THE MONSTROUS POLLUTION OF THE WATER SUPPLY OF JERSEY CITY AND NEWARK.

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At the present time Jersey City has a population of 160,000; Newark has very nearly the same number of inhabitants. In addition to these, Bayonne, Kearney and Harrison derive their water from the same source, so that the entire population using the water of the Passaic River, as supplied by the pumping stations at Belleville, is 350,000.

My object is to establish the fact of the monstrous pollution of this water supply, and the consequences resulting therefrom. In proving the fact I shall rely :

1st. Upon the proof afforded by inspection and common observation.

2d. Upon the testimony of many hundred chemical analyses extending over the period from the year 1872, to August, 1887.

3d. Upon many contemporaneous biological analyses.

4th. Upon comparative mortuary statistics.

I.

Statement of the principal sources of the pollution of the water supply of Jersey City and Newark, together with the amounts of the various polluting materials entering the Passaic River below the Great Falls at Paterson.

In order to render my statement intelligible, I have prepared a map which shows the changes that the waters of the Passaic River undergo, from their bright and limpid condition above the Great Falls to their foul and turbid condition when discharged into Newark Bay.

FIRST SOURCE OF POLLUTION.—Representing their natural condition of purity by the blue shading, I show them running the

gauntlet of the sewers at Paterson, the sewers being so numerous and so close together that it was hard to find room on the map for the crimson lines, each crimson line representing a sewer. The city of Paterson, which is represented by the large brown patch, has grown with great rapidity, having already a population of about 70,000. And this rapid growth means not merely an increase in the number of people sewering into the river, but an enormous growth of factories, each of which pours out its own peculiar filth. There are more and more cotton mills and woolen factories, great locomotive works, a jute mill, silk and silk dyeing establishments, with other factories too numerous to mention, employing, all told, over seven thousand operatives, and every day pouring forth millions of gallons of brilliantly colored and poisonous dyestuffs into the river. *The city is rapidly extending its sewer system, and fœcal matter which formerly was held in cesspools is now being discharged into the river. There are already* 28 *miles of sewers, emptying by* 13 *large outlets, to say nothing of canals, tail races and private drains innumerable.*

SECOND SOURCE OF POLLUTION.—After getting by the houses and cemetery, and flowing over the Dundee Dam, the waters of the Passaic encounter the leakages of the oil tanks belonging to the Oil Storage Station opposite the city of Passaic.

These great tanks have a storage capacity of about 160,000 barrels, and are so located that, as I have represented by the red lines, all the leakages of oil and the drainage therefrom empties directly into the Saddle River, and thence into the Passaic. Still worse, a number of breaks have occurred in the pipe line crossing the Saddle River, and the oil escaping from these bursts has covered the surface of the water for miles down the river.

THIRD SOURCE OF POLLUTION.—The city of Passaic has no public system of sewers, so that comparatively few are represented on the map. A system, however, has lately been adopted by the city authorities *which contemplates the immediate building of about thirteen miles of sewers, with seven large outlets directly into the Passaic River; ordinances for the building* of sewers were passed in 1884 and again in 1885, and the matter is being strongly agitated

at the present time by the 10,000 citizens of Passaic. There are six large mills and a chemical factory employing about 5,500 operatives. The surface drainage of the city, together with much of the refuse and waste dyes of these mills, empties into the tail race of the Dundee Works, and thence into the river, and also into the Passaic River directly. This is still the case, though much has been done by the manufactories to abate some of the more dangerous nuisances.

FOURTH SOURCE OF POLLUTION.—This is the Third River. It rises in a great spring just beyond the Notch in the First Mountain, which pours out 200,000 gallons of exquisitely limpid water that the town of Montclair has long coveted in vain for its domestic supply.

It is presently defiled by the refuse of Oakes' Woolen Mills, and by the Manila Paper Factory at Bloomfield, and by the Morris Canal, which crosses the Third River at this point, and pours its waste into it. Then comes the refuse of Davies' Paper Mill; then the slops and washings from the dyed yarns, etc., of Underhill's Woolen Knitting Mill. After that the spent dyestuffs from Duncan's Woolen Mills, and finally, the chloride of lime and other chemicals from the Kingsland Paper Mill. The mountain spring by this time has become a large sewer, and after having collected the drainage of the village of Franklin and part of the town of Bloomfield, it pours the accumulated *filth cast into it during its downward course of ten miles directly into the Passaic, at a point about two and a half miles above the Jersey City Intake and only a mile and a quarter above the Newark Intake.*

FIFTH SOURCE OF POLLUTION.—This is the town of Belleville, with its 3,500 inhabitants. It has no sewers, but a large number of drains, which carry off the surface drainage and the contents of its sinks and cesspools into the Passaic River directly opposite the Jersey City Intake.

SIXTH SOURCE OF POLLUTION.—This is the Second River. It is about five miles in length, rising in the vicinity of West Orange, and flowing through the towns of Orange, Watsessing, Bloom-

field, and the village of Soho, into the Passaic River at a point about a quarter of a mile below the Jersey City Intake. *This is one of the worst sources of pollution of the Jersey City and Newark water supplies.* There is a population upon the area of drainage of this stream of about 8,000 people. At Orange there are several large hat factories, employing about 4,000 hands, and the chemicals and dyes used in the manufacture of hats in these factories, all wastes into Second River. At Watsessing is Seabury & Johnson's Porous Plaster Factory, which empties its refuse chemicals into this river. Here also Tony's Brook empties into Second River. This large brook of five miles in length rises below the Great Notch and drains the villages of Montclair, Ridgewood and part of Bloomfield. There are three factories upon it—first, Moffett's Rolling Mill, discharging waste acids used in the washing of copper, brass, etc.; second, Wheeler's Paper Mill, which manufactures straw board, and wastes the refuse of a composition of chloride of lime, decomposed reeds and straw into the river; third, Krump's Label Factory. This factory wastes arsenic and other deleterious chemicals and high colors, used in label printing, into the brook. From the junction of Tony's Brook with Second River to where Second River empties into the Passaic river there are three factories—first, Chemical Works, near Bloomfield; second, Hendrickson's Copper Rolling Mills, and third, DeWitt's Copper Wire Mills. Various chemicals, washings of the wire, and other factory products, pour from these three into Second River.

SEVENTH SOURCE OF POLLUTION.—Unhappily this is the city of Newark itself. It has a population of about 160,000, and the entire sewerage of the city proper, with about sixty miles of sewers, empties directly into the Passaic. The population of East Newark is about 7,000, and this mostly sewers directly into the river. There are seven large public sewers and a great number of private drains emptying into the river at Newark. The distance from the nearest of the large sewers of Newark to the Jersey City Intake is about two and a half miles. This is the Fourth Avenue four foot sewer.

Twice every twenty-four hours the tide carries the sewage of Newark up the river past the Jersey City and Newark Intakes, the

salt water penetrating above the Jersey City Intake and nearly to the Newark Intake, *the sewage, however, being forced far beyond that point by the backing up of the tide.* (*See map.*) *In* addition to these chief sources of pollution, there is a large population scattered along the river and its tributaries between Paterson and Newark, the surface drainage of which finds its way *into the river eventually. There are also two cemeteries,* the Mt. Pleasant at Newark, and Cedar Lawn at Paterson, both of *which immediately adjoin the river, and are situated on* gravel beds which slope toward the river from elevations varying from 50 to 100 feet.

For many of these interesting facts I am indebted to Mr. James Courter, who was inspector for the Joint Board of Pollution from the date of its formation in 1881 until the year 1885. He also informs me that he was accustomed to take out of the river, during the course of every year, at least a hundred sheep, goats, cattle, horses, dogs and hogs.

II.

Chemical testimony, including a statement of the extent to which the pollution has increased since my earliest analysis made for the Board of Public Works of Jersey City in the year 1872.

I find stated in my report made to Mr. Andrew Clerk, that "the water during the midsummer of 1872 was highly offensive both to smell and taste; was turbid from the presence of great numbers of miscroscopic vegetable and animal organisms, and revealed, when proper chemical tests were applied, a shocking degree of contamination by organic matter." Details are given in this report of analyses of samples collected on the low and high tide at the Jesey City Intake, at a point above the Paterson High Falls, and from the Jersey City Reservoir. These analyses pointed to the existence of serious sewage contamination. And in bringing them to the notice of the Board of Public Works, Andrew Clerk, as Chairman, says: "The Special Committee have to report that, after a careful examination, they are satisfied that the subject is of such vital importance as to demand critical con-

sideration. As the waters analyzed were taken at the most favorable season of the year, and under circumstances calculated to give the best results attainable, your committee would suggest the propriety of further examination during the months of July and August, so that, by comparison, the accuracy of the various conclusions may be tested *and the maximum of impurities and deterioration determined upon.*"

I have italicized the concluding remarks of the report, because from this time forth the fact of the existence of impurities and deterioration was acknowledged, and the chief concern was to determine how great and how serious such deterioration might be.

The next information of an official character was obtained during the year 1873, under the terms of "An act to authorize the appointment of Commissioners to ascertain the probable cost and the best means of supplying the city of Hoboken and other northern portions of the county of Hudson with pure and wholesome water." The Commissioners procured the waters of the Passaic River and the Hackensack River to be analyzed by Prof. A. K. Eaton, and so unfavorable was the report of the chemist to the purity of the Passaic, at Belleville, that on the *ground of its impurity, more than for any other reason,* they decided against the Passaic and in favor of the Hackensack. They say: "The source of supply, known as the Passaic scheme, recommends itself to this Board—first, because this source is deemed practically inexhaustible; second, because it is considered cheapest, costing, as per annexed report, some $550,000 less for a given quantity of water, etc." The objections to this scheme are—first, the impurities that now exist in the waters of the Passaic, as compared with the waters of the Hackensack (see analyses), and the certainty that these impurities will be rapidly on the increase in a far greater ratio than they are likely to be increased in the waters of the Hackensack. These impurities in the Passaic will certainly render necessary, in the near future, the construction of filtering basins, etc."

Hoboken and the adjoining cities did not avail themselves of the recommendations of Mr. Kirkwood and the other eminent men associated with the Commission, though their labors had been per-

formed at a cost to these communities of $10,000. Hoboken continued to purchase Passaic water from Jersey City until 1881, notwithstanding the outcry became louder year by year against the bad taste and odor of the article purchased. But the Council in Hoboken would not or could not do anything, and it was not until 1881 that Hoboken had relief. Then the Hackensack Water Company brought in a supply of pure, sparkling, wholesome water, amounting to four million gallons a day, from its pumping station at New Milford, on the Hackensack river. There has never been a word of complaint against the purity and wholesomeness of the new Hoboken supply, except during the drought in the Summer of 1884. Then the water became offensive from the growth of water plants in the reservoir. The bad taste was done away with, and the plants ceased to grow, as soon as the water was thoroughly aerated, and, inasmuch as this practice of forcing air into the water increases its sparkle and brilliancy, it has been continued ever since.

Whilst Hoboken and the northern portion of Hudson County for the past five years have reaped the great benefits to life, health and property from carrying into practice the recommendations of its commission, Newark and Jersey City have been less fortunate. In 1878 the former city, at a cost of many thousand dollars, procured the very trustworthy and elaborate "Report on Additional Water Supply," to be made by Messrs. Croes and Howell. These engineers carefully inquired into and tabulated the various sources of pollution of the Passaic water below the Great Falls at Paterson, such as sewers, woolen, cotton, silk mills, dye houses, factories, etc., and believed themselves *warranted at that time, nine years ago, in condemning it on account of its demonstrable contamination by filth and refuse of every description.*

The startling array of statistics presented in this report caused very general alarm, and this had not subsided before an occurrence happened which led to the first practical steps to restrain the growing evil. In the Spring of 1880 the Passaic water became most disagreeable and offensive on account of carbolic acid derived from refuse thrown in at Kingland's Paper Mill. The defense set up the plea, and brought in a vast deal of evidence to show, that the water of the Passaic was already so foul that the carbolic

acid they had emptied into it made no appreciable addition to the gross amount of pollution already existing; that, in fact, the emptying into it of a powerful disinfectant and deodorizer like carbolic acid, made it *less* foul and dangerous to health. But these grounds of defense were not considered valid by the court, and the case having been decided against the polluters, the Newark Aqueduct Board addressed itself vigorously to further action. After various preliminary meetings, on the 27th of October, 1881, a joint committee of six members, three from this Board and three from the Board of Public Works of Jersey City, held their first session under the able presidency of Dr. Lott Southard, and began an energetic warfare against the parties polluting the water supply.

On entering upon my duties as consulting chemist of this committee, I made a comparison of the water supplies of eleven cities, the samples being all collected on or about the 23d of June, 1881, and found that, in respect to quality, the water of two cities only, viz., Brooklyn and Rochester, were satisfactory. These stood at the head of the list, and then followed Philadelphia, Baltimore, Washington, New York, and in the seventh place Newark and Jersey City. Since that time I have had occasion to make many hundred analyses of the Schuylkill water supplied to the city of Philadelphia, and have reported it as grossly polluted by the factories of Manayunk, located seven miles above the Fairmount pumping station. The vital statistics *of Philadelphia show that its percentage of deaths from typhoid fever is very large—much larger than in many* cities otherwise less salubrious than this so-called "City of Homes," *and this great mortality from typhoid fever is generally and popularly attributed to its sewage polluted water supply.* But Manayunk, though a town of woolen and cotton mills, dye houses and factories, like Paterson and Dundee, is a much smaller place than Paterson, and dangerously polluted as the Schuylkill *water is, it is certainly of better average quality than that supplied to Newark and Jersey City. Compare* these figures (which give the average composition in 100,000 parts) of the Schuylkill river—I., at Phœnixville, where it is nearly, though not quite, pure, with II., the same stream at Spring Garden pumping station after it has received the sewage of Mana-

yunk; and this again with the still more polluted waters of the Newark and Jersey City intakes, No. III.

	I. Philadelphia water before receiving Manayunk sewage. Mean of 17 analyses, made in 1883–1886.	II. Philadelphia water after receiving Manayunk sewage. Mean of 59 analyses, made in 1883–1886.	III. Jersey City water after receiving Paterson, Dundee, and New'k sewage. Mean of 50 analyses for the whole year of 1884.
Free ammonia	0.0035	0.008	0.01
Albuminoid ammonia	0.0097	0.015	0.022
Nitrous acid	0.00012	0.0006	0.0002
Nitric acid	0.369	0.39	0.53
Oxygen required to oxidize organic matter	0.188	0.22	0.53
Chlorine	0.324	0.523	0.93

A mere inspection of these figures tells the story. Evidently *the water flowing into the intake of the Jersey City pumping station each day contains a great weight of sewage.*

It is certain that if the contents of the sewers and dye houses of Paterson were delivered directly into the pumping engines at Belleville, no citizen would willingly taste or smell, much less drink, the disgusting compound. What becomes of all this sewage and of that additional load dumped into the river at Dundee and many points lower down? This was the question the Board of Pollution asked me to study in November, 1881. I answered it by making analyses of the pure water, etc., of the Passaic as collected above the Great Falls, and of forty-four samples taken at equal intervals down the river as far as Newark. The samples taken above the Great Falls were "sweet tasting and limpid," those immediately below Paterson were a "bluish-red liquid."

The analyses show that at that time no less than twenty-five tons per day of sewage and refuse matter were added to the Passaic as it flowed past the sewers of Paterson.

In the course of its flow down the river, the dirt and solid particles going to the bottom, and the urine and fæcal matters breaking up into ammoniacal compounds, nitrates, and so forth, a great change took place. As we approached Dundee Dam, the impurities diminished. I stated that at the same *rate* of improve-

ment, the water sixteen miles below Paterson would not have differed materially from its composition above Paterson. But at Passaic it was again befouled. And so it came to pass, that while above the Great Falls the volatile and organic matters were only 0.875 grain per gallon, they increased to 3.21 grains at Paterson. Then, at a point a short distance above Dundee Dam, they had diminished to 1.52 grains. After receiving the refuse of Passaic they increased to 3.26 grains, and then diminished again until they amounted to 2.16 grains at a point above the Newark Intake opposite the Third River. From this point on, they increased again until at the Newark Intake at low tide *they amounted to 3 grains, and on the high tide, to 6.6 grains. At the Jersey City Intake on the same day they were 5 grains, and on the high tide, 12.5 grains. Each day the river at, or a little above, Belleville carried down with it 30 tons of sewage and refuse.*

The sea salt held in solution by the tidal waves backing up the stream, and making their influence felt even so far up as Passaic, amounted to 32.59 grains per gallon. Out of every million gallons of water pumped at the Jersey City Intake 30,000 gallons were sea water. The reason why the Jersey City water was then, and usually is, so much worse than that supplied in Newark, is due to the out-pouring of the Newark sewers.

The high tide sweeps this sewage directly up against the Jersey City Intake.

Comparatively little sea water reaches the Newark Intake except at seasons of drought. Then there is more, the *sea water* backing up the river being greater in volume than the *fresh water* coming down.

This certainly was a nasty condition of affairs. As early as 1873 the analysis of Prof. Wurtz had shown a great deterioration in the water pumped at Belleville as compared with its quality in 1872, and as it was before the removal of the bar between the pumping stations and Newark by the United States Government. In the report of Croes and Howell, estimates are given of the cost of the various schemes for protecting the Passaic from sewage pollution. To shut off the filth flowing *up* the river from the Newark sewers it was proposed to build a dam at Belleville; to keep out

the sewage coming *down* the river it was proposed to build an intercepting sewer along its shore from Paterson to the dam. A most streuous effort was made in February, 1882, to secure the passage of a bill by the Legislature which should authorize damming the Passaic. The effort failed, and since *that time the people of Newark have drunken much of their own sewerage, but a very much larger share has gone into the Jersey City water.*

Unsuccessful in this direction, the Board of Pollution directed its entire energies to abating the nuisances located up the river. During the year 1882 the water closets connected with mills at Passaic, employing 2,200 hands, were disconnected with the stream and their sewage disinfected in tanks by chemicals. Similar changes were effected, through the labors of the Sanitary Inspectors, at Avondale, Belleville and along the course of the Second and Third Rivers and Tony Brook. The carcasses of eighty dogs, together with other animals found floating in the river, were removed and buried.

In referring to my analyses made for the Board, I find that I speak of the water as exhibiting in the month of October of this year, "a lamentable degree of impurity." In consequence of the very prolonged drought in the Autumn of 1881, the water became very impure and remained so up to the month of December. After attaining its condition of maximum purity in the months of February and March, the Newark water remained of excellent quality until the month of May, when it had so far deteriorated as to contain 0.0245 parts per 100,000 of albuminoid ammonia, and passed from the category of pure to that of impure waters. The deterioration in the Jersey City waters was still more rapid and decided.

During the Winter and Spring of 1883, my attention was called to the peril connected with drinking the Passaic water during cold weather and especially when the river was covered with ice. I had been asked by the Commission of Engineers, consisting of Messrs. Cheeseborough, Vaughan Merrick and Fred. Gräff, to determine the causes of the excessive foulness and nauseating taste and smell of the Philadelphia water during the months of January and February of that year. The analyses showed that the oxygen gas which should always be present in properly aerated

water, had been mainly used up in the oxidation of the sewage pouring into the Schuylkill at Manayunk. The oxygen having been used up, and the river at the time being covered with ice, the water had no opportunity of taking up a fresh supply of oxygen from the air. Under these circumstances the excess of sewage, with all its virulence in the breeding of disease, remained in the waters unoxidized and unchanged. I took some of this Philadelphia water and submitted it to the action of air under pressure by means of a water pump. That is, I sucked in air by water falling from a height and then caused this air under pressure to act on the sewage dissolved in the water. The purification was so considerable that Philadelphia shortly afterwards appropriated ten thousand dollars for the purchase of machinery for aerating the water. The same dangerous condition appeared in the Passaic water during the Winter of 1883. The river was covered with ice, and the analyses showed that the sewage remained dissolved in the water in an unoxidized and actively poisonous condition.

Much sickness prevailed at Passaic, where the smell of sewage was readily recognizable in the drinking water, and the symptoms of this sickness were such that it was popularly known as the "water cholera."

There was no change in the volume of water flowing in the Passaic nor any increase in the volume of its usual pollutions. The *danger arose from the sewage which is at all times present*, but which did not get an opportunity to undergo oxidation when the river was ice covered. The difficulty continued on in March and April, and the fact of the presence of unoxidized sewage in the water as supplied to Newark and Jersey City, was demonstrated by the notable amounts of *nitrous acid* revealed in the analyses of the samples collected at that season.

As to the total amount of sewage entering into the composition of the water during the *Spring of* 1883, the analyses made at that time supply the required information. They show that of the total decomposable organic matter present in the water, part of which came from purely natural sources and was harmless, *twenty-eight* per cent., or more than one-quarter, was sewage.

Having made hundreds of analyses during the preceding three years, in the year 1884 I was able to arrive at the average differ-

ence of composition between the pure waters of the upper Passaic and the sewage polluted water drunk in Newark and Jersey City. In the latter the free ammonia is fifty per cent. greater; the albuminoid ammonia is forty-seven per cent. greater; and the amount of oxygen required to oxidize the organic matters is thirty per cent. greater. The nitrous acid, from a mere trace and frequently not even that, is increased to easily measurable quantities. The nitrates are fifty per cent. greater; the chlorine is two hundred and seventy per cent. greater; and the total amount of salts and matters of every kind in solution in the Newark and Jersey City is water, one hundred and eighty-five per cent. greater than that which is contained in the Passaic River above the Great Falls.

Now I shall throw out of the calculation the enormous excess of chlorine and total solids. Chlorine is a characteristic constituent of urine, manure and fæcal matters, and an increase in the amount of chlorine is properly ascribed to the presence of excrement and voidings of the human body in the water drank. Unquestionably it is so in the present instance. But some of this chlorine is also due to salt water brought up by the flood tide. For this reason, and in order to understate rather than exaggerate the grossness of the pollution, I shall leave out of consideration the chlorine, and, for the same reason, the one hundred eighty-five per cent. increase of solids also. With regard to the other constituents revealed by analyses, this excuse does not hold good. Their increase is due to sewage and to sewage only.

I am within the limit when I state that fifty per cent. or one half of the organic matter in the Jersey City water during the year 1884 was sewage.

III.

Comparative Chemical and Biological Analyses.

It would not be possible at the present time to give, in extenso, the results of experiments upon the relative condition of the water of the Passaic River above the Great Falls and below this point;

or, in other words, before it had encountered the pollution of Paterson and afterwards. But a few instances will suffice. A series of samples were collected in sterilized flasks on the 29th of July, 1887. The results were as follows :

I.—Four miles above Great Falls yielded 5,000 colonies of bacteria per cubic centimeter.

II.—Half mile above Great Falls, 4,000 per c.c.

III.—Just below Paterson, the colonies were innumerable. principally micrococci.

IV.—One mile below Paterson, 72,000 per c.c.

V.—Two miles below Paterson, 64,800 per c.c.

Chemical Analyses.	*Parts per 100,000.*	
	II.	III.
Free Ammonia	0.005	0.007
Albuminoid Ammonia	0.015	0.019
Required Oxygen	0.56	0.59
Vpc dissolved Oxygen	0.53	0.41
" " Carbon Dioxide	0.07	0.10
" " Nitrogen	1.16	0.95

As a general rule the multiplication of the bacteria in the sewage-polluted waters is far greater than would be anticipated from the change in the chemical date. In some instances the number of bacteria in the water above the Great Falls is much less than in the instances quoted, but the vast numbers in the samples taken from below is very convincing as to the grossness and the danger of the pollution. Along with the increment of sewage and bacteria, the decrement of the oxygen held in solution is a correlated and most important factor.

IV.

Comparative Death Rate Statistics.

I give below the comparative death rates of Jersey City and Hoboken, compared with reference to Hoboken's change of water

supply in 1882, compiled from the annual reports of the Board of Health and Vital Statistics of the County of Hudson :

	Total Death Rate per 1,000 of Population.		*Death Rate per 1,000 from Zymotic Diseases.*	
YEAR.	JERSEY CITY.	HOBOKEN.	JERSEY CITY.	HOBOKEN.
1875	25.9	30.5	No report.	No report.
1876	26.8	30.7	do.	do.
1877	22.3	26.4	do.	do.
1878	20.7	25.0	do.	do.
1879	20.3	22.4	do.	do.
1880	22.4	23.7	5.9	6.8
1881	26.2	29.9	8.0	10.0
Averages	23.5	26.9	6.9	8.4

Hoboken is naturally more unhealthy than Jersey City, by reason of her large extent of lowland and undrained meadows, so that a death rate of three or four per 1,000 higher than Jersey City's was reasonably to be expected when both were using the Passaic water, and was actually the case, as shown above.

Hoboken changed her water supply from Passaic River water, furnished by Jersey City, to Hackensack River water, in 1882. Moreover, this water supply was itself greatly improved in purity and quality at the time when I introduced the process of aeration of potable waters, in the year 1884. Since that time the amount of air pumped into the ascending main at the pumping station at New Milford, has varied from 4 per cent. to 10 per cent. of the volume of water pumped. It has been least in Spring and late Autumn, and greatest in Midsummer. Also, when the Hackensack River has been ice bound, the improvement due to the aeration has been very notable. The process has never been interrupted except for repairs of the pumps and engines.

		Total Death Rate per 1,000 of Population.		*Death Rate per 1,000 from Zymotic Diseases.*	
	YEAR.	JERSEY CITY.	HOBOKEN.	JERSEY CITY.	HOBOKEN.
a	1882	26.0	24.9	7.7	7.7
b	1883	21.9	21.3	5.2	4.5
c	1884	21.7	21.1	5.2	3.9
	1885	22.8	23.6	5.9	5.4
	1886	22.5	22.4	5.5	5.4
	Averages	22.9	22.6	5.9	5.4

Note a—(Report of 1882.) "Hoboken had 848 deaths in a population estimated at 34,197, giving a death rate of 24.9, against that of 29.2 in 1881. It was 1.7 below Hoboken's eight year average, and 2.6 below that of the county at large in 1882. This very notable decrease was mainly caused by the falling off of the number of deaths from zymotic diseases, in which class fifty per cent. of the lessening of the mortality is found."

b—(Report of 1883.) "Hoboken's great fall of the death rate, when compared with the average for the past three years, is seen to extend over the entire list, and is most notable in the case of malarial and typho-malarial fever, scarlet fever, diphtheria, diarrhœal, digestive and intestinal diseases."

c—(Report of 1884.) "Hoboken's rate for 1884 was the lowest for ten years. There was a very marked decrease in number of deaths from zymotic diseases."

From a comparison of the above statistics we find that Hoboken's total average death rate per 1,000 per year, for the seven years previous to her change of water supply, was 26.9, as against 23.5 for Jersey City, being an increase over Jersey City's rates of 3.4 per 1,000; and that for the five years subsequent to her change it was 22.6, as against 22.9 for Jersey City, being a decrease from Jersey City's rate of 0.3 per 1,000, or a total change or saving to Hoboken of 4.3 lives per 1,000 per year. Of this saving to Hoboken of 4.3 per 1,000, such as may be proved to be due to the decrease in zymotic diseases (other things remaining equal), may be fairly credited to the change in the water supply. We find that Hoboken's average death rate per 1,000 per year, due to zymotic diseases, for the two years previous to her change of water supply, was 8.4, as against 6.9 for Jersey City, being an increase over Jersey City's rate of 1.5 per 1,000; and that for the five years subsequent to her change it was 5.4, as against 5.9 for Jersey City, being a decrease from Jersey City's rate of 0.5 per 1,000, or a total change or saving to Hoboken of 3 lives per 1,000, or 120 lives for the city per year.

This rate, if applied to Jersey City with a population of 160,000, would result in a saving of 480 lives per year.

The total decrease in Hoboken's death rate from all causes as above shown, since the change of water supply, is 4.3 per 1,000,

or a saving of 172 lives per year (Hoboken's population estimated at 40,000); this decreased rate, if applied to Jersey City, would represent a saving of 688 lives per year (Jersey City's population estimated at 160,000).

Since the compilation of the above matter the following death rate statistics have been published by the Hudson County Health Board: Average death rate per 1,000 for the first quarter of the year 1887—Hoboken. 20 deaths per 1,000; Jersey City, 22.73 deaths per 1,000.

From the above it will be seen that Jersey City's death rate has been about 23 per 1,000 for the past twelve years, and is about that at the present time, while Hoboken's rate has been steadily decreasing since her change of water supply, and is now, according to the last mentioned figures, 2.72 below that of Jersey City; this decreased rate of Hoboken, if applied to Jersey City, would represent a saving of 435 lives per year.

The April report of the Hudson County Health Board gives death rates as follows: Jersey City, 22.6 per 1,000; Hoboken, 18.9 per 1,000.

Compare this last death rate of Hoboken, viz., 18.9, with its average rate for the seven years immediately preceding its change of water supply in 1881, viz., 26.9, which represents a saving of 8 lives per 1,000 per year, or 320 lives per year, for its 40,000 of inhabitants.

If a similar change in water supply would produce a like change in Jersey City's death rate, it would represent a saving to Jersey City of 1,280 lives per year for its 160,000 of inhabitants.