frequently soft than hard.

Vegetable matter contains, on the whole, nearly 2 per cent. of nitrogen; when dissolved or suspended in water, a portion of this nitrogen is converted by fermentation into ammonia, which ultimately becomes oxidised into nitric acid. In the statement of the results of a water analysis, the amounts of albuminoid ammonia and saline ammonia are always mentioned, and sometimes the amount of nitrogen in the form of nitrous and nitric acids. The albuminoid ammonia does not actually exist in the water, but is formed in it by the analytical process—a better term, sometimes used, is albuminoid, or organic nitrogen. The greater the propor-

tion of this ingredient the worse the water, for the presence of a large quantity of nitrogenous organic matter is dangerous, whilst practically no amount of actual ammonia or nitric acid is injurious. Nevertheless, we do not like to find much saline ammonia in a water, as it generally indicates the presence of sewage. In a peaty water the albuminoid ammonia is often twenty times more abundant than the saline; but when sewage is present, the saline ammonia usually exceeds in quantity the organic ammonia. It is easy to understand why this should be so. The peaty matter in water slowly decomposes, whilst the urea which is usually present in sewage, and contains 47 per cent. of nitrogen, speedily becomes carbonate of ammonium. I often meet with a peaty yellow water containing per imperial gallon—

Albuminoid ammonia, -	-	-	0.020 grain,
Saline ammonia, -	-	-	0.001 „

whilst in a bright and sparkling water we may often have per gallon—

Albuminoid ammonia, -	-	-	0.008 grain.
Saline ammonia, -	-	-	0.012 „

I should much prefer to drink the former water, notwithstanding its flat flavour and yellow hue; for in the bright and colourless water the albuminoid matter would probably be derived from an animal source, and possibly contain the germs of a contagious disease.

In some waters large amounts of nitric acid are present. This is especially the case in the wells sunk in the carboniferous rocks. The nitric acid is generally derived from the oxidation of vegetable matter and, but to a limited extent, from manure. By filtration throughout large masses of soil the water is purified from organic matters, but it contains the products of their decomposition. I prefer a water free from nitrates, and derived from untainted sources; but in certain districts we must tolerate the nitrates, if the water present no other objectionable features.

Chlorine, in the form of common salt, is present in water polluted by sewage, but it is often found in large proportions in really good water. The significance of chlorine has been much exaggerated. In hard and good water it is often present to the extent of from 4 to 10 grains per gallon. Frequently it exists as magnesium chloride or calcium chloride.

It is desirable that the amount of albuminoid ammonia should be less than 0.01 grain per gallon, and of saline ammonia less than

0·008. In the best waters the albuminoid and saline ammonia are low down in the third decimal place.

In 1881 there were in Ireland 11 cities and towns governed by Corporations or Town Councils. Their aggregate population amounted to 683,502, and their valuation to £1,743,317. Their revenue amounted to £794,625.^a

The 9 townships surrounding the City of Dublin had a population of 95,400, a valuation of £390,667, and a revenue^b of £63,219.

There were 92 cities and towns governed by Towns' Commissioners; their population amounted to 434,138, their valuation to £671,153,^c and their annual revenue to £103,527.

The population of all these towns was therefore, in 1881, 1,213,040, and their valuation for rating amounted to £2,805,137. In Irish towns the valuation is about two-thirds of the actual letting value.

I have endeavoured to ascertain the nature of the water-supplies to these 112 cities, towns, and townships, and the following is a brief summary of the facts ascertained:—

THE ELEVEN TOWNS GOVERNED BY TOWN COUNCILS.

Belfast.—Population, 207,671; valuation, £568,137. The water is almost wholly supplied from a reservoir situated near Carrickfergus, about twelve miles from Belfast. The pressure is good, and the reports upon the quality made by Dr. Hodges, of Belfast, are satisfactory. It contains 12·6 grains of solid matters per gallon, and 0·11 part of albuminoid, and 0·07 part saline ammonia per million parts. These figures show that it is not equal to the Dublin pipe water.

Clonmel.—Population, 10,519; valuation, £15,424. Supplied by local pumps and wells. I have from time to time examined a large number of specimens of the water used in this town. On the whole, they have not been of the quality suitable for domestic purposes. As a rule they were exceedingly hard, containing nearly 100 grains of solid matters per gallon. A few were highly polluted with sewage. The waters from Clonmel, which I have lately analysed, were purer, probably because their sources were better protected from pollution. A town so large as Clonmel

^a These figures (with some corrections) I have taken from Thom's Directory for 1884, pages 668 to 670.

^b Exclusive of Drumcondra Township, of which I have no return.

^c Exclusive of a few small towns.

should be provided with a good supply of water, obtained from some of the neighbouring high grounds.

Cork.—Population, 78,361; valuation, £226,022. The supply of water is obtained from the River Lee, at a point about a mile above the city. Mr. O'Keefe's (Public Analyst for Cork) analysis of the water, made some years ago, did not give favourable results. He found that an imperial gallon contained—total solids, 5·57 grains, including albuminoid ammonia, 0·075 grain; saline ammonia, 0·04 grain; and chlorine, 0·661 grain. These figures indicate pollution. Since this analysis was made the waterworks have been improved, and the water is now filtered properly. Still a water supply from a river bordered by towns is not a desirable one. I think the sewage of Macroom enters the river at a point 27 miles above the City of Cork.

Drogheda.—Population, 12,516; valuation, £28,121. This town is supplied partly with pressure water supplied by a Waterworks Company, partly by local pumps. The pipe-water is collected at a gathering ground about two miles distance from the town, and stored in a reservoir. It is a fairly good water, but not equal to the pipe-water of Glasgow and Dublin. It contains about 13 grains of solid matter per gallon, and from 0·005 to 0·01 of albuminoid ammonia, and somewhat smaller quantities of saline ammonia. In winter the supply is abundant, but in summer it is so scanty that the supply to the houses is limited to two hours daily. A small reservoir, situated one mile from the town, supplies two fountains. Sixteen of the local pumps are in possession of the Corporation. I have analysed the water yielded by all of them. They are mostly free from sewage; but the greater number are too hard for washing with, or, indeed, for any purpose save flushing sewers, &c. Perhaps the Corporation might see their way towards purchasing the waterworks and extending them. The water-supplies of towns should always be under the management of the governing bodies thereof.

Dublin.—Population (of City), 249,486; valuation, £657,820. The gathering ground of the water supplied to Dublin consists of mountains, chiefly of the lower Cambrian formation, situated about 26 miles from the city, in the County of Wicklow. The reservoir is very large, and is capable of supplying 35 gallons per diem per unit of the population. At first the water impounded had a faint yellow colour, which gradually became deeper, and after three or four years became so deep as to excite alarm. The colour was caused

by the peaty and other organic matter in the reservoir becoming soluble by fermentation. After a time the hue became less intense, and now the water is almost colourless. It is soft. One imperial gallon contains about $4\frac{1}{2}$ grains of solid matters, 0.005 grain of albuminoid ammonia, 0.0008 grain of saline ammonia, faint traces of nitrates and nitrites, and 0.96 grain of chlorine. Its hardness is about 1.8° , of which 0.8 is permanent. It is one of the purest waters in the world. With respect to pressure and quantity, the citizens have nothing to complain of. Cost of the works, £640,682 10s. 2d. up to 1884.

There are some well-waters still used in Dublin. They are generally very hard, owing to the presence of large quantities of earthy salts. I have often found in Dublin pump waters from 50 to 75 grains of calcium sulphate per gallon. I consider most of these waters unfit for use, but there are some exceptions—notably the pump water in the Bank of Ireland; this water has the following composition per gallon:—

					Grains.
Total solid matters	-	-	-	-	24.500
Including—					
Albuminoid ammonia	-	-	-	-	0.004
Saline ammonia	-	-	-	-	0.003
Nitrogen in nitrates and nitrites	-	-	-	-	0.090
Calcium sulphate	-	-	-	-	4.420
Chlorine	-	-	-	-	2.491
Oxygen required to oxidise organic matter					0.208
Hardness	-	-	-	-	1.8°

Kilkenny.—Population, 12,182; valuation, £33,155. This city is supplied wholly by local wells, and, but to a limited extent, from a river. I have analysed, I think, the water from all the public pumps and from many of the private. There is no pressure water. The water from the wells is exceedingly hard, owing to the presence of lime and magnesia salts. They contain from 50 to more than 100 grains of solids per gallon. The majority are free from actual sewage; but as a rule they contain extremely large quantities of nitric acid—a product of the decomposition of nitrogenous organic matter. The sources of the water are as a rule tainted, but the water as taken from the wells is in general so well filtered by passage through a calcareous soil that it is generally very free from organic matter. Some are, however, more or less polluted. Kilkenny is one of the Irish towns which most urgently require a good water-supply.

Limerick.—Population, 38,600; valuation, £65,547. This city is supplied with pipe-water taken from the river Shannon, about $1\frac{1}{2}$ miles distant from the city. For many years the quality of the water has been complained of, owing chiefly to its great turbidity, for the water was not filtered. The Corporation have recently purchased the waterworks from a company. It may be that the water supply to the city will still be taken from the Shannon, but I am of opinion that a better quality of water is procurable in sufficient quantities from drainage areas in the high grounds not very distant from the city. I have analysed several samples of water proposed to be supplied to Limerick, and consider them much superior to the Shannon water. Many of the local wells are still in use, but as a rule they furnish impure water.

Londonderry.—Population, 28,947; valuation, £74,595. High-pressure water is supplied from reservoirs situated outside the city. The quantity is insufficient for a constant service, but the Corporation propose to procure an increased supply. Professor Leebody's analysis shows that the water is of good quality. It is soft, containing nine and a half grains of solids per gallon. It is delivered unfiltered.

Sligo.—Population, 10,764; valuation, £18,619. This town will soon be supplied with pressure water of good quality and soft, taken from a reservoir situated five miles from the town. Estimated cost of the works, £28,000.

Waterford.—Population, 22,401; valuation, £39,866. Until very recently this city was wholly dependent upon local pumps, the water from which was, with few exceptions, of extremely bad quality. The worst water which I have, I think, ever analysed came from a public pump largely used in this city.

This water contained per gallon in grains—

Solid matters	-	-	-	-	385.8
Including—					
Albuminoid ammonia	-	-	-	-	0.4
Saline ammonia	-	-	-	-	1.5
Sodium chloride	-	-	-	-	76.0
Calcium sulphate	-	-	-	-	34.0

The amount of ammonia in this water exceeded that often present in sewage.

A few years ago a new supply of water was obtained by impounding the drainage of a hilly region at Knockaderry, 10 miles from the city. The water proved to be extremely brown in colour,

which circumstance created great dissatisfaction amongst a large section of the citizens, some of whom refused to use the water. I predicted that in the course of a few years the hue of the water would be much less deep. The last specimen sent to me for examination, though still somewhat coloured, was comparatively pale as compared with the specimens sent to me three or four years ago. The citizens now seem satisfied with the water. The cost of the waterworks, &c., was £77,000.

Wexford.—Population, 12,055; valuation, £16,011. I have analysed several specimens of pump water used in this town. The majority were soft and fairly good, but several were hard and bad. One contained 95·2 grains of solid matter per gallon. A high pressure supply of good water was lately procured. The waterworks have cost £30,000.

THE DUBLIN TOWNSHIPS.

These districts are, with exception of a very small portion of their area and exclusive of Rathmines, supplied with the Vartry pipe water (the same as that furnished to Dublin). Rathmines township is at present supplied with water from a canal. It is hard and of somewhat doubtful purity. The township will, however, soon be supplied with soft and remarkably pure water collected from the Dublin mountains.

THE NINETY-TWO TOWNS UNDER TOWNS COMMISSIONERS.

Antrim.—Population, 1,647; valuation, £3,554. Supplied with pump water of, it is believed, good quality and palatable. The “Six-mile” river, which flows past the town, supplies water for various purposes.

Ardee.—Population, 2,622; valuation, £4,060. The water is derived from pumps and wells. The quality is believed to be fairly good, but no analyses of it have, I believe, been made.

Armagh.—Population, 10,070; valuation, £16,925. A high pressure supply from a small lake, two and a half miles from the city, was procured some time ago. It is rather peaty, and when in summer the lake falls considerably the colour is somewhat high. On the whole, however, the water supply of this city is fairly good.

Athlone.—Population, 6,755; valuation, £9,671. This town is supplied with water from the Shannon, which flows through it. There are seven pumps attached to wells. The water supplies are on the whole fairly good.

Athy.—Population, 4,181; valuation, £5,680. I have examined a great number of the well waters, which furnish exclusively the supply of this town. About one-third were very much polluted, and the rest were first or second class waters. Some of the pump waters in this town contain about 100 grains of solids per gallon. This town requires an improved water supply.

Auchnacloy.—Population, 1,333; town revenue, £77. The town is supplied by wells, one of which is much used by the poorer inhabitants, though the water is impure.

Bagenalstown.—Population, 2,141; valuation, £3,414. The supply of water is from local wells and a river. Some of the well waters are fairly good, others are of indifferent quality. Some of the water is filtered.

Balbriggan.—Population, 2,443; valuation, £4,014. The water is derived from wells and pumps. It is far too hard for potable purposes, and in some instances it is otherwise impure.

Ballina.—Population, 5,760; valuation, £8,154. This town will soon be supplied with high pressure and good water from Loch Brohly, six miles distant. Professor Townsend, C.E., informs me that the contract for executing the works was £8,556. This was exclusive of law costs, &c. The supply will be 20 gallons per head.

Ballinasloe.—Population, 4,772; valuation, £8,740. The town is supplied wholly from local wells, some of which yield an inferior water.

Ballybay.—Population, 1,654; town revenue, £142. This town has an insufficient supply of water, which, moreover, is of very bad quality. It is derived chiefly from wells; but a small river yields water which is much used, though it is known to be highly polluted.

Ballymena.—Population, 8,883; valuation, £21,423. I have analysed twenty-one of the well waters of this town; with some exceptions they proved to be hard and fairly good. One of these waters contained 137·9 grains of solid matters per gallon, including the enormous quantity of 37·64 grains of nitric acid. Another contained 136½ grains of solids, including 19·11 grains of nitric acid. An improved water supply from a distance of about seven miles is now being procured at a cost of £23,000.

Ballymoney.—Population, 3,049; valuation, £6,034. The supply is taken from local pumps, and is deficient in both quality and quantity. But a good high-pressure water will soon be supplied to all the houses in the town at a cost of £6,000.

Ballyshannon.—Population, 2,840; valuation, £4,022. The supply is from pumps and wells. I have analysed only one water from this town, and it proved to be a good one, but the inhabitants are dissatisfied with their water-supply, and the question of improving it has lately been considered.

Banbridge.—Population, 5,609; valuation, £12,716. I have examined about 40 well waters used in this town. Most of them were very hard, and several were polluted with sewage. This town urgently requires an improved water.

Bandon.—Population, 5,945; valuation, £9,621; town revenue (1881), £1,890. Supplied by wells and pumps—one of the waters of which I have examined was hard, but otherwise good. A scheme for supplying the town with high-pressure water is now under consideration, and the proposed water is being analysed in my laboratory.

Bangor.—Population, 3,006; valuation, £10,287. Works to supply high-pressure water are nearly completed. They will cost about £10,000. I have analysed the water proposed to be used, and have found it to be of good quality. I have found the pump waters of this town to be superior to average well waters.

Belturbet.—Population, 1,807; town revenue, £375. The River Erne and three pumps furnish the water. One of the pumps yields a supply of very doubtful quality.

Boyle.—Population, 2,994; valuation, £3,847. The town is supplied with well waters only. Those that I have analysed proved to be fairly good.

Bray.—Population, 6,535; valuation, £24,503. This town is supplied with good high-pressure water.

Callan.—Population, 2,340; valuation, £2,002. Supplied by local pumps, some of which are of doubtful quality.

Carlow.—Population, 7,185; valuation, £11,157. The town depends upon local wells for its supplies. I have analysed many of the waters used in this town, and, on the whole, have an unfavourable opinion of them. Many of them contain from 70 to 112 grains of solids per gallon, including from seventeen to twenty-two grains of nitric acid. The rise of the River Barrow appears to affect the quality of the Carlow well waters. The town urgently needs a good supply of high pressure water.

Carrickfergus.—Population, 10,009; valuation, £5,561; revenue, £1,275. The town is supplied with good water from reservoirs, situated at one and a half miles from the town.

Carrickmacross.—Population, 2,002; valuation, £2,893. This

town is supplied by well waters, several of which I have analysed and found to be impure.

Carrick-on-Suir.—Population, 6,583; valuation, £8,836. This town has no pressure water; some of the well waters which I have examined are of good quality.

Cashel.—Population, 3,961; valuation, £5,695. A good supply of pure water of high pressure is obtained from the neighbouring hills. It is filtered before being delivered to the *city*—for this small but ancient place is entitled to the rank of city.

Castlebar.—Population, 3,855; valuation, £4,132. The town depends upon wells and pumps. The water from them is, as usual in such towns, not altogether pure.

Castleblayney.—Population, 1,810; town revenue, £100. Supplied by local wells and pumps. The water is believed to be fairly good.

Cavan.—Population, 3,050; valuation, £5,155. The results of analyses of fifteen of the pump waters in this town enable me to state that Cavan is one of the towns in this country most urgently requiring good water. There are hills not far distant from which good supplies might be procured.

Clonakilty.—Population, 3,676; valuation, £4,824. A supply of good water gathered from neighbouring hills is delivered, under pressure, to the town.

Clones.—Population, 2,216; valuation, £3,356. The supply is chiefly from five public pumps, two of which are adjacent to and below the level of churchyards. The local sanitary authority (the Board of Guardians) has hitherto not complied with the oft-expressed request of the Town Commissioners, for a more abundant and purer supply of water.

Coleraine.—Population, 5,899; valuation, £12,805. This town is supplied with water collected from springs situated about three miles distant. It is conveyed direct from the springs, and has a considerable degree of pressure. In case of a contingency water may be also obtained from a small reservoir, which contains sufficient for fourteen days' supply. Fifty gallons per head is the quantity delivered. The water contains $11\frac{1}{2}$ grains of solids per gallon, and is very free from organic matter. I have analysed two specimens of pump water from this town, and found them to be of good quality. The waterworks of this town have cost £9,600.

Cookstown.—Population, 3,870; valuation, £6,187; town revenue, £189. This town has no high-pressure water. Fifteen public

and several private pumps supply water, concerning which local opinion is much divided. Some of the townspeople are satisfied with its quality; others consider it for the most part impure. In 1876 seven of the waters used in this town were submitted to me for analysis. I found that they were free from sewage. The total solids varied from 8 to 45 grains per gallon. Professor Hodges has, however, found impurities in some of the pump waters. Some of the waters which I have examined are undoubtedly too hard. The subject of obtaining a supply of good high-pressure water has long been discussed. A scheme for this purpose was proposed in 1876 by Mr. J. F. Mackinnon. He proposed to take water from Loughbrackin, a distance of $7\frac{1}{2}$ miles. The cost was estimated at £8,430. He proposed another scheme for taking water from Mountober springs, situated $4\frac{1}{4}$ miles from the town. This scheme, which involves the construction of a reservoir, would cost as estimated £12,500.

Cootehill.—Population, 1,789; town revenue, £152. The Town Commissioners have control of five pumps, which supply very inadequately the wants of the town. Many private wells and some small streams are brought into requisition to make up the deficiency. Some of the pump waters are very inferior, and the town ought to be provided with a good and sufficient supply.

Downpatrick.—Population, 3,419; valuation, £8,001. Some of the pump waters in this town are exceedingly hard, and some are impure. For several years past the Downpatrick Board of Guardians have been discussing schemes for supplying the town with pure water; but though much expense has been incurred by them in commissions, &c., the supply is still wanting.

Dromore.—Population, 2,491; valuation, £4,363. I have lately analysed 9 waters from the public supplies in this town. Several of them were very hard and impure, and most of the others were second class waters.

Dundalk.—Population, 11,913; valuation, £20,692. The pump waters in this town are, on the whole, of very inferior quality. A good supply of almost colourless water will, however, soon be procured from neighbouring hills. It is one of the purest waters that I have ever examined. A loan of £26,000 for waterworks has been secured.

Dungannon.—Population, 4,084; valuation, £8,114. A high-pressure supply is procured from a distance of $7\frac{1}{2}$ miles, at a cost of £13,500. It is of good quality.

Dungarvan.—Population, 6,306; valuation, £8,265. All the pump waters sent to me from Dungarvan proved to be free from pollution.

Ennis.—Population, 6,307; valuation, £6,944. The well waters in this town are, as a rule, very impure. One of the town pumps was closed by order of the magistrates sometime ago, on the application of the local authorities. My analysis proved that the water was largely composed of sewage. Ennis has lately been supplied with pressure water from a neighbouring reservoir connected with a lake. The cost of this improvement has been £11,000. It is slightly peaty, but good in all other respects.

Enniskillen (population, 5,712; valuation, £11,714), is supplied with high-pressure water, taken from Lough Erne at a point distant $4\frac{1}{2}$ miles from the town. The lake has an area of 36,923 acres, and its waters ought to be pretty pure, but as supplied to the workhouse I found it rather yellow. It contained 7·7 grains of solids per gallon. The pump waters of Enniskillen are not, as a rule, very good. The water rate is 6d. in the pound on the Poor-law valuation.

Fermoy (population, 6,454; valuation, £9,931) will soon be supplied with good high-pressure water from a reservoir situated $3\frac{1}{2}$ miles from the town. The works will be completed at a cost of £13,000.

Fethard (population, 1,926; town revenue, £168) is supplied with 4 public and several private pumps. One of the pumps yielded water which I found to be very impure.

Galway.—Population, 15,597; valuation, £26,240. High-pressure water is supplied from the river Corrib, which discharges the waters of a large lake—Lough Corrib—into the sea. The water contains about 11 grains of solids per gallon, 0·008 grain of albuminoid ammonia, 0·002 grain of saline ammonia, and 1·4 grain of chlorine. Hardness, 7°. It is, therefore, a fairly good water, but not equal in colour or purity to the Dublin pipe water. The pump waters in Galway are all hard, from presence of lime and magnesia salts, and some of them are somewhat impure.

Gilford.—Population, 1,324; valuation, £1,834. Supplied by local wells, the water of which is pretty good.

Gorey (population, 2,450; valuation, £3,148) is supplied with high-pressure water of good quality, but, so far as 1884 is concerned, deficient in quantity. One spring supplies a reservoir, and water from other springs is conveyed direct to the town.

Holywood.—Population, 3,293; valuation, £12,480. This town was, in 1883, supplied with water collected at a distance and delivered to the town under pressure. My analysis shows that it contains 14 grains of solid matter per gallon, including 0·005 grain of albuminoid ammonia; saline ammonia, 0·006; nitrogen in nitrites and nitrates, 0·015 grain; chlorine, 1·886. The water is nearly colourless. Cost of the waterworks, £10,000.

Keady.—Population, 1,598; town revenue, £253. The public fountains and some of the houses are supplied with high-pressure water from a reservoir in connexion with Clea lake. Dr. Allen, Chairman of the Town Commissioners, informs me that some of the well waters still used are scarcely fit for potable purposes. Several of the wells dried up this year.

Kells.—Population, 2,822; valuation, £3,508. The water is derived from pumps and wells. It is mostly very hard and some of it impure.

Killarney.—Population, 6,651; valuation, £4,928. Many of the pump waters in Killarney are soft and pretty good, but several are very impure. A supply of good soft water will soon be collected from a stream from neighbouring hills and stored in a tank. The cost is estimated at £8,000.

Kinsale.—Population, 5,386; valuation, £5,454. I have examined a pretty fair specimen of water for the Kinsale Harbour Commissioners. This is all the knowledge which I possess of the water supplies of this town.

Larne.—Population, 4,716; valuation, £4,782. This town has just been furnished with a supply of water from the "Sallagh" springs, situated on elevated ground, $3\frac{1}{2}$ miles from the town. The water is good and abundant. There is a tank, but the water in it is intended to be used only in case of fire.

Letterkenny (population, 2,188; valuation, £3,215) was long dependent upon the scanty and impure supplies of water furnished by local wells, but now it has abundance of good water, obtained from a distance. The main reservoir is one mile from the town.

Limavady (population, 2,954; valuation, £5,795) is supplied with high-pressure water from a tank having a capacity of 135,000 gallons. The water is good, and is collected from springs. The works cost £6,000.

Lisburn.—Population, 10,753; valuation, £18,751. The greater part of the town is supplied with pressure water from a reservoir, one mile distant. Its composition, according to Dr. Hodges, is as

follows:—Total solids, 12·6 grains per gallon; albuminoid ammonia, 0·199 parts per million; saline ammonia, 0·055 parts per million. The quantity of albuminoid ammonia appears to be excessive. On the outskirts of the town the people depend upon wells.

Lismore (population, 1,860; valuation, £2,212) is supplied with high-pressure water brought direct from springs in the clay slate rocks lying north of the Blackwater. The water is very good, but in summer it is occasionally defective, and fails to supply the houses in the higher parts of the town. The supply is usually turned off at night. Lismore therefore requires an improved water supply.

Longford.—Population, 3,590; valuation, £7,029. I have analysed several of the pump waters, and found the greater number to be impure.

Loughrea.—Population, 3,072; valuation, £3,665. The water used is taken chiefly from a neighbouring lake, and is delivered with some degree of pressure into many of the houses. My analysis of the water, as supplied to the town, showed that it had in some way become somewhat polluted. The water supply to Loughrea requires investigation. The water is pumped by turbines into a tank having a capacity of 118,000 gallons. Cost of the works, £3,770.

Lurgan.—Population, 10,135; valuation, £18,348. The water used in this town is derived from public pumps and private wells. Their quality varies considerably. Several specimens which I have analysed proved to be impure. One contained 113 grains of solids per gallon.

Mallow (population, 4,439; valuation, £6,478) is famous for its springs and spas; yet in some parts of the town the pump waters are impure. When Asiatic cholera visited this town it was in the quarters where the impure water was used that the disease was most prevalent. The town is now supplied with pressure water from a reservoir at a cost of £6,250.

Maryborough.—Population, 2,872; valuation, £3,869. The waters—derived from wells and pumps—is extremely hard, but generally free from sewage impurities.

Midleton.—Population, 3,358; valuation, £5,675. The waters in use in this town are deficient in quality and quantity. The Board of Guardians have undertaken to supply the town with pure water.

Monaghan.—Population, 3,369; valuation, £5,967. Nine public pumps and numerous private wells and pumps supply water to the

inhabitants. Some of the wells are 50 feet deep. In most cases the water is pure.

Mountmellick.—Population, 3,126; valuation, £4,052. Excessive hardness is the characteristic of the well waters which supply this town. Although some of them are free from pollution, others are not so; and, on the whole, I think Mountmellick requires an improved water supply.

Mullingar.—Population, 4,787; valuation, £7,541. I have examined a large number of the pump waters which supply this town; some of them are fairly good, but others are hard and bad. In one I found 137 grains of solid matters per gallon, including the very high proportion of 0·05 grains of albuminoid ammonia.

Naas (population, 3,808; valuation, £7,612) depends altogether upon local wells and pumps, many of which I have found to be very impure.

Navan.—Population, 3,873; valuation, £5,660. The town depends altogether upon supplies from local sources, which have no pressure. There are nine public pumps, and many public and private wells, including a so-called spa. Some of these waters are good, though somewhat hard for detergent purposes; others are of indifferent quality. In one I found 119 grains of solid matters.

The following are analyses of the water of the River Boyne, taken above the town, and of the Blackwater taken in the town:—

One imperial gallon (70,000 grains) of each contain—

	Boyne. Grains.	Blackwater. Grains.
Total solid matters - -	19·600	13·300
Including—		
Albuminoid ammonia -	0·012	0·012
Saline ammonia -	0·002	0·002
Nitrogen acids - -	traces.	traces.
Chlorine - - -	0·980	0·985

The Blackwater filtered would furnish a better quality of water to Navan than it obtains from the local wells.

Newbridge.—Population, 3,372; valuation, £4,325. The pump waters which supply this town are exceedingly hard; in four of them I found more than 200 grains of solid matters per gallon. They are, however, pretty free from actual sewage matter.

New Ross.—Population, 6,670; valuation, £8,039. Four conduits convey water from springs situated in the higher portion of the town, and deliver it with some degree of pressure to the lower

portions of the town. In 1877 I found the water from the principal tank was fairly but not very good. There are six public pumps which also supply water to the town. Their quality is variable as a rule. The New Ross waters are pretty soft.

Newry.—Population, 15,096; valuation, £32,450. This important town is supplied with water taken from the Lake of Camlough, which covers an area of 160 acres, and is situated at a distance of four miles from the town. 650,000 gallons are delivered at a very high pressure, and the great majority of the houses have the water laid on to their interiors. There are numerous street fountains for the use of the poorer classes. The composition of the water is somewhat variable, but on the average it contains about 11 grains of solid matters, and very moderate amounts of albuminoid and saline ammonia. Newry is therefore one of the few towns in Ireland provided with really good and abundant water.

Nenagh (population, 5,422; valuation, £8,312) is altogether supplied by well and pump waters. I have not examined many of them, but the few which have come under my observation have been pretty good.

Newtownards.—Population, 8,676; valuation, £10,005. I have made a very large number of analyses of the water used in this town. Twenty-two of the pump and well waters were analysed in 1877; of these 7 were unfit for use, and some of the others were second class. The solids in solution varied in amount from 15·4 to 91 grains per gallon. Eighteen specimens analysed in 1881 were of better quality, their worst features being excessive hardness and the presence of much nitric acid. Three pump waters examined in 1882 were fairly good.

Omagh.—Population, 9,755; valuation, £6,251. Pressure water is supplied to this town. Its composition I found in 1882 to be as follows:—

One imperial gallon contained—

Total solid matters - - - - 4·900 grains

Including—

Albuminoid ammonia, - - - 0·006.

Saline ammonia, - - - 0·004

Nitrogen acids, - - - traces.

Chlorine, - - - 1·415.

The water is derived from a reservoir $2\frac{1}{2}$ miles distant from the town. Amount of waterworks loan, £12,115.

Parsonstown (population, 4,126; valuation, £8,712) has only

pumps and open wells to procure water from. These waters are very hard. Some of them are free from organic impurities, others are polluted. In one I found 111·15 grains of solids per gallon.

Portadown.—Population, 4,955; valuation, £17,066. Supplied by local wells. In one of their waters I found 114 grains of solids and 30 grains of chlorine. It was, however, free from sewage. Others examined by Dr. Hodges and the late Mr. Whitla were with one exception found to be pretty good.

Queenstown.—Population, 9,755; valuation, £19,908. This town has just secured an excellent supply of water from a distance of about 8 miles, and at a cost of about £20,000. I have analysed the water, and found it to be very pure.

Rathkeale (population, 2,549; revenue, £192) is supplied with pump water only, which, on the whole, appears to be of fairly good quality.

Roscommon.—Population, 2,117; valuation, £2,880. Supplied only by pumps, the water from which is pretty good.

Strabane.—Population, 4,196; valuation, £9,187. Has a high-pressure supply, but the quantity is most defective, and the town may be said to be really badly off for water.

Skibbereen.—Population, 3,631; valuation, £4,699. The springs and wells which supply this town are deficient in quantity, and some of them in quality; during the recent hot weather they almost disappeared. The Board of Guardians—the sanitary authority—have undertaken to improve the water supply of this town, but up to the present have not realised their promises.

Tandragee.—Population, 1,592; town revenue, £56. Four water pumps supply this town. I have analysed three of them; one was bad, one good, one indifferent.

Templemore.—Population, 2,800; valuation, £3,886. Has a rather scanty supply of indifferent quality of pump and well waters.

Thurles.—Population, 4,850; valuation, £6,107. Local wells supply the water used for potable purposes, and for other purposes the River Suir is made available. One of the well waters sent to me for analysis in June last was very hard (105 grains solids per gallon), one was slightly polluted, and another specimen was found to be pure.

Tipperary.—Population, 7,274; valuation, £8,663. The town is supplied by a spring termed Church Well (which has not failed during the recent drought), and several public and private pumps and wells. Several of the wells are very hard—one contains 137·9

grains of solids per gallon and is somewhat impure; yet, on the whole, this town is pretty well supplied with water, which, however, has the disadvantage of not being delivered under pressure. The water used in the barracks was analysed in 1877 at Netley by Professor De Chaumont and found to be "usable."

Tralee.—Population, 9,910; valuation, £12,303. The well waters of this town are generally unfit for use. I have analysed about 30 of them. Some contain from 100 to 200 grains of solid matters per gallon. Recently a supply of water from a tank situated $4\frac{1}{2}$ miles from the town has been procured, and it has been conveyed under high pressure into many of the houses in the principal streets.

The composition of this water, according to my analysis, is as follows. I give it as an example of a really good water.

One imperial gallon (70,000 grains) contains:—

	DISSOLVED	Grains
Lime - - - - -	-	0·24
Magnesia - - - - -	-	0·11
Potassium and sodium - - - - -	-	0·69
Oxide of iron, silica, &c. - - - - -	-	0·28
Chlorine - - - - -	-	0·68
*Organic and volatile matters - - - - -	-	2·50
Total solid matters per gallon - - - - -		4·00
*Including organic nitrogen - - - - -	-	0·004
„ ammonia - - - - -	-	0·002
Nitric acid - - - - -	-	faint trace.
Nitrous acid - - - - -	-	none.

Matters Suspended in the Water.

Organic and volatile (at a red heat) - - - - -	-	0·55
Fixed solids - - - - -	-	·17
Total suspended matters - - - - -		·72

One gallon of this water, therefore, contains of solid substances:—

	Grains
Suspended matters - - - - -	0·72
Dissolved matters - - - - -	4·00
Total solid matters - - - - -	4·72

Of the solid substances 0·86 grain is precipitated by boiling a gallon of the water for 10 minutes.

Trim.—Population, 1,586; valuation, £2,115. The town has no pressure water. Many of the pump and well waters are impure. Two of the public pumps were closed by order of the sanitary authorities, my analysis having shown that they were unfit for use. Trim has, for a small town, a very large revenue—namely, about £800 a year. Good water is procurable from springs situated near the town. There would, therefore, seem to be no good reason why this town should not be supplied with pure water.

Tuam (population, 4,223; valuation, £4,035) is supplied by pumps and wells, and their waters are “good, bad, and indifferent,” as is usually the case in such towns. In a water sent to me from this town by Mr. French, solicitor, there were 164 grains of solids per gallon, and in other respects the water was bad.

Tullamore.—Population, 5,098; valuation, £5,392. The water supply is derived from five public pumps, and from private pumps and wells. It is generally very hard, but, on the whole, free from pollution.

Westport.—Population, 4,469; valuation, £6,243. The town is supplied by wells and pumps. Their waters are generally somewhat peaty, but free from sewage.

Wicklow.—Population, 3,391; town revenue, £1,361. The majority of the pump waters in this town are impure or second class. A pressure supply has lately been procured. The reservoir is about one mile from the town. The water is of good quality, though somewhat high in colour; but no doubt, as in similar cases, the colour will in time become less intense. The waterworks cost about £6,000.

Youghal.—Population, 5,936; valuation, £9,571; town revenue, £2,144. Four public pumps and several private wells supply the inhabitants with water. The quality is locally believed to be good. I have not seen any analysis of Youghal waters.

In concluding these brief notices of the supplies of water to Irish towns, I have to point out that, as a rule, they are of defective quality, and that, in the great majority of cases, the towns of Ireland have no high-pressure water, which is so useful in the case of fires and for other purposes. The Metropolitan area and 8 of the towns governed by Corporations have high-pressure water supply, but very many of the 92 smaller towns are dependent upon local wells, &c., which, on the whole, furnish impure supplies.