REPORT

ON THE

Condition of the Pawtuxet Water,

SUPPLIED TO THE

CITY OF PROVIDENCE, R. I.,

MADE BY

JOHN HOWARD APPLETON,

Professor of Chemistry in Brown University.

APPENDIX TO THIRD QUARTERLY REPORT OF THE BOARD OF PUBLIC WORKS,
CITY DOCUMENT NO. 20, SERIES OF 1883.

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THE CITY OF PROVIDENCE.

IN BOARD OF ALDERMEN, October 18, 1883.

ORDERED, That fifteen hundred copies of the report upon the condition of the Pawtuxet water made by Professor John Howard Appleton, and presented by the board of public works to the city council as an appendix to their quarterly report in city document No. 20, series of 1883, be printed.

Witness:

HENRY V. A. JOSLIN, CITY CLERK.

REPORT

OF

PROFESSOR JOHN HOWARD APPLETON.

To the Board of Public Works, Providence:

Gentlemen:—I propose in this report to present in a convenient and popular form some of the results of my examinations of the water of the Pawtuxet river as supplied to the city of Providence.

My analyses of this water have continued for a term of nearly eight years; a few analyses were made in the year 1875, and then, beginning with the year 1876, the water has been tested regularly twice a month up to the present time. For this series of tests, the water has been obtained from the river itself, near the in-take of the Pettaconset pumping station. At certain irregular intervals, however, the water has been tested from the distribution pipes of the city of Providence.

PURPOSES OF THESE TESTS.

In having these tests made it has been the intention of the Water board and the Board of public works to keep a vigilant watch over the quality of our water at its source of supply, and also to keep a permanent record of the results.

The superior softness of our water, whereby it is so excellent for washing purposes, is readily recognized by all users; and again its fitness for use in steam boilers has been beyond question. For the variety of other business uses to which it is put, it is acknowledged to be admirably fitted. While then, my tests had reference to the qualities which adapt it to these uses, I have given special attention to those which applied in any way to its fitness for drinking and cooking purposes.

In case of nearly every sample a series of six tests has been applied. Notwithstanding this number of tests it cannot be denied that chemistry finds one of its most difficult problems in the question—Is a certain given sample of water fit to drink? Some of the sources of this difficulty will be now stated.

THE SOLVENT POWER OF WATER.

One of the most important of the properties of water is its solvent power. Thus it is capable of dissolving greater or less amounts of a large proportion of all the substances known. Now in nature, water is constantly progressing from stage to stage in a sort of circulation, in course of which there are frequent opportunities for the water to exert its solvent power upon the substances with which it comes in contact. For example, the atmospheric air is permeated with water in the form of an almost invisible vapor, and this vapor is readily condensed into the liquid drops of rain; now, while these drops are at first pure water—that is consist of absolutely nothing else but water—they do not long remain so. In falling, they begin to dissolve substances they meet in the air during their downward progress. Upon reaching the earth, portions, at least, of them flow from the surface into larger bodies of water, as rivers for example; other portions soak into the ground and flow beneath the surface toward wells or other subterranean reservoirs. In either case the water takes into solution certain substances with which it comes into contact in the earth; indeed the water that flows into rivers carries to them in addition various floating solid matters that hang suspended in it and cannot be said to be ever properly dissolved in it. These matters are carried to the ocean, whence great quantities of pure water evaporate into the atmosphere, ready upon proper occasion to begin again the round we have briefly pictured. Of course the substances left behind in the ocean, serve in some degree to increase the impurities already gathered in it.

RARITY OF PERFECTLY PURE WATER.

So it appears that in nature it is difficult to find anywhere, water that is perfectly pure; in fact it is no easy matter for the chemist to prepare—even by the most skilfully devised artificial processes—absolutely pure water, that is water in which he cannot detect some substances dissolved. And thus it occurs that the principal differences between natural waters arise from variations in the kind, character, and amount of the impurities that they contain. Of course it is plain that the word impurity may be used in two widely different senses; in the chemical sense it is not intended to convey any suggestion other than that of some substances different from water itself, dissolved or suspended in the latter; in the every-day sense, the word impurity appears to carry the impression that the thing referred to possesses some foul or unwholesome quality. It is evident then that two different samples of drinking water may contain substances which the chemist would designate as impurities, of which those in the one sample may be harmless or even beneficial, while those in the other may be highly injurious to health.

THREE CLASSES OF WATERS.

Of course the chemist encounters a class of waters, the members of which are extremely unwholesome; they contain mineral substances well known to be injurious or they are charged with animal matters in a recognizable condition of putrefaction. He also meets another class which are in the opposite extreme: it consists of waters of marked degree of purity, almost entirely free from mineral and organic matters of any kind.

Evidently, then, it is in waters of a third class that the chemist finds difficulty in forming a correct opinion. These may contain, in moderate quantities, impurities which in larger amounts would be plainly unwholesome.

Here, then, must be met the not uncommon difficulty of adopting some definite point, in a continuous series of numbers, at which it will be decided that all less quantities are harmless and all greater quantities are dangerous.

Again it is difficult to experimentally determine the effects of samples of water of this third class upon individuals using them; for initial physical condition, the articles of food of a more decided character, as well as various other circumstances make it hard to fix any given effect as distinctly referable to the use of water of this class.

METHOD OF THIS REPORT.

In this report, I propose to dwell mainly upon two kinds of tests that have been applied to the Pawtuxet water.

The one test gives us the *total amount of solids* yielded upon evaporation of the water—a very general sort of test; the other gives us the amount of *albuminoid ammonia* yielded by the water—a very special sort of test.

In discussing each kind of matter I intend to refer to the amount of it in the water supplied to other cities and also in the water supplied to the city of Providence for the last eight years.

In my references to other cities I compare the waters by means of the tests made by Professor Albert R. Leeds, of Hoboken, N. J. In the months of June and July, 1881, this gentleman, one of the most eminent of American chemists, was called upon to examine the waters of the Passaic river which supply the cities of Newark, Jersey City and Hoboken. He obtained in addition, samples of water from a number of the principal cities of the Union (but not including Providence) and tested them. His results were intended to be compared with each other; they may be fairly compared also with those of tests of the water of the city of Providence made at that time in accordance with our custom. While it is probable that the water of some of these cities may have been better at some other dates than at those chosen by Professor Leeds, and the same is known to be the fact in case of the Providence water, viz.: that on many occasions, both before and since, it has been better than in June and July, 1881, yet on the whole, the report of Professor Leeds affords the best means of comparison of city waters to which I have been able to gain access.

TABLE I. TOTAL SOLIDS IN PAWTUXET AND OTHER WATERS.

The amount of total solids in a water is learned by evaporating a measured quantity of the water in a suitable weighed dish; the water then goes off as steam while there is left behind in the dish, as a residue, every solid substance that was either floating in the water or was dissolved in an invisible condition within it. Upon taking the weight of such residue, we obtain an outside datum which is a very valuable one, since it tells us at once whether a water is grossly polluted or not. Now I have prepared table I. for the purpose of displaying both the absolute and the relative amounts of total solids in our water supply.

This table expresses throughout the *number of parts*, by weight, of total solids that the various kinds of water referred to yield *per million parts of water*, also by weight; moreover the kinds of water are in all cases placed in the order of their amounts of impurities—those having the least impurity coming at the top.

First. Column one (table I.) shows the total solids existing in waters furnished to certain of the principal cities of the United States in June and July, 1881.

The list will be found to include the following important municipalities:—

New York, (population by census of 1880)	1,206,299
Philadelphia, - - - - -	847,170
Brooklyn, - - - - - -	566,663
Boston, - - - - - -	362,839
Baltimore, - - - - - -	332,313
Cincinnati, - - - - - -	255,139
Washington, - - - - - -	147,293
Jersey City, - - - - -	120,722
Providence, - - - - - -	104,857
Rochester, - - - - - -	89,366
Paterson, - - - - - -	51,031
Wilmington, - - - - -	42,478
Hoboken, - - - - - -	30,999
Oswego, - - - - - -	21,116

This column also contains the results of the analysis of one sample of water from the Providence *distribution pipes* which was taken incidentally on June 8, 1881.

From this column it appears that at the comparison dates the Providence supply, both in the river and in the distribution pipes, had a smaller amount of total solids than had any of the other cities mentioned; so far then, it must be credited with a higher degree of purity than any of them.

Second. Professor Leeds also examined waters from the sources of the Boston supply; for purposes of comparison with the water of our own source, I have placed the result from the Boston sources in the second column. It is plain that so far as this datum is concerned the Boston sources are far below our own in purity.

Third. The results in the first and second columns may be said to refer to one particular period or occasion; in the third column therefore I give a resumé of the results obtained in case of the Pawtuxet water upon nearly two hundred different occasions and covering a period of about eight years.

From this column it appears that the average amounts of total impurities in our source of supply for each and every one of the last eight years—and consequently for the whole of them—was much less than in the purest of the other city waters upon the comparison dates.

The third column of table I. is one of averages. Now it may be said of averages that *they sometimes flow from the improper combination of discordant extremes* and thus become meaningless or misleading. In order to try the Pawtuxet averages just given, upon this point, I have introduced column four in which is given the very largest amounts of total solids found in the water upon any occasion during the last eight years—those in which we have had a critical examination of it. The figures of this column clearly show that our averages are not open to the objection suggested; for the variations have been extremely moderate; and even at the times of largest amounts our water compares favorably with that of the other cities at the comparison dates.

Fourth. Columns five and six of table I. relate to waters from the Providence distribution pipes. They display the results of tests of nearly twenty samples of water tested in the last few months of the year 1882 and in the first few months of the year 1883.

If we except numbers 14 and 21, which I am informed came from points entirely inaccessible to consumers, we find that the average amount of total solids is slightly less in these samples tested from the distribution, than the average amount in water taken at the same period from the river.

TABLE II. ALBUMINOID AMMONIA IN PAWTUXET AND OTHER WATERS.

This table needs less explanation than table I. because the principles guiding in its arrangement are the same as in that one. The fact must not be overlooked however that *in this table the numbers represent amounts only one one-hundredth* *as great as in the other*—namely, they represent *hundredths of one part* of albuminoid ammonia by weight *in one million parts of water*, also by weight.

Again the substance—albuminoid ammonia—which forms the subject of the table demands some comment. As has been already suggested some of the matters dissolved in water defy the attempts of the chemist to definitely characterize them. Thus it is often impossible to declare the presence of animal matter upon the basis of any direct test. Hence recourse must be had to an indirect one. The test based upon albuminoid ammonia is that which is almost universally adopted as the best at present known. The term implies that kind of ammonia which is produced by the natural or artificial decomposition of animal matters — and in some cases of vegetable—of which albumen is taken as the type. In testing water, the chemist subjects it to a process which will develop ammonia from all of the matters present, capable of this change; then he finds out with exactness the quality of ammonia so formed. The value of this test is enhanced by the fact that the process used—called Nessler's test—is one of the most delicate known to science. *On the other hand, as has been acknowledged, certain harmless animal and vegetable matters may by this method be counted as dangerous ones. But as this course keeps us on the safe side it is usually adhered to, and the test for albuminoid ammonia is considered one of the most important.*

First. Column I. (table II.) shows that the amounts of albuminoid ammonia, of the principal city waters compared, group themselves mostly in a space between the numbers $\frac{18}{100}$ and $\frac{33}{100}$.

At approximately the same dates, the three tests of the Providence sources all came well up in this space, while the sample from our distribution was surpassed by only one, and that one, much the best of all those compared.

Second. Column II. (table II.) shows that at the comparison dates, the Boston sources were all of them inferior to ours.

Third. Column III. (table II.) shows that for a period of eight years the average amounts of albuminoid ammonia per year, have been between $\frac{16}{100}$ and $\frac{25}{100}$; that is, always above the middle of the group already referred to; and further, column IV. shows that these averages are legitimately derived and are not merely the results of calculations from remote extremes.

Fourth. Columns V. and VI. (table II.) show the amounts of albuminoid ammonia in the samples of water from the Providence distribution in 1882 and 1883.

If we except numbers 14 and 21, which I have remarked came from points entirely inaccessible to consumers, we discover that the average amount is $\frac{18}{100}$, an amount much less than the average ($\frac{25}{100}$) in the water taken directly from the river at the same period.

CONCLUSIONS.

The results given and the explanations added, appear then to show conclusively that our water is one of the best; that it is not now grossly polluted and has not been so since our critical knowledge of it; that there is no distinct ground for decided complaint of its quality nor for fear with regard to its use.

These statements are of course based largely upon its analytical returns as compared with those of other cities. But is comparison valuable in such a case? I think it is; and that for two reasons. First, in the matter of water supply there exists no *absolute* standard of fitness; thus we are necessarily shut up to comparison. Second, cities must get their water from natural terrestrial sources (not from ideal or supernal ones); now when a careful search for good water is prosecuted by a large number of communities, especially by those possessing well-ordered, healthy, intelligent and opulent populations, it may be fairly assumed that some among them will discover superior sources of supply. So that if the Providence water were now, or ever had been, in the inferior condition some persons have imagined, it would not be able to take the high position among those of American cities, that it properly secures in the tables herewith presented.

To the conclusions already stated, I wish to add this qualification. So far as *any* pollution of our water supply is known to be in progress now or at any future time, it ought to be arrested. While notwithstanding some differences of opinion, it is generally admitted that even sewage in moderate quantities is often oxidized and rendered harmless in flowing streams, it is also universally accepted that it is not wise nor right to allow such contamination to go on under cover of a reliance upon the unremitting purifying processes of nature.

Again, in matters of health we ought not to be satisfied with a fair position or even a good one; a city like Providence ought to demand the very best. I believe, therefore, that unceasing efforts ought to be made to preserve the Pawtuxet water supply free from every sort and kind of impurity that may be liable to get into it.

Respectfully submitted,

JOHN HOWARD APPLETON.

Brown University,

Providence, September, 1883.