Water supply of the city of Aberdeen : general report on the water supply of large towns, as compared with Aberdeen : and financial memorandum on the Aberdeen Water Works : with analyses of the Aberdeen water by Professor Brazier, of the Aberdeen University.

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WATER SUPPLY

OF

THE CITY OF ABERDEEN.

GENERAL REPORT

ON THE

WATER SUPPLY OF LARGE TOWNS,

AS COMPARED WITH ABERDEEN;

AND

FINANCIAL MEMORANDUM ON THE ABERDEEN WATER WORKS;

WITH

ANALYSES OF THE ABERDEEN WATER BY PROFESSOR BRAZIER, OF THE ABERDEEN UNIVERSITY.

ABERDEEN:
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1869.

GENERAL REPORT.

In following out the remit of the Water Works Committee on this subject, the object being to print along with Professor Brazier's Chemical Analyses of the Aberdeen Water Supply, as much general information on the Water Supply of large towns throughout the kingdom as could be obtained, for purposes of comparison, the Clerk of Police despatched Circulars and Queries to various towns, and replies were received from five London Companies, and from Manchester, Sheffield, Oxford, Cambridge, Bristol, Lancaster, Sunderland and South Shields, Newcastle-upon-Tyne, Cardiff, Glasgow, and Dundee. Various Blue Books have also been examined bearing on the subject, and recent discussions as to the Edinburgh Water Supply have been referred to. The information thus obtained naturally divides itself into the two great branches of Quantity and Quality.

I.—Water Supplies—Quantity.

The Works for the supply of Aberdeen are now fully consolidated, and having been recently overhauled, and some necessary repairs already effected or in hand, they may be said to be in perfect order. From experiments made at the Upper and Lower Service Reservoirs, at different times since the opening of the Works, it is found that the quantity of water consumed daily in Aberdeen is $2\frac{1}{2}$ million gallons as a maximum. This falls in winter to a little over 2 million gallons per day. We estimate the population supplied at about 72,000, including Old Aberdeen, which is supplied during part of the year; and the average amount per head per diem would there fore be upwards of 31 gallons. This includes the quantity taken for manufacturing purposes, which amounts to about 160,000

gallons per day, being about one-eighteenth of the total consumpt. This proportion is small compared with other towns, but several manufacturers and traders here have artesian wells, or other sources of supply. The amount supplied to Shipping by the Tacksman, and that used in flushing closes, which is large, and in watering streets (in the season) may be reckoned at 20,000 gallons a-day at least. In towns, generally, where the waste is controlled, about 15 gallons per head per day is found to be a very good and sufficient supply ; and it appears from evidence laid before a Parliamentary Committee, that 20 gallons a-day per head is an abundant allowance for all domestic purposes, allowing for considerable, but perhaps unavoidable waste. In Shields, Norwich, Cambridge, Sunderland, &c. where there is strict supervision over the distribution, so as to prevent wastes, this is found sufficient ; and the returns furnished in reply to our Queries state, that in Manchester 20 gallons per head per day is the total quantity supplied, and of this one-third is for trading purposes. In Bristol, the total daily supply is 24 gallons per head, including perhaps one-sixth for trading purposes. In Sheffield, the total daily supply per head is 18 gallons, including one-sixth for trading purposes. In Glasgow, the supply is 50 gallons per head per day, and of this, 5 gallons per head per day sold by meter for manufacturing purposes. The Metropolis Water Supply is at the rate of 28 gallons per head per day. It thus appears, as far as returns have been obtained, that the supply to Aberdeen is fully equal to that of any other town in the United Kingdom, Glasgow and Oxford excepted.

It will be observed that less than one-half is taken from the Dee of what the Commissioners are entitled to take, viz., 6 million gallons a-day. The supply from the Bridge of Dee was only 18 gallons per head per diem : an increase of about 60 per cent. has therefore taken place since the new supply was introduced. The reporters beg to call the attention of the Committee to the question of wastes of water throughout the city, which, though not equal to what take place in Glasgow and Oxford, are, nevertheless, great. Assuming, as already noted, that a supply of 20 gallons per head per diem is amply sufficient for all purposes, it thus appears that about 10 gallons per head per diem must be set down to waste, being about 33 per cent. This waste takes place in various ways—by defective

plumber work in houses, in service cocks, leakage of water from pipes and cocks,* ball-cocks and cisterns in water closets, and other cisterns being allowed constantly to overflow, and by water closet handles being propped up, and the water left to run all night.† There is also a great loss of water by *Fountains* playing in private gardens—also, by watering of flowers in lawns by hosepipes, which, not being strictly domestic purposes, ought to be charged for additional. Owing to the difficulties of prevention of waste, when once it becomes a habit of the people in large towns, it is important that measures should be adopted of frequent house to house inspection by the officials of the Board, in order timeously to check this wasteful practice. The results of the information obtained under this head are briefly condensed in the following table :—

	SOURCE OF SUPPLY.	Gallons per head per diem, inclusive of manufacturing purposes.	For Manufacturing Purposes.
ABERDEEN,	**RIVER DEE,** -	**31**	**2**
London,- -	Thames, New River, & River Lea, - -	28 to 29	‡ 5 galls.
Manchester,	River and Springs, -	20	7 „
Sheffield, -	Moors, - - -	18	3 „
Bristol, - -	River and Springs, -	24	‡ 4 „
Sunderland,	Shafts sunk in the Lime-stone, - - -	20	‡ 5 „
Newcastle, -	River and Springs, -	30	‡ 7 „
Oxford, -	Artificial Lake, - -	70 to 80	‡ 4 „
Cambridge, -	Springs, - - -	19	8 „
Lancaster, -	Do. - - -	27	5 „
Cardiff, -	River and Springs, -	26	‡ 5 „
Glasgow, -	Loch Katrine & Rivulet Brookburn, - -	50	5 „
Edinburgh, -	River and Springs, -	‡ 40	‡ 4 „
Dundee, -	Streams, - - -	No return	No return

* Complaints are sometimes made as to scarcity, which, on investigation, are found to rise from some defect, radical or accidental, in the house pipes or cisterns. From the same cause the quality of the water is also often deteriorated. Hence, one step, if not the first, to be taken in cases of this kind, should be to find out if these local causes exist.

† This practice was publicly recommended in an address by an eminent Medical Practitioner to the Aberdeen Ladies' Sanitary Association.

‡ These figures are approximations.

It will thus be observed that Aberdeen is especially favourably situated in respect of quantity of Water Supply.

II.—Quality of Towns' Waters.

The *quality* of water supplied to a large town has obviously an important bearing on the public health, as well as on the convenience and comfort of the inhabitants. The site of the present intake at Cairnton was fixed on, not merely from its level admitting of the supply coming to the town by gravitation, but because it ensured that, for a very long period at least, the water should be placed beyond risk of contamination. In Mr. Simpson's report of 10th Sept., 1855, he states that, "from examination of the present source [*i.e.* near the Bridge of Dee] it was obvious to me that at times the river Dee must be seriously affected by impurities, and on investigation, this evidently proceeded from some of the small streams flowing into the Dee, and more particularly from the Loch of Skene and the Mills on the Culter Burn (the water of the latter being occasionally in an extremely foul state), also, from the Burns of Bennie and Cannie and the river Feugh, which are decidedly moss waters." It has also to be noted that the drainage of Banchory is discharged into the Dee at two different points—one at Banchory Bridge and the other at the Railway Station. There is also a growing population near the various stations from Banchory to Aberdeen, more especially from the extension of building at Cults, while the manufacturing operations at Culter are also being enlarged. It has to be borne in mind that even chemical analyses are not so perfect as to discover every element of impurity, and that, although the power of running water, aided by the animal and vegetable life abounding therein, to purify itself, is great; yet the best security for a pure supply is to be found in taking it from a source where there is no possible danger of its being mixed with sewage or other known sources of contamination. Hence the advantage of such an Intake as that at Cairnton having been selected.

It should also be observed that, from the large size of the Reservoir at Invercannie (which is capable of containing 15,000,000 galls.) the supply of the town can be maintained for 6 or 7 days without taking any water from the Dee. During spates or flood, the water

is shut off from the intake, and as spates are generally over within three days, the town is perfectly insured of a supply without drawing on the river during its impure state. By the old works this arrangement was of course impracticable, the water being taken in at all states of the river.

The complete action of the filters at Invercannie also gives a further advantage over the system of filtration at Hildon Tree, and latterly in the case of the old works it might be said that there was no filtration whatever. The tunnel through the rock at Cairnton gives an additional supply of spring Water of about 8 per cent. of the present consumption, and about two per cent. more may be calculated as the supply from several small springs out of the rock at various parts of the line of the aqueduct. In addition, the water is improved, and rendered cooler in the summer months by flowing a distance underground of some 20 miles, a course which it requires about 16 hours to traverse. The essence of the returns from other towns, as to quality, will be found in the annexed table :

Towns.	Total solid matter. Grs. per gal.	Of which Organic. Grs. per gal.	Degrees of Hardness.
ABERDEEN :—			
Cairnton, - - -	2·850	0·35	1·45
Pitfodels, - - -	3·650	0·55	1·85
Town's Well, - -	3·450	0·45	1·75
London (average of all Cos. in 1867)	21·30	0·74	13·9
Manchester, - - - -	4·515	·840	2·0
Sheffield, - - - -	7·20	1·60	2·5
Birmingham,* - - -	37·70	1·65	15·5
Liverpool,* - - - -	14·64	0·55	9·6
Leeds,* - - - - -	13·37	0·58	7·5
Sunderland and S. Shields, -	28·67	0·22	26·
Newcastle-on-Tyne, - -	18·16	0·79	14·2
Oxford, - - - - -	23	—	14
Cambridge, - - - -	22	2	15
Lancaster, - - - -	Scarcely a trace: less than 1		
Cardiff, - - - - -	16·76	0·60	13·4
Edinburgh,* - - - -	10·30	·57	7
Glasgow (Loch Katrine) - -	1·90	0·30	1
Dundee,* - - - -	7	0·50	4·3

* Parliamentary Blue Book.

It will thus be noted that, with the exception of the Loch Katrine water supplied to Glasgow, north of the Clyde, and the Lancaster supply, the City of Aberdeen enjoys the distinction of having the purest water of any town in the United Kingdom. A similar advantage is enjoyed in respect of *hardness:* the extreme softness of the Dee Water effecting (compared with other towns) a great saving in soap, tea, &c., to the community.

It will be seen, from the foregoing observations, that the Commissioners have at their command an abundant supply of water for all the future requirements of the town, even though the population should increase to 200,000.

The Commissioners expected that, previous to this time, there would have been a demand for water for hydraulic purposes in the vicinity of the Railway Stations, and about the Quays and other low lying parts of the town. In many large towns water power is extensively used, and is found to be easily worked, being a very convenient and economical power. It may also be used with equal readiness and advantage in warehouses and shops for hoists, small grinding machines, printing, &c. There is no doubt that, whenever a commencement is made of the use of this power for such purposes, it must become general wherever it can be applied ; and the Commissioners will have to keep in view the necessity of taking means to meet this demand, which would ensure for them a large pecuniary return.

ROBERT ANDERSON,
Resident Engineer.

JAMES VALENTINE,
Clerk of Police.

5th Januar 1869.

FINANCIAL MEMORANDUM.

The cost of the New Water Works, including Land Compensations, Law and Parliamentary Expenses, is, in round numbers, £155,000.

The following Table shows the Income and Expenditure, for the last three years, of the Water Department—

	Income.	Expenditure.	Surplus.	Deficiency
Year ended 31st May, 1866,	£8,363	£9,516	...	£1,153
„ 31st May, 1867,	8,830	9,107	...	276
„ 31st May, 1868,	10,814	9,405	£1,409	...

From the foregoing Table, it will be seen that, since the introduction of the new supply of Water, there has been a regular increase on the Annual Income, viz.—

For the year 1867 over 1866 of £467.
„ 1868 over 1867 of £2,034.

From this latter sum, however, a deduction of £1,100 must be made, on account of the increased rate levied for the year ended 31st May, 1868, which still leaves a sum of £934, as the increase that would have taken place had no additional rate been imposed; of this sum, nearly one-third arises from new supplies granted to parties residing *beyond* the Police boundary. There is also a considerable portion of it (about £250) derived from an increased consumpt of water for manufacturing purposes. The quantity registered by meters last year was 47,300,000 gallons, being an increase over the preceding year of about 7,000,000 gallons.

GEO. MILNE,
Treasurer of Police.

5th January, 1869.

ANALYSES OF THE WATER SUPPLIED TO THE CITY OF ABERDEEN.—REPORT.

UNIVERSITY OF ABERDEEN, Nov. 10, 1868.

ON THE COMPOSITION OF THE WATER OF THE RIVER DEE, AND OF THE WATER AS NOW SUPPLIED TO ABERDEEN; TOGETHER WITH AN INVESTIGATION INTO THE ACTION OF THE WATER ON LEAD.

GENERAL CHARACTER OF THE DISTRICTS DRAINED BY THE RIVER DEE.

In a report upon this subject by Dr. John Smith, the general character of the district drained by the River Dee is so concisely given by him that I cannot for my purpose do better than quote his words—

"The sources of the Dee are found amidst the lofty granite mountains of Braemar, on the confines of the Counties of Banff, Inverness, and Perth. The river flows from thence, in an easterly direction, along a narrow valley, till it falls into the sea at Aberdeen, its length being 80 miles, or when measured in a straight line, 65 miles. The banks of the river are gravelly, and the alluvial deposits few, and of limited extent. The bounding ridges of the valley are mostly of granite and gneiss. The flow of the water is pretty rapid, the alteration of level between the Linn, (16 or 17 miles below the source) and Aberdeen, being nearly 1200 feet. From the small proportion of clay and peat in the valley of the Dee, its waters during dry weather are usually quite clear; in rainy weather, however, they are often charged with mud from the swollen mountain torrents. The Dee and its tributaries drain about 900 square miles of country.

"The rocks near the sources of the Dee are quartzoze mica-slate. Though very insoluble in their nature, these rocks will, by slow decomposition, yield to the water minute portions of silica, potash, and iron. The Springs of the Dee must, however, be very pure. Further down, the river receives water that flows over patches of crystalline limestone, and a tributary (the Muick) passes along a range of serpentine. From these rocks, the water will derive a small proportion of lime and magnesia. Proceeding still farther down, the rocks present little variety; granite and gneiss, with occasional veins of felspar-porphyry, and more rarely, patches of limestone, making up the geology of the district."

The water for the supply of Aberdeen is now taken from the river at Cairnton, about 20 miles from its mouth, at a level of 210 feet above high water at Aberdeen. It is brought by excavated tunnel to Invercannie, where are situated the subsiding Reservoir and Filter beds

Thence again it is conveyed by aqueduct into a service reservoir at the Brae of Pitfodels, and from this it is distributed by iron mains throughout the streets of the City of Aberdeen.

Composition of the Water.

For the present investigation three samples of water were collected and forwarded to me for examination.

Sample I., taken from the Inlet Tank at Cairnton.

Sample II., from the entrance to Lower Reservoir at Pitfodels.

Sample III., taken from a Street Well in Gallowgate, near Porthil[Close.

These specimens were collected on the 6th and 7th of Aug. last, after a continuance of remarkably fine weather—(the rainfall of the preceding month being only 0·711 inch). The river at the time was very low.

All three samples as collected were remarkably clear and bright, possessing only a very slight green tint, such as could be noticed by comparison of a large mass of the water on a sheet of white paper. They contained little or no sedimentary deposit.

Sample I., taken from the Inlet at Cairnton, was found to contain per imperial gallon, = 10 lbs. = 70,000 grs., the following weights of soluble contents expressed in grains :—

Combustible (Organic) Matter, - - -	0·350
Incombustible (Mineral) Matter, - -	2·500
	2·850

Expressed more in details as follows :—

Organic Matter, - - - -	0·350
Carbonate of Lime, - - - -	0·930
Sulphate of Lime, - - - -	0·243
,, Magnesia, - - -	0·423
Chlorides of Sodium and Potassium, - -	0·684
Sesquioxide of Iron and Phosphates, - -	0·040
Silica, - - - - -	0·180
Total, - - -	2·850

Sample II., taken from the entrance to Lower Reservoir at Pitfodels, was found to contain per imperial gallon = 10 lbs. = 70,000 grains, the following weights of soluble contents expressed in grains :—

Combustible (Organic) Matter, - -	0·55
Incombustible (Mineral) Matter, - -	3·10
	3·65

Expressed more in details, as follows :—

Organic Matter, - - - -	0·550
Carbonate of Lime, - - - -	1·210
Sulphate of Lime, - - - -	0·315
,, Magnesia, - - -	0·503
Chlorides of Sodium and Potassium, - -	0·742
Sesquioxide of Iron and Phosphates, - -	0·080
Silica, - - - - -	0·250
Total, - - -	3·650

Sample III., taken from Street Well in Gallowgate, near Porthill Close, was found to contain per imperial gallon, = 10 lbs. = 70,000 grains, the following weights of soluble contents, expressed in grains :—

Combustible (Organic) Matter, - -	0·45
Incombustible (Mineral) Matter, - -	3·00
	3·45

Expressed more in details, as follows :—

Organic Matter, - - - -	0·450
Carbonate of Lime, - - - -	1·110
Sulphate of Lime, - - - -	0·292
,, Magnesia, - - -	0·521
Chlorides of Sodium and Potassium, - -	0·737
Sesquioxide of Iron and Phosphates, - -	0·110
Silica, - - - - -	0·230
Total, - - -	3·450

In neither specimen could nitric acid be detected. Iron was detected in each specimen, but was not more perceptible in No. 3 than in No. 1. The combustible or organic portion, as indicated in No. 1, is remarkably small, and is by no means excessive in No. 3, which contains the most. In its nature it resembles that found in most of the waters of our mountain springs, being of a woody (mossy) rather than of a nitrogenous (animal) origin. This conclusion is supported by the fact that the presence of nitrates could not be detected, even by operating upon a considerable bulk of the several specimens.

The proportion of this organic matter is liable to great variation. The small quantity found in the samples under present investigation, is to be attributed to their having been collected under an especially auspicious circumstance, namely, after an almost unprecedented continuance of dry weather.

* Rain-fall during May, - - -	1·348 inches.
,, ,, June, - - -	0·629 ,,
,, ,, July, - - -	0·711 ,,
,, ,, August, (after the specimens had been collected), - -	6·938 ,,

* For this and other estimations of rainfall alluded to in this report, I am indebted to the kindness of the Rev. Alex. Beverly.

When examined by Dr. Smith, in 1850, three days after heavy rain, the water had a brownish tint, and contained more than a grain and a half of organic matter. He states that this quantity is more than what the Dee water usually contains. Another specimen, collected in February, 1851, the river being of its usual size, and the water clear and colourless, gave 3 grains per gallon of solid contents, of which only 4-10ths of a grain were organic matter.

The Hardness.

Where the proportion of soluble mineral matter is so small as in these waters, the only important quality that can arise from this matter is hardness. By hardness in a water is meant the property of destroying soap. Now, of the mineral substances commonly found in waters, only two produce this quality—these two are lime and magnesia. The particular acids that these or other saline bases present may be combined with has no effect on the hardness.

A particular scale of degrees for expressing hardness, and for comparing different waters in this respect, was introduced amongst Chemists twenty years ago by Dr. Clark, and a mode of ascertaining those degrees was at the same time published, capable of such precision in use as to have been generally acceptable to Chemists of accurate habits. One degree of hardness (1 ° H.) means as much hardness as would be produced by one grain of pure chalk (carbonate of lime) in a gallon of pure water, no matter how dissolved; 10 degrees of hardness (10 ° H.) means as much hardness as would be produced by dissolving 10 grains of chalk in a gallon of pure water. The soap destroyed by the hardening matter of a water is proportional to the degrees of hardness.

I found the hardness of the three samples as in the following table, where I have added, by way of comparison, the average hardness of the Dee and Don, as stated by Dr. Smith in his report of 1854, and of the Metropolitan waters; also the quantity of soap destroyed by the hardening matter in 100 gallons of each water:—

	Deg.	100 gallons destroy of Soap.
Sample I., - - -	1·45	3·0 oz.
Sample II., - - -	1·85	3·8 oz.
Sample III., - - -	1·75	3·6 oz.
Dee (Dr. Smith), - -	1·25 to 1·75	2·6 oz. to 3·6 oz.
Don („), - -	3·14	6·5 oz.
Metropolitan Waters, - -	14·00	29·1 oz.
Distilled Water, - -	0·0	0·0 oz.

NOTE.—As an addenda to the foregoing portion of the report, the followi estimations may be interesting:—

A sample of water as supplying Aberdeen, collected on the 1st of March, 1867, rainfall of previous month having been - 1·444 inches,
Gave of total grains per gallon, - - 4·00
Hardness, - - - 1·75 deg.

A sample, collected June 29, 1867, rainfall of month having been 1 286 inches,
Gave of total grains per gallon, - - 4·50
Hardness, - - - 2·00 deg.

A sample, collected June 22, 1868, rainfall of previous four weeks having been - - - - - - - - - - - 0·322 inches,
Gave of total grains per gallon, - - 3·45
Hardness, - - - 1·80 deg.

EXPERIMENTAL TRIAL OF THE ACTION OF THESE SAMPLES OF WATER UPON THE METAL LEAD.

For this purpose the following comparative experiment was arranged. Equal quantities of the three specimens of water were submitted in separate vessels, for the same length of time, and under precisely the same circumstances to the action of the metal lead. The result of the experiment proved that each specimen acted similarly to the other, and that the proportion of lead taken into solution by the water in each case was one-twentieth of a grain. I have had occasion to make this experiment repeatedly as a comparative test to other waters during the Spring and Summer of the present year, and have always arrived at the above result. The proportion of lead taken into solution by the water at present is about one-half of the quantity formerly dissolved. Previous to the present year, the last time that I had occasion to ascertain the exact amount of lead taken into solution by the Dee water was in August, 1866, when I found it to be one-tenth of a grain per gallon. Earlier still, in 1858, when reporting, in company with Dr. Clark, upon the action of certain waters upon lead, we found Dee water took up one-tenth of a grain of the metal per gallon. This again is the average proportion recorded by Dr. Smith in 1850.

On account of the above result, I thought it expedient to ascertain (if possible) the proportion of lead in some of the specimens of water from house pipes and cisterns, formerly examined by Dr. Smith; in every case experimented upon, the proportion of lead was very much lower than that stated by him.

I believe, however, this lessened action of the water on lead at the present time is easily explained. During the past winter (1867-68), the hills supplying the river Dee received scarcely any snow, and the river, therefore, during the present year has been remarkably free from snow-water, a substance well known to increase the action of any soft water upon the metal lead.

From the foregoing analyses and experiments, I am of opinion that the character of the Dee water is not altered since the earlier analysis by Dr. Smith in 1850, nor is it more than slightly interfered with by admixture of other water, during its course from the inlet at Cairnton to Aberdeen.

Although at times, during a period of heavy rain, the water may be somewhat higher charged than usual with peaty colouring matter, still I think the inhabitants of Aberdeen have reason to congratulate themselves upon having a water as wholesome, and with scarcely an exception, as soft as that supplied to any other large town in the united kingdom.

JAMES S. BRAZIER, F.C.S.,
Professor of Chemistry.