From the Report of the Cochituate Water Board, Boston, 1876.

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Peculiar Condition of the Water

SUPPLIED TO THE

CITY OF BOSTON.

1875-76.

BY

PROF. NICHOLS, DR. FARLOW, AND MR. BURGESS.

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REPORT ON A PECULIAR CONDITION OF THE WATER SUPPLIED TO THE CITY OF BOSTON.

By Prof. Nichols, Dr. Farlow, and Mr. Burgess.

Jos. P. Davis, Esq., *City Engineer:* —

Dear Sir, — In the latter part of October, 1875, I was requested by you to investigate the condition of the water supplied to the city, with reference to which there were numerous and well-founded complaints, and to ascertain, if possible, the cause of the peculiar taste then affecting the water. On October 27th, in company with Mr. FitzGerald, I visited the lake and the several reservoirs, and found that the bad taste was entirely confined to the Bradlee basin of the Chestnut-Hill reservoir. The water of the lake and that in the Brookline reservoir were free from the peculiar "cucumber" taste which was so strongly marked in the city and at Chestnut Hill. As far as I was able to observe, the taste was nearly uniformly diffused throughout the Bradlee basin; the Lawrence basin, separated at the connecting gate-house by an embankment only 100 feet wide, was perfectly free. On Saturday, October 30, the gates were closed and no water was supplied to the city from the Bradlee basin until April 1, 1876. For some time after the reservoir was thus isolated there seemed to be no change, but after some weeks the taste became less marked, and then gradually passed away. The taste seemed to pass away first from the surface near the office, and to remain the longest in the coves on the north side. On February 21 it had disappeared from the water in the neighborhood of the gate-house and about the margin of the basin, and on the 1st of April the water was let into the pipes.

The taste to most persons seems like that of "cucumbers;" other persons, and indeed the same persons at other times, have pronounced it a "fishy" taste. At Brookline reservoir, especially at the screens, a "fishy" taste may usually be noticed; at Chestnut Hill I never distinguished anything but the "cucumber" taste.

When the water was allowed to stand in an open vessel, the taste soon passed away; when boiled an unpleasant odor was perceived, and the water when cold was found to have lost the peculiar taste. When the water was distilled something of the same taste was observed in the condensed water, but it was almost overpowered by the disagreeable earthy taste which is always to be perceived in water produced by distilling a soft water containing vegetable matter. Filtration through bone-black did not remove the taste completely, although even a sponge-filter would retain some odorous and unpalatable matter.

I must frankly confess that as yet I am quite in the dark as to the cause of the trouble, although I have made a careful examination of the circumstances which would seem able to throw any light on the subject. Various theories have been proposed to account for the occurrence, most of which are untenable. It may be well to allude to some of them and to point out the bearing of our observations upon them. I may say, however, what is well known to those who have professionally to do with the water-supply of cities, that many reservoirs, perhaps most reservoirs of considerable size, are liable at times to be affected in some way, by which the water for a longer or shorter period is rendered unpleasant and sometimes absolutely unfit for use. In the fall and winter of 1854, Lake Cochituate itself was affected by a trouble, the cause of which was never satisfactorily ascertained, but which manifested itself by a "cucumber" or "fishy" taste, precisely similar, as far as I can learn, to that which has been observed the present winter.

In many cases where examination has been made of an affected water, certain things have been regarded as causes which are probably accidental accompaniments, or which would be found also, if sought for, in the water when unaffected; and the individual observer, considering only the conditions of his particular case, conceives that he has, without doubt, discovered the cause of the trouble, and in some instances the theories advanced are not unreasonable. It is not necessary to suppose that the cause is the same in every case.

I have had correspondence and personal intercourse with a number of persons in charge of water works, and am now examining other cases where trouble has occurred. At some future time I hope to communicate to the Board the results of my efforts to collect all available information in the matter, together with the results of experiments now in progress, and others planned for the summer months when I have more time at my command.

THEORIES THAT HAVE BEEN SUGGESTED.

First. Many persons are confident that the dead body of some animal decaying in the pond is the cause of the bad taste. I am convinced that this solution of the problem is out of the question. Repeated chemical examination of the water could hardly have failed to detect an abnormal amount of ammonia and of nitrogenized animal matter, if such were the case, even supposing that nothing either sooner or later was noticed by those employed about the works. If dead fish were the cause they would also be discovered at the screens and at the borders of the reservoir. None such have been observed.

Second. — Some assign the cause to decaying vegetable matter. This was the theory to which some who investigated the question in 1854 seemed to lean. While it is not impossible that this may be directly or indirectly the cause, it is to be considered that the Bradlee basin is the most free of all the reservoirs from vegetable deposit, and that its bed was prepared with great care; and if this water was bad from this cause, we should expect to find that of the Lawrence basin and the Brookline reservoir much worse. Moreover, I have been unable to produce any similar taste from the leaves of the various species of trees which grow in the neighborhood, from the mud taken from the bottom of the reservoir, or from rotten wood, by soaking these various articles in water.

In some cases, as at Holyoke, Mass., where the muck bottom of the pond has been recently disturbed, and at Keene, N. H., where there is a large amount of shallow water resting on ground somewhat recently cleared from growing trees and shrubs, and where, consequently, much vegetable matter is undergoing decay, it is not unnatural to assign the cause to vegetable decomposition. In these instances, the taste and odor are distinctly "fishy," and not those of cucumbers. But even here I am not prepared to say that vegetable decay is the actual cause.

Third. — It was firmly believed by some that the trouble in 1854 was caused by an abnormal condition of the minute crustacea (principally cyclops) which was then observed.* Whatever may have been the case then, this is certainly not the cause of the recent trouble, as these little creatures were,

* Rankine's Civil Engineering (edition of 1874), page 737, refers to such a case (this same case of Cochituate lake?), which was examined by H. D. Rogers. It is said that the remedy was to stock the lake with fish. I am informed that there is no deficiency of fish in the Bradlee basin.

if anything, less abundant than usual, and in no abnormal condition. In order that any statement on this point might be made with authority, I requested Mr. Edward Burgess, Secretary of the Boston Society of Natural History, who has made a special study of crustacea, to investigate the matter, which he kindly consented to do. His statement of the results of his examination of the water and of various deposits collected from the bottom of the pond, from the screens and the gate-house, and from sponge-filters, through which a quantity of water had been passed, will follow this report.

Fourth. — It has been suggested that the cause was the abnormal growth of some low order of vegetable life. This opinion has considerable weight, as there are a number of places where the bad taste has been accompanied by, and by many believed to be caused by, an abundant growth of microscopic plants. Such has been the case at the Ludlow reservoir (Springfield water supply), where a copious growth of a member of the Nostoc family was accompanied by a marked odor and taste of "green corn." Such is the case on the filter-beds at Poughkeepsie, N. Y., where certain oscillatoriæ develop in the heat of the summer to a great extent; such is the case at New Britain, Conn., where the trouble occurs periodically; at Albany, N. Y., and in some of the reservoirs in London, England. In fact, I do not remember to have encountered a case, except our own, where the "cucumber" taste has been distinctly noticed, without some such accompanying growth. In the case of Jamaica pond, there was a disagreeable taste and odor to the water (not that of cucumbers, however), with reference to which, it is stated by Mr. S. Dana Hayes,* who examined the water: "By filtration through paper, the water becomes clear and brilliant, the odor and taste of the filtered water being natural; and it is possible in this way to separate the offensive matter from the water, and retain it for examination. This substance, which gives odor, taste, and additional weight to the impurities, consists of organized and vegetating bodies, which, as seen with the lens, are short, white threads, somewhat like conferva in form; but the threads are very short and perfectly white, differing in these respects from the green or brown confervoid growth of the summer months.

. . . "Crustaceous animalculæ, common in the water usually, are not to be found, while there is an extraordinary growth of subaqueous vegetation, of a low order of organized forms, emitting a repulsive odor." In this case, boiling did not remove the offensive odor and taste.

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* American Chemist, II. (1872), p. 323.

In order that the present investigations on this point might be perfectly conclusive, application was made to Dr. W. G. Farlow to conduct the observations. Dr. Farlow is Assistant Professor of Botany in Harvard University, and is acknowledged to be one of the first authorities in the United States on the lower order of plants, to which he has specially devoted himself. His report, which follows, shows that nothing was discovered either in the water or in the sediment from the bottom and sides of the reservoir, or in the slime which collects on the screens, which can be accused of being the cause of the evil. I may say, also, that since the conclusion of the trouble I have collected some more of these slimy deposits, and had them submitted to Dr. Farlow. No essential difference was discovered between the slime in its present tasteless condition, and that previously examined.

Other theories than those which I have mentioned have been proposed, to which it is not necessary to allude. I do not feel that we possess sufficient evidence as yet to lead to the adoption of any theory. In conducting the chemical examinations I have, as a rule, compared, in every point, the water possessing taste, from Bradlee basin, with tasteless water from the lake, or from the Brookline reservoir, or with the water delivered in Boston. With the exception of the very volatile or easily decomposed matter which gives the "cucumber" taste, and which we have not succeeded in isolating, there is nothing in which the water of the Bradlee basin has been inferior to the water delivered in Boston. I have examined, at various times, the water itself, samples of the deposit from the bottom of the reservoir taken at different points, as well as the material collected on sponge-filters and on the screens. I have been able to detect no essential difference which could be regarded as the cause of the trouble. I have made experiments on the oily matter referred to in the reports of Dr. Farlow and Mr. Burgess, but I have not discovered any difference between the two waters in this respect, unless possibly there has been a trifle more in the Bradlee basin than in the Brookline reservoir (and even this I doubt). I have extracted the oil by various means from the water, and for comparison, from several species of plants growing in the reservoir, also from the deposit on the bottom and on the sponge-filters. I cannot see any reason to regard it as the cause of the trouble, nor when isolated does it have the taste in question. The oil is certainly in part of vegetable origin; no doubt some comes from animal sources, but what proportion it is impossible to tell. I have also compared the two reservoirs with reference to the dissolved oxygen in the water, but no marked difference exists.

I do not regard it as at all impossible that the taste may have been due to some cause which had passed away before systematic observations were begun, and as there was no discharge of the water from the Bradlee Basin after October 30, it required considerable time for so large a body of water to lose the taste, although a small amount of the water in a pitcher or other vessel became tasteless after a short time.

In comparing my first observation of the water in the basin with your observation of the water in the pipes on the preceding day, there would seem to be no doubt that the trouble originated in the pipes themselves, and that the impregnation (if I may use the word) of the whole basin required not more than twenty-four hours. It was a consideration of this sudden development, which made me think that the trouble might be due to the rapid multiplication of some low order of animal or vegetable life; but when the microscopical examination began, nothing was discovered to bear out this idea.

It would seem desirable to watch the reservoirs rather closely during the coming summer and fall, in order that if the trouble should occur again, we might be able to investigate it in its early stages. In addition to collecting such further data on the subject as I may be able, I propose to keep such a watch myself. I may further state that Dr. Farlow has promised, during the coming spring and summer, to make some experiments on the taste communicated to water by different varieties of microscopic plants, a matter of great interest, and one about which we know very little. I shall be very glad to lay before the Water Board such information as we may be able to obtain.

As there is yet no certainty as to the cause of the trouble, it is not, of course, possible to suggest any means either of prevention or cure. There is no proof that the water would be actually injurious to a healthy person, although it was certainly very unpalatable. It is a matter of congratulation that the whole water-supply was not affected, and that it was possible to avoid using the affected water.

Yours, very respectfully,

WM. RIPLEY NICHOLS.

Mass. Institute of Technology,
April 3, 1876.

Memoranda of some Partial Examinations of Cochituate Water.

[Results expressed in parts per 100,000.]

Date.	Locality.	Unfiltered.		Filtered.		Solid Residue.			Remarks.
		Ammonia.	"Albuminoid Ammonia."	Ammonia.	"Albuminoid Ammonia."	Inorganic.	Organic and Volatile.	Total at 212° F.	
July—Dec. 1873 . .	Boston. Laboratory of Mass. Institute of Technology,	. . . .	. . . .	0.0035	0.0113	2.84	2.06	4.90	No taste. Mean of seven samples taken at different times.
October 25, 1875 . . .		0.0033	0.0157	0.0035	0.0148	. . . .	. . . .	. . . .	Cucumber taste.
October 26, 1875 . . .		0.0033	0.0192	0.0033	0.0187	. . . .	. . . .	. . . .	Cucumber taste.
October 30, 1875 . . .		0.0033	0.0240	0.0033	0.0133	3.56	1.48	5.04	Cucumber taste.
November 1, 1875 . .		0.0033	0.0173	0.0033	0.0176	3.24	1.32	4.56	No taste.
December 17, 1875 . .		. . . .	. . . .	. . . .	. . . .	2.56	1.80	4.36	No taste.
October 27, 1875	Gate-house at Lake . . .	0.0059	0.0197	0.0059	0.0165	3.04	1.14	4.18	No taste.
October 27, 1875 . . .	Gate-house at Bradlee Basin	0.0048	0.0177	0.0048	0.0155	2.92	1.28	4.20	Cucumber taste.
October 27, 1875 . . .	Gate-house at Brookline Reservoir	. . . .	. . . .	. . . .	. . . .	3.40	1.36	4.76	No taste.
April 1, 1876	Bradlee Basin, centre, 12 feet from surface	0.0020	0.0160	0.0024	0.0128	2.40	1.64	4.04	No taste.
April 1, 1876	Gate-house, Bradlee Basin, at surface	0.0032	0.0200	0.0036	0.0172	2.64	1.64	4.28	No taste.

REPORT OF DR. FARLOW.

To Prof. W. R. Nichols: —

Dear Sir, — I have the honor to transmit the results of the examinations made by me at your request, by order of the Board of Water Commissioners of the City of Boston. The object of the examination was to ascertain, if possible, whether the peculiar taste of the Cochituate water, known as the "cucumber" taste, arose from any vegetable matter or organism, which could be detected by the microscope. Having been informed by you that the taste was confined to the water of the Bradlee basin, I went to Chestnut Hill to examine that basin. The arrangements for surface drainage were explained to me by Mr. FitzGerald, and it seemed highly improbable that anything could have been washed into the reservoir from the surrounding land; and, as the taste was not found in the water of the aqueduct above, it was evident that the cause of the trouble must be looked for in the Bradlee basin itself. I tasted of the water at the surface, and at the bottom in different parts of the basin. It seemed to me that the taste was decidedly stronger on the surface than at the bottom; but this opinion was not confirmed by Mr. FitzGerald, who was with me at the time. I took away with me a quantity of water and some of the deposit at the bottom for examination. Since, I have examined two cloths which had been allowed to remain some hours on the gratings of the Bradlee basin and the Brookline reservoir [*i. e.*, on the wire-screens in the gate-houses. W. R. N.]; a number of bottles containing specimens of water, and the deposit from the last-named reservoir; and, finally, material collected on sponge-filters at Brookline and at Chestnut Hill. As would naturally be supposed, the largest amount of floating material was collected by the sponge-filters, but, except as regards quantity of material, the results were the same. It will be borne in mind that I am speaking only of the *vegetable matter* in the water.

First. In neither reservoir, the Bradlee basin nor Brookline, was there found any peculiar vegetable organism such as might not be expected in any fresh-water pond of this region.

Second. The plants found in both reservoirs were practically the same, consisting mainly of unicellular and filamentous algæ and fragments of higher plants. The algæ belonged, principally, to the orders *Palmellaceæ*, *Diatomaceæ* and

Conjugatæ. Of the *diatoms*, which were more numerous than any other plants, I need mention only *Stephanodiscus Niagaræ*, *Asterionella formosa* and a small *Melosira*, which were much more abundant than any other species, both floating, and in the deposits of the Brookline reservoir as well as of the Bradlee basin. The *Conjugatæ* were principally *desmids* belonging to the common genera *Desmidium*, *Sphærozosma*, *Xanthidium*, *Closterum*, *Micrasterias*, besides a species of *Spirogyra*, the largest alga found, which occurred in small quantities in the water of both reservoirs, but which was found, at one time, in a considerable mass by Mr. FitzGerald in the Bradlee basin. Of flowering plants, with the exception of a *Potamogeton* found in the Bradlee basin, only fragments were seen. From the enumeration just given, it will be seen that there is nothing which, under ordinary circumstances, could produce the cucumber taste. The algæ which most commonly produce disagreeable odors and tastes belong to the order *Nostochineæ*, but none of these were seen in the water examined microscopically, nor have they been observed in any part of the reservoir. The alga vulgarly called "frog-spawn," *Batrachospermum moniliforme*, being unusually abundant in brooks in the town of Newton, it occurred to me that there might be a quantity of this plant growing concealed in the Bradlee basin. Experiments with the frog-spawn, however, show that when decaying, the plant gives to water a peculiar taste, but not that complained of in the Cochituate water.

Third. — Looking at the relative quantity of vegetable matter, much more was found in the Brookline reservoir than in the Bradlee basin. This is accounted for by the fact, of which I was not aware at the beginning of my observations, that the Brookline reservoir has not been cleaned out for quite a number of years, and has a large deposit on the bottom. The water of the Bradlee basin is unusually clear and free from vegetable matter, particularly fragments of leaves.

Fourth. — Although the species of plants in the Bradlee basin are not such as would naturally produce any "cucumber" taste in the water, the question arose whether it might not be caused by them when in a state of decomposition. It was, principally, for the purpose of settling this point that comparative examinations were made of the water in the Bradlee basin and that in the Brookline reservoir. The vegetable matter in *both* cases was often far advanced in decomposition, as was shown by the presence of oil in the cells of the algæ. Some of the oil in the water was undoubtedly

due to other causes than vegetable decomposition but some must certainly be attributed to that cause. The quantity of oil seemed to me somewhat greater in the Bradlee basin than in the Brookline reservoir, but on the supposition that the oil causes the cucumber taste, how are we to account for the lack of taste in the Brookline reservoir?

In conclusion, I would give it as my opinion that the cucumber taste is not caused by the presence of any living plant nor by any plant undergoing any form of decomposition which can be detected by the microscope. Repeated examinations of the water and deposit have shown practically the same result in the case of the Bradlee basin where the taste is very marked and in the the Brookline reservoir where it is entirely wanting. As no additional light seems likely to be thrown upon the subject by further botanical investigation, I should hardly think it advisable to spend more money in that direction. Certainly, if any further investigations are to be made, there is no probability of obtaining any definite results from the botanical side of the question, unless a long time — several months, or even years — is devoted to the subject.

Respectfully submitted.

(Signed) W. G. FARLOW.

Dec. 14, 1875.

REPORT OF MR. BURGESS.

To Professor W. R. Nichols: —

Dear Sir, — I beg to present the following report in answer to the question you have asked me to consider, viz.: "Is there any reason to attribute the disagreeable taste of the water in the Bradlee basin at Chestnut Hill to its animal inhabitants?"

As nothing abnormal in the condition of the fishes of the basin is known, my attention has been wholly devoted to the smaller animals and, chiefly, to the crustacea, since in 1854 some of the gentlemen busied with the solution of the so-called "cucumber taste" question asserted that a species of cyclops, a very common genus of Entomostraca, was the cause of the trouble. They believed that the cyclopses in the Cochituate water then examined, contained an unusual amount of oily matter, and they stated that if a few of these animals were crushed and placed in distilled water, the "cucumber taste" was produced. Without opening the question

as far as concerns that time, the following examinations show that this theory fails to adapt itself to present facts.

Specimens of Entomostraca were collected between November 6 and November 8 in both the Bradlee basin, to which the cucumber taste is confined, and in Lake Cochituate, whose water is tasteless, and sent to me in bottles of their respective waters for comparison. It may be observed here that Entomostraca are scarce in our water-supply this season, while I have known seasons when it was impossible to draw a glass of water without obtaining some of these little animals. In the bottle of lake water I found Entomostraca belonging to the genera *Latona*, *Bosmina*, *Daphnia*, *Diaptomus* and *Cyclops*, while the water from the Bradlee basin contained the last two genera only: in later specimens from the basin, however, *Latona* and *Daphnia* were also found. The species of these genera were alike from both localities and the individual specimens showed no distinguishing peculiarities while the cyclops from the lake were quite as oily* as those from the basin. I crushed several of the latter and placed them on my tongue but could detect no taste of any kind. It is interesting also to note that the water sample from the basin, although tasting strongly when given to me, had, by December 20, become perfectly tasteless, while living specimens of cyclops and diaptomus were quite as numerous as at first.

For the sake of further comparison, I have also examined specimens of water and sediment from the bottoms of the Bradlee basin and the Brookline reservoir. The former sample (*i. e.* from the Bradlee basin) contained cyclops, fairly abundant, and a few infusoria. The sediment consisted chiefly of inorganic matter with a small amount of vegetable matter, for the most part in a state of decomposition. The sample from the Brookline reservoir contained an equally large number of cyclops and swarmed with a small species of *Cypris* (also a genus of Entomostraca), besides containing various infusorians, insect larvæ, etc.: in short, the amount of animal life was very large in comparison with the basin sample. The sediment was chiefly vegetable matter and contained common desmids, diatoms and other algæ living and dead, but of which it is unnecessary to speak, as I understand the botany of our water-supply is being investigated by Dr. Farlow. This sediment also contained plenty of entomostracan remains.

I have also examined the following material from the Bradlee basin with similar negative results.

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*All Entomostraca contain oil, the amount varying with supply of food.

November 10. Sample of surface water containing a large quantity of cinders and tasting strongly. Latona, daphnia, and cyclops were present, but of perfectly normal appearance. A sample of bottom sediment of about the same date seemed to contain little besides vegetable matter with a very few infusoria and a very few remains of Entomostraca.

A quantity of slime, collected by a sponge-filter, November 20, was also found to be almost exclusively vegetable matter, which seemed to me, I may observe, rather unusually oily. A few living cyclops, rotifers and infusoria were found here, as well as a small amount of entomostracan remains, but neither living or dead Entomostraca were as abundant as I have usually found them while collecting these animals by filters from our water in previous years.

Samples of slime scraped, November 29, from the wooden bars crossing the screens in the gate-house and which gave an extremely strong cucumber taste, like the last sample, contained little else than desmids, diatoms and other vegetable organisms; while of animals a few infusoria, rotifers, a worm or two, and portions of latona shells were alone noticed.

Besides the samples already referred to, pieces of cloth which had been placed over the screens at the outlets of the Brookline reservoir and Bradlee basin were also given me, but these had already become dry before I saw them, and a soaking revealed only a small quantity of entomostracan remains, with a few insect larvæ, etc., and showed no difference between the cloths from the two localities in these respects.

I should state that repeated examinations have been made of each sample referred to, in order to be sure of a fair average result.

It will, therefore, be seen that all examination, so far, has been unable to detect either the presence of unusually large numbers of microscopic animals of any kind, or any abnormal appearances in those which have been noticed. The theory that a peculiarly oily condition of any species of Entomostraca is correlated with the "cucumber taste" is, in this case at least, entirely without foundation.

To your question, heading this report, I am obliged to give a decided negative answer.

Yours very truly,

(Signed) EDWARD BURGESS.

Boston, Dec. 29, 1875.