RESULTS OF EXAMINATIONS

OF

WATER

FROM THE

RIVER SCHUYLKILL.

BY

CHARLES M. CRESSON, M.D.

COMMUNICATED, BY REQUEST, TO

Dr. W. H. McFADDEN,

Chief Engineer of the Water Department of the City of Philadelphia.

March 3, 1875.

PHILADELPHIA:
WM. MANN, PRINTER, 529 MARKET STREET.
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LABORATORY, 417 WALNUT STREET.
PHILADELPHIA, March 3, 1875.

DR. W. H. McFADDEN,
Chief Engineer Water Department.

DEAR SIR: In answer to your inquiry, I must say that I am not prepared to furnish an exhaustive report upon the sources of water supply to our city; but having made very many analyses, with especial reference to the presence of sewage and to the prevention of the ill effects of it, I gladly furnish you with selections from them, and herewith present the results of examinations of waters from various locations on the Schuylkill, and from streams emptying into it. (See Tables A, B, C, D, E, F, annexed.)

The mode of examination adopted is one which has received the approbation of the highest authorities at home and abroad as being the best suited for the analysis of potable waters. For drinking and household purposes it has already been decided that the *nature* and not the *quantity* of the ordinary mineral constituents is of the greatest moment, so long as the amount of inorganic impurity does not exceed 30 to 35 grains in one gallon, and of which not more than 2 or 3 grains are salts of lime or magnesia.

With respect to the organic constituents, such an amount is not allowable, and as the hygienic effects of different sorts of organic matter have been the subject of discussion for several years past, I shall quote freely in relation to them from the standard authorities. ([1])

"The amount of organic matter, and closely connected with it, the amount of ammonia, is a matter of prime consequence."

"The extreme minuteness of the quantity which makes the difference between a good and a bad kind of water renders this branch of the inquiry difficult, and excludes the employment of all the ordinary methods of chemical analysis. The detection and measurement of the organic matters in water belong to the domain of micro-chemical investigation."

A comparison of the amounts of the "organic matter," as obtained by the old method of ignition, with those got as "sewage" by the new methods (representing the deleterious matters contained in water), shows that no reliance whatever is to be placed in the amount of "organic matter" by ignition as a means of determining the purity of waters.

A reference to Table D, which exhibits the amounts of *organic matter by ignition*, more fully illustrates this point.

From this table it appears that the extreme variations in the amount of *organic matter* in these samples amount to but 16.2 per cent., whilst that of the *sewage* varies to the amount of 220 per cent., and the water containing the greatest amount of "organic matter" really has in it but "*traces*" of sewage.

The relative wholesomeness of water is undoubtedly dependent upon the relative amount of certain kinds of organic substances which may be present.

The kinds of organic substances that are deleterious are those which contain nitrogen, and are therefore liable to putrefaction. All such bodies can by proper treatment be

([1]) Journal Chemical Society; Wanklyn & Chapman, Water Analysis; H. Watt's Dictionary of Chemistry; the works of Bloxam, Tyndale, Fownes, Schorlemmer, Chandler, Krepp; Reports of the Commission appointed to inquire into the best mode of distributing the sewage of towns, etc., by Parliament, London.

converted into ammonia, and upon this property is based the most approved method of determining the healthfulness of drinking water.

"By estimating the amount of ammonia obtainable from water, noting the circumstances under which it is obtained, we have a measure of the nitrogenous organic matter present in water.

"In the whole range of chemical analysis there is no determination which surpasses that of ammonia in point of delicacy. It is questionable, indeed, whether any other approaches it. The Nessler test is capable of indicating 1 part of ammonia in 200,000,000 parts of water, and even this statement, surprising though it may seem, is an understatement of the delicacy of the test. Such being the character of the measurement of ammonia, the great advantage of causing determinations of organic matter to depend on measurements of ammonia will be manifest. By making these measurements of ammonia stand for measurements of organic matter in water, we apply micro-chemistry."

Modern chemistry has also given us very delicate re-agents for the determination of sulphuric acid, of which the presence in very minute quantities may materially affect the wholesomeness of our water supply ([2]).

([2]) I find upon my laboratory record the following memorandum by Mr. Howard W. Mitchell, who has made a great number of determinations of free acid in waters:

"Hæmatoxyline in neutral solution, though belonging to the class of general rather than special re-agents, seems as deservedly to possess a claim in the domain of micro-chemistry, as either the Nessler test for ammonia, or the sulpho-cyanide test for ferric iron. Its efficacy as a re-agent in the estimation of free acid in waters does not appear to have met with that general recognition which is certainly its due. The perfect simplicity of its application, and, within certain definite limits, the unvarying character of its color changes, render hæmatoxyline solution especially efficient for this purpose. In the examination of natural waters with this re-agent by the use of a standard ammonia solution, it has been found quite possible to detect the presence of .016 grs. of free sulphuric acid in the gallon, or, in other words, to detect one part in about three and a half million parts of water. This, however, requires some nicety

The presence of salts of lime and magnesia concerns chiefly the relative economy of waters; that is, their power to destroy soap, a necessary detergent in household use.

The destruction of soap is due to the formation of insoluble salts, and not until the salts of lime and magnesia present in the water have exhausted their chemical powers upon the soap will there be a formation of lather.

Soft waters destroy at most but five or six grains of soap to the gallon of water used; but hard waters are in use which will destroy over forty grains of soap to the gallon of water, so that the additional cost of soap required for household use becomes a considerable item.

In addition to their soap-destroying power, there should be considered the effects of the salts of lime and magnesia in water used in steam boilers. This item is of considerable consequence in a city of manufactures, such as is Philadelphia.

Since January, 1872, my examinations of Schuylkill, Delaware, and other sources of city supply have been made upon the improved methods referred to, and have been directed as follows:

FIRST, To the ESSENTIALS of a city supply—
a—Healthfulness;
b—Economy;
c—Quantity;
d—Suitability for manufacturing purposes.

SECOND, To the sources of DEPRECIATION—
a—Natural sewage;
b—Sewage incident to cultivation of the land;

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of discrimination. A very marked transformation is shown in the addition or subtraction of .06 grains of free acid, when one gallon of water is the quantity operated upon. From the first result it is readily seen that, when working with .01 gallon, to determine .00016 grs. of sulphuric anhydride is quite within experimental limits. The second result indicates that in ordinary manipulation, within the detection of one part in the million, no restriction to determination need be made. The presence of sulphurous acid or other deoxidizing agents seems to impair, though not entirely to destroy, the delicacy of this remarkable color reaction." —H. W. M.

c—Sewage from factories;

d—Sewage from slaughter houses, cesspools, cemeteries; and

e—Presence of hurtful metallic solutions.

Third, To the PRECAUTIONS that are best suited to preserve the water supply from contamination, and the REMEDIES most appropriate to restore its purity when lost, either by ordinary causes or by those that may produce epidemic disease—

a—Exclusion of improper sewage.

b—Natural treatment for the purification of bad waters.

c—Filtration.

d—Chemical agents to be used in case of emergency.

It is not necessary to discuss here in detail the course of experiments or results obtained; but I will in a general way give the conclusions to which I have arrived.

The river Schuylkill drains a vast agricultural territory, and receives the drainage from two large and growing cities, ([3]) beside many smaller towns, several of which are centres of manufacturing industries.

Within a few years numerous iron banks have been opened upon its tributaries, and iron furnaces built upon its margin.

The quality of the water varies materially with the location from which it is taken, the season of the year, and is gradually being deteriorated by the influx of foreign matter,

[3] Cities and towns draining into the river Schuylkill above Fairmount dam:

Population from Census, 1870.

Reading,	33,930
Pottsville,	12,384
Norristown,	10,753
Tamaqua,	5,960
Schuylkill Haven,	2,940
Pottstown,	4,125
Phœnixville,	4,886
Manayunk,	7,000

Auburn, Port Clinton, Hamburg, Shoemakersville, Leesport, Birdsboro, Douglassville, Schwenksville, Bridgeport, in all representing an aggregate population of over 90,000.

both organic and inorganic, from the refuse of the manufacturing establishments which it drains.

As a natural source for city supply, the river Schuylkill is unequalled. It furnishes a soft water containing but little mineral matter, running in a shallow stream over a rough rocky bed, with numerous rapids and cascades, which give it every opportunity for aeration and the destruction of organic matter. The limited amount of salts of lime and magnesia renders it a suitable and an economical water, not only for household use but also for most manufacturing purposes. The frequent examinations made by the city authorities and the corporations using the water, show that the volume is such that with the precautions and the devices that have been suggested "the average flow of the river would then give sufficient water power to raise into distributing reservoirs at Philadelphia over three and one-half billion gallons per month, or 116,000,000 per day, throughout the driest portion of the year." ([4])

Depreciation of the water supply by sewage, incident to natural causes, is at its maximum in the autumn, when the leaves and seeds have fallen from the trees, and when the ground is closed by frost, so that the winter showers and water from melting snows do not soak into the ground but flow over the surface into the creeks and rivers.

For a similar reason the sewage from the manuring of farms is greatest in spring, at the breaking up of frost, and entirely ceases when the surface of the ground is broken up by the plough. Fortunately at such season there are usually freshets, which rapidly and effectually cleanse the river from impurity, and a sufficient margin of the river is enclosed within the limits of the Park to prevent the entrance of such drainage unless at points at such a distance (several miles) from where our chief supply of water is taken as to secure sufficient exposure to natural influences and counteract any ill effects.

([4]) Report of a special committee of the Commissioners of Fairmount Park, upon the preservation of the purity of the water supply.—1867.

Natural sewage rarely exceeds 1 to 1½ pounds to the 1,000,000 U. S. G.

The sewage run into the river from the manufactories located within ten miles of Fairmount dam consists chiefly of the following materials:

Refuse from bleaching and printing.
" " scouring and dyeing.
" " paper works (alkaline).
" " gas works, tar, ammoniacal liquor, and wash from foul lime.

The nearest mill is about 3½ miles, and a majority of them are over 5½ miles, from the Fairmount dam.

That portion of the sewage which consists of decomposing vegetable substances does not produce the hurtful effects of that from decaying animal matters, and if cesspool and surface drainage could be excluded, the whole of the refuse matter from the factories (except that of wool washing and scouring) at present put into the river by these factories could readily be rendered innocuous by proper exposure to air and light.

That not only the whole of this sewage, but also a great portion of that received from the borough of Norristown, is reduced by oxygenation during its course down the river is evident from an inspection of Table A.

Analyses Nos. 1266 and 1269 (lines 17 and 20) were made of samples taken the same day, one from the inlet to the Roxborough Water Works, containing sewage (from Norristown) to the amount of 42½ lbs. to the 1,000,000 U. S. gallons, and the other from the pool of Fairmount dam, at the inlet to the Belmont Works, containing 19.4 lbs. of sewage; so that 23 lbs. of sewage had been oxydized, in addition to that received by the river from the factories and from Wissahickon Creek and elsewhere.

That portion of the sewage which is most dangerous, and which would in the presence of an epidemic produce fatal results, is derived from the cess-pools and the drainage of slaughter houses. Singularly, the river is tolerably free from such sewage until it enters the pool of Fairmount dam.

Into this pool from both sides of the river is poured an enormous quantity of animal refuse from slaughter houses, in which I am informed not less than 25 per cent. of the whole number of animals needed for our market are killed.

The accumulation of this drainage when the water ceases to flow over the dam at Fairmount is evidenced by the amount of sewage found July 24, 1874, in Analyses Nos. 1152, 1153, 1154 (Table A, lines 16, 19, 24), at the inlets to the pump works at Belmont, Fairmonnt, and Spring Garden to the enormous amounts of 98.06, 97.14, 121.37 lbs. to the 1,000,000 U. S. G., respectively. It is to be noted that the creek emptying into this river below the inlet to the Spring Garden Water Works was, September 5, 1873, conveying water containing 227.68 lbs. to the 1,000,000 U. S. G. (Table A, Analysis No. 658, line 8), whilst Mantua Creek, on the western bank, was conveying the drainage from slaughter houses killing a much larger number of animals than that upon the eastern shore. The amount of sewage found in Fairmount forebay, February 9, 1872, was 6.65 lbs. per 1,000,000 U. S. G., and gradually increased until about November, when a large increment was added, and it has been steadily increasing since that time, until the water is occasionally charged with an amount of sewage exceeding that carried by the river Thames at London (England), and is totally unfit for use. Unless some precautions are soon taken to prevent the influx of this great amount of sewage of animal matter into our source of supply, we may certainly expect to have our city visited by some epidemic scourge.

The remedies to be applied are, first:

The exclusion of improper sewage.

Channels should be provided *at once* for the conveyance of all sewage on both banks of the river that now enters it below Columbia Bridge.

Provision should be made to exclude (at an early day) all sewage that enters the river at and below Manayunk.

In this sewage should be included, if possible, the waters of the Wissahickon Creek, which now drains a large portion of a thickly inhabited district.

Water plants, such as float upon the water with their roots in the liquid and leaves in the air, should be cultivated in the stream.

The drainage from the gas works especially should be diverted.

If practicable, it should be so arranged that the water which is pumped into the reservoirs shall flow into each reservoir over an artificial bed, forming as extended a cascade as possible, thus obtaining as much as can be the benefit of exposure to air and light, and so reduce to a minimum the amount of oxidizable matter.

Filtration would remove much of the floating matter, and greatly improve the quality of the water; but if proper precautions are used, it may be rendered unnecessary.

If at any time the condition of the water supply should become seriously polluted, chemical agents may be employed, which will at least render it harmless.

The following extracts from "The Sewage Question," by Krepp, show the mode of the propagation of epidemics, and from a study of the conditions therein stated, we are able to learn the means of prevention and of cure should epidemics unfortunately make their appearance:

"Dr. Klob, of Vienna, has recently, by means of a microscope of 800 to 1000 power, discovered in the evacuations of cholera patients millions and millions of microscopic fungi very similar in form to common mushrooms.

That these fungi form the basis and medium of propagation of that terrible disease, there can hardly be any more doubt, as all kinds of fungi most rapidly propagate under favorable circumstances."

"The most eminent physicians of the southern part of the United States now acknowledge that yellow fever is much promoted, if not actually generated, by the decomposition of large masses of human faeces left exposed to the open air, though they very much disagree respecting the manner in which this terrible distemper is propagated. According to

Captain Liernur, who was for a number of years a resident of the Southern States, and from whose notes, as stated in the preface, we are working—according to his decided opinion the infection by yellow fever is simply caused by the germs of infusoria or fungi, developed by a combination of faecal matters with vegetable substances, putrefying together under the influences of a torrid clime."

"Both yellow fever and cholera germs, whether of the vegetable or animal, fungus or infusoria class, abound of course in the evacuations of the stomach and bowels of the patients, a single drop of which, however diluted, contains millions of these poisonous atoms, which are ever taken up into the air by the evaporation of the infectious fluid, and afterward return in the rain.

"The scientific investigations of the celebrated Professor Pettenkofer, of Munich, have thrown additional light upon this subject, and disclosed important facts, which may be summed up as follows:

"1. Cholera is neither altogether a contagion nor entirely a miasma, but a most dangerous bastard, combining all the virulence of both.

"2. The origin of cholera lies in a specific ferment or germ, contained in the excrements of cholera-stricken persons, or even of otherwise healthy people, coming from an infected locality.

"3. Cholera, if once introduced, in the shape of this germ, develops itself into an epidemic only in such localities where the water, circulating in a loose, porous soil, is impregnated with faecal matter, through percolation out of cesspools, sewers, and gutters.

"4. Such polluted subsoil water becomes the more dangerous when, by atmospheric influences, it alternately rises and falls, leaving in the latter case the upper strata impregnated with putrid organic matter to dry up, and thereby exhale volumes of most poisonous gases, which enter the human system through our lungs.

"5. Cholera is, therefore, propagated not only by the atmosphere, when charged with fæcal gases, but also by wells, when contaminated by excremental percolation: the latter being by far the more dangerous mode, as the cholera ferment or poison is much more concentrated and powerful in the water we drink than in the air we inhale.

"6. Excrements, even of cholera-stricken persons, never spread their infectious ferment whilst they are fresh, but only after the second day, when alkaline fermentation sets in, which therefore must be prevented by admixture of proper disinfectants in sufficient quantity."

"In the year 1849 nearly all the water used in London for drinking and culinary purposes was notoriously contaminated by cesspools and water-closets, in many instances even by direct percolation of the evacuations of cholera patients. Fortunately the quality of London water has since improved. Hence the mortality by cholera in the years 1849, 1864, and 1866, has decreased as follows: 62—43—18 of every 1000 inhabitants."

"When river water holds in suspense effete organic substances of the animal or vegetable kingdom, a process of combustion rapidly goes on by the oxygen contained in the water itself; and when all the oxygen which for that purpose can be spared is consumed, the remaining organic ingredients pass into a state of putrefaction."

From the above statements it appears that a condition of alkalinity is necessary for the propagation of typhoid and choleraic disorders, and all of the modern authorities assert the danger of drinking alkaline waters containing much sewage.

The best corrective is sulphuric acid. By the use of a proper amount of this acid putrefaction is prevented, and the dangerous characteristics of the water disappear.

Its properties and therapeutical effects are thus expressed in the U. S. Dispensatory, 1865, Wood & Bache:

"Diluted sulphuric acid is a tonic, refrigerant, and astringent.

"It is given in typhoid fevers, and often with advantage. The dose is from ten to thirty drops, three times a day.

"In 1851 attention was called by Mr. Buxton, of London, to the remarkable efficacy of diluted sulphuric acid in severe forms of diarrhœa, especially choleraic diarrhœa.

"In October, 1853, Dr. H. W. Fuller, of St. George's Hospital, published a paper in the *London Medical Times and Gazette*, in which he strongly recommends it in choleraic diarrhœa, from his own experience and that of his friends in more than ninety cases without a single failure."

During the summer of 1849 the workmen employed at the Philadelphia gas works were directed, before drinking the river water, to add to each pint one or two drops of sulphuric acid, which was furnished to them for the purpose. So far as my knowledge goes, and I was constantly at the gas works during that summer, not a single case of cholera occurred among them, although the employment, location, and habits of the men predisposed them, and favored an attack of the epidemic, of which they were in the midst.

In addition to the natural advantages possessed by the river Schuylkill for the purification of the water, it happens that it receives from many sources quite large amounts of free sulphuric acid. (See Table C.) This acid is derived chiefly from the decomposition of the pyrites of the coal waste at the mines near its source and from the refuse of the iron furnaces erected along the course of the river.

From an inspection of the table, which contains the results of observations upon samples taken from the river on one day and on one ebb tide, below the Fairmount dam, it will be seen that the amount of acid, free and combined, varies very much, although the points from which the samples were taken are but a few miles apart.

These changes are the result of the action and reaction between the acid and the organic matter, resulting in the oxidation of one and the conversion of the other into a gaseous form, in which shape it escapes into the air.

The additions of acid below the City of Reading come chiefly from the oxidation of the sulphur in the slag heaps from the furnaces; a portion is, however, derived from ore heaps exposed to atmospheric influences upon the banks of streams emptying into the river, and from chemical works similarly located. ([5])

At the foot of the table I have placed the results of an examination of water from a well at the "George's" Mansion, near George's Hill, in Fairmount Park. This water, which contains 0.98 of a grain of Sulphuric Acid of commercial strength in each gallon, is in constant use for drinking purposes, and is considered to be an especially excellent and healthful water.

To neutralize the free Ammonia in the Schuylkill water on February 25th, 1875, would for every gallon have required of commercial Sulphuric Acid only 0.05363 of a grain, or one grain of acid in about 19 gallons of water, and it is only proposed to neutralize and not to add an excess of acid.

As the amount of free ammonia rarely exceeds that stated, the proportion of acid needed is very minute and affords a ready and safe remedy in case of necessity.

The pollution of the Schuylkill river has been increased to such an extent as occasionally to class the water as "unwholesome;" prompt measures should therefore be taken to relieve it of sewage containing fæcal and decaying animal matter. The greatest proportion of these are now received from the streams draining into the pool of Fairmount dam. Preparations have been made to conduct that on the west side of the river below the dam by means of a sewer, and provision should at once be made for the sewage on the eastern shore.

When the flow of this sewage shall have been diverted into some new channel, then the sedimentary matter deposited in the river near the places of its entrance should be at once

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[5] The sewage of the city of Reading not only neutralizes the free acid found in the river at Schuylkill Bridge, but renders its waters alkaline. This alkalinity is in turn corrected by the free acid draining into the river from the slag heaps of the iron furnaces located just below the city at Upper Neversink.

removed, and before the summer heat can set up putrefactive fermentation.

In conclusion, I will briefly enumerate what I deem to be the proper steps to be taken to restore and maintain the purity of our water supply:

1. The diversion of *all sewage* now flowing into the pool of Fairmount Dam below the Falls Bridge into some other channel.

2. The diversion of all sewage containing *fæcal and animal matter* now flowing into the river below Flat Rock dam into some other channel.

3. The filtration of the sewage from all mills, so as to exclude solid matter, animal or vegetable.

4. The exclusion of Ammonia waste and surface wash coming from the Gas Works, cemeteries, etc.

5. The cultivation of fish and of suitable plant life in and upon the waters of the river,

6. The erection of suitable cascades over the reservoirs, so as to secure the benefits of æration to as great an extent as possible.

7. The employment of proper prophylactic and curative agents as occasion may require.

Respectfully yours,

CHARLES M. CRESSON, M.D.

NOTE.—The tables annexed are expressed in pounds to the 1,000,000 U. S. gallons.

To convert pounds in the million U. S. gallon into *grains to the gallon*, it is only necessary to set the decimal point three figures to the left and multiply by 7, thus:—92.85 lbs. to the 1,000,000 U. S. G. = 0.09285 x 7 = 0.64995 grains to U. S. G.

To convert pounds in the 1,000,000 U. S. G., into *parts in the* 1,000,000, divide the pounds to the 1,000,000 U. S. G. by 8.33, thus:—92.85 lbs to U. S. G. = 11.14 parts in the 1,000,000.

United States gallon = 231 cubic inches = 8.332698 lbs.

Results of the Examination of WATER from the River Schuylkill.

Table Aa.

Charles M. Cresson, M.D., 417 Walnut Street, Philadelphia.

From Whence Obtained.	Anal. No.	Date.	Ammonia. Free.	Ammonia. Albumenoid.	Ammonia. From Nitrat's	Sewage.	Sulphuric Acid.	Chlorine.	Remarks.
			Pounds in 1,000,000 U. S. Gallons.						
1. Roxborough Inlet,	1499	June 9, 1875.	1.21	1.21	9.71	***12.14***	24.28	21.42	Very clear.
2. Heft & Ogle's Mills,	1500	" 12, "	3.03	121.42	7.28	***1214.28***	285.71	20.00	Nearly black, with floating matter, and odour of ink.*
3. Littlewood & Lancaster's Dye House,	1501	" 12, "	48.57	121.42	91.07	***1214.28***	582.85	285.71	Almost black and inky in appearance, and odour of ink.*
4. Manayunk Gas Works, River below, close to shore,	1498	" 9, "	155.43	21.25	8.50	***212.50***	228.55	82.85	Comparatively clear, with very little floating matter, with strong [odour of tar.†
5. Mouth of Wissahickon Creek,	1497	" 9, "	4.61	4.85	12.14	***48.57***	14.28	20.00	Clear, with few floating particles.
6. Dobson's Mill, River at Outlet from,	1496	" 9, "	48.57	206.42	29.14	***2064.28***	Trace.	388.57	Turbid, almost black, with sediment, and of a disgusting odour.*
7. Simpson's Mill, " " "	1495	" 9, "	9.71	7.28	4.85	***72.85***	297.14	24.28	Slightly turbid, with a few floating particles.
8. Belmont Forebay,	1494	" 8, "	Trace.	1.21	3.15	***12.14***	197.14	15.71	Clear.
9. Spring Garden Forebay,	1490	" 8, "	7.28	2.42	9.71	***24.28***	265.71	28.57	Clear, with floating particles.
10. Creek below Spring Garden Inlet,	1493	" 8, "	60.71	78.92	23.07	***789.28***	Trace.	Trace.	Very offensive odour.*
11. Fairmount Forebay,	1491	" 8, "	1.82	1.82	4.37	***18.21***	185.71	14.28	Clear, with suspended particles.

* Taken from drainage into the River, the volume of which drainage should be determined.

† This water contains also Sulphides and Sulphites corresponding in Sulphur to 188.59 lbs of Sulphuric Acid, and when fully oxidized yields of Sulphuric Acid to 417 14 lbs. to 1,000,000 U. S. gallons.

Results of the Examination of WATER from the River Schuylkill.

Table A.

Charles M. Cresson, M.D., 417 Walnut Street, Phliadelphia.

From Whence Obtained.	Anal. No.	Date.	Total Solid Matter.	Ammonia. Free.	Ammonia. Album-enoid.	Ammonia. From Nitr'tes	Sew-age.	Sul-phuric Acid.	Chlo-rine.	Remarks.
			Pounds in 1,000,000 U. S. Gallons.							
1. Fairmount Forebay,	329	February 9, 1872.	899.10	0.99	0.66	10.27	*6.65*	169.53	37.18	No Water over Dam for 8 days previous, and very little for 15 days previous.
2. Belmont Inlet,	330	" 9, "	928.80	0.17	2.13	. .	*21.28*	202.28	34.62	
3. Schuylkill River, below Manayunk, G. W.,	336	" 9, "	993.60	7.32	0.67	. .	*6.65*	198.53	39.95	
4. " " " Wissahickon Creek,	335	" 9, "	594.00	Traces only	1.99	. .	*19.96*	63.67	39.95	
5. " " " Dobson's Mill,	333	" 9, "	982.80	0.17	0.70	. .	*6.98*	191.13	31.97	
6. " " " Simpson's Mill,	334	" 9, "	934.20	Traces only.	. .	. .	. .	195.07	37.28	
7. Creek below Spring Garden Water Works Inlet,	361	April 26, "	. . .	1.66	9.98	3.33	*99.79*	. . .	. .	Sewage from Slaughter Houses, etc., on east side of River.
8. " " " " " " "	658	September 5, 1873.	. . .	2.73	22.77	. .	*227.68*	38.57	65.71	
9. Schuylkill River, below Manayunk, G. W.,	600	July 24, "	. . .	4.57	6.86	. .	*68.57*	140.00	45.71	
10. " " " Wissahickon Creek,	599	" 31, "	. . .	17.14	4.57	. .	*45.71*	None.	40.00	
11. " " " Simpson's Mill,	364	April 20, 1872.	. . .	3.66	3 33	4.82	*33.26*	. . .	. .	
12. " " " " "	656	August 29, 1873.	. . .	0.46	2.28	. .	*22.77*	133.57	28.57	
13. Belmont Inlet,	331	March 9, 1872.	901.80	0.17	1.33	. .	*13.30*	226.19	38.72	
14. " "	634	July 31, 1873.	. . .	15.17	3.21	. .	*32.14*	82.86	40.00	
15. " "	657	September 5, "	. . .	0.30	1.82	. .	*18.21*	127.14	50.00	
16. " "	1152	July 24, 1874.	. . .	2.43	9.81	19.43	*98.06*	70.00	34.29	No Water over Dam for 4 days previous.
17. " "	1266	November 7, "	. . .	None.	1.94	12.14	*19.42*	205.71	25.71	
18. Spring Garden Water Works Inlet,	655	August 27, 1873.	. . .	7.86	1.79	. .	*17.85*	122.85	40.00	
19. " " " " "	1154	July 24, 1874.	. . .	2.42	12.13	14.57	*121.37*	71.43	31.43	No Water over Dam for 4 days previous.
20. Roxborough " " "	1269	November 7, "	. . .	4.12	4.25	18.21	*42.50*	197.14	21.42	
21. Fairmount Forebay,	329	February 9, 1872.	899.10	0.99	0.66	10.27	*6.65*	169.53	37.18	No Water over Dam for 8 days previous.
22. " "	512	January 6, 1873.	1067.10	1.67	2.51	. .	*25.17*	91.11	110.00	Slight freshet. High Water for 2 days previous.
23. " "	1025	" 22, 1874.	817.31	0.76	2.13	4.68	*21.25*	210.00	114.28	
24. " "	1153	July 24, "	. . .	1.94	9.72	19.43	*97.14*	71.43	30.00	No Water over Dam for 4 days. Low Water for 10 days [previous.
25. " "	1414	January 19, 1875.	998.57	1.21	3.06	24.28	*30.60*	168.57	71.42	No Water over Dam for 6 days previous.
26. Croton—New York City Supply,	337	March 7, 1872.	507.60	0.99	0.99	1.25	*9.97*	34.92	21.36	
27. Loch Katrine—Glasgow,	. .	. . . .	235.73	0.03	0.66	2.58	*6.66*	46.64	39.15	From Watt's Dictionary, and Wanklyn, Chapman, and Smith's Manual.
28. Bala Lake.	. .	. . . .	233 40	0.08	2 08	. .	*20 82*	29.15	60.80	
29. Thames—London Supply,	. .	. . . .	2577.30	0.24	1.33	28.82	*13 32*	261.56	118.28	
30. " London Bridge,	. .	. . . .	3401.97	. .	4.91	. .	*49.14*	268.22	529.78	
31. River Lea, London,	. .	. . . .	2798.88	0.24	0.74	30.07	*7.41*	369.01	127.45	

RESULTS OF THE EXAMINATION OF WATER FROM THE RIVER SCHUYLKILL.

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Table B. FAIRMOUNT FOREBAY.

	DATE.	Anal. No.	AMMONIA. Free.	Albumenoid.	From Nitr'tes	Sulphuric Acid.	Chlorine.	Sewage.
			POUNDS IN 1,000,000 U. S. GALLONS.					
1.	February 9, 1872.	329	0.99	0.66	10.27	169.53	37.18	***6.65***
2.	April 26, "	364	None.	0.95	. .	. .	. .	***9.55***
3.	May 11, "	364 *c*	"	0.95	. .	. .	. .	***9.55***
4.	June 8, "	364 *d*	"	0.83	. .	. .	. .	***8.32***
5.	July 6, "	364 *e*	Traces.	0.66	2.69	. .	. .	***6.65***
6.	September 7, "	364 *f*	0.99	0.99	2.69	. .	. .	***9.97***
7.	November 2, "	364 *g*	None.	2.69	1.25	. .	. .	***26.99***
8.	January 6, 1873.	512	1.67	2.51	. .	91.11	110.00	***25.17***
9.	March 29, "	548	0.70	1.80	5.80	94.20	125.70	***18.80***
10.	January 22, 1874.	1025	0.75	2.13	4.68	210.00	114.28	***21.25***
11.	July 24, "	1153	1.94	9.72	19.43	71.43	30.00	***97.14***
12.	November 7, "	1268	Traces.	3.15	18.21	162.85	30.00	***31.57***
13.	January 19, 1875.	1414	1.21	3.06	24.28	168.57	71.42	***30.60***
14.	February 25. "	1431	2.67	5.15	24.28	134.28	27.14	***51.57***
15.	Well Water.	1428	None.	2.62	48.57	155.71	275.71	***26.22***

Table C. SULPHURIC ACID AND CHLORINE.

	Anal. No.	LOCATION.	SULPHURIC ACID Free.	Combined.	Total.	Chlorine.
			POUNDS IN 1,000,000 U. S. GALS.			
1.	1302	Canal Level above Schuylkill Haven, ...	38.03	476.25	514.28	20.00
2.	1300	Lippincott Dock, Schuylkill Haven, ...	12.89	379.97	392.85	21.42
3.	1301	Port Clinton, Canal Dock, ...	7.87	1363.56	1371.43	18.57
4.	1424	Schuylkill River, at Port Clinton, ...	4.80	378.06	382.85	21.42
5.	1245	" " at Schuylkill Bridge, Reading, . . .	54.28	245.72	300.00	12.14
6.	1237	" " at Neversink, Upper Station, ...	24.00	461.71	485.71	14.28
7.	1235	" " at Monocacy, ...	28.57	337.14	365.71	18.57
8.	1223	" " above French Creek, ...	Not det	Not det.	391.42	17.14
9.	1230	" " at Perkiomen Junction, ...	"	"	411.42	14.28
10.	1267	" " at Spring Garden Forebay, ...	None.	154.28	154.28	35.71
11.	1268	" " at Fairmount Forebay, ...	"	162.85	162.85	30.00
12.	1276	" " below Dam at Fairmount Bridge, . .	"	382.85	382.85	11.42
13.	1277	" " at Gray's Ferry Bridge, ...	"	967.14	967.14	21.42
14.	1278	" " at Penrose Ferry, ...	"	845.71	845.71	18.57
15.	1428	Pump Well at George's Mansion, near Fairmount Park,	114.28	41.43	155.71	275.71

Table D.

ORGANIC MATTER DETERMINED BY IGNITION AND SEWAGE BY THE METHOD OF WANKLYN AND CHAPMAN.

	SAMPLES FROM SCHUYLKILL RIVER AT	Analysis No.	Solid Matter after Ignition.	Organic Matter by Ignition.	Sewage.
		POUNDS IN 1,000,000 U. S. GALLONS.			
1.	Fairmount Forebay. .	329	675.00	224.10	***6.65***
2.	Inlet to Belmont, . . .	330	712.80	216.00	***21.28***
3.	" " . . .	331	677.20	224.60	***13.30***
4.	Wissahickon, ...	335	378.00	216.00	***19.95***
5.	Dobson's, ...	333	761.40	221.40	***6.98***
6.	Simpson's, ...	334	702.00	232.20	Traces.
7.	Manayunk Gas Works,	336	793.80	199.80	***6.65***
8.	Croton, N. Y., ...	337	372.60	135.00	***9.98***

Table E. MEMORANDUM.

In the analysis (329, Table F) of water from Forebay at Fairmount, February 9, 1872, there was found sedimentary matter (to U.S.G.) = 1.92 grains.

This consisted of			or		
Silica, ...	43.3 per ct.		or	Clay, ...	65.0 per ct.
Alumina, . . .	35.0 " "			Alumina, ...	13.3 " "
Combined water,	18.0 " "			Water, ...	18.0 " "

A trace of Lime and of Oxide of Iron.

The particles of this sedimentary clay are very minute, of dimensions between the 1-20,000 and 1-30,000 of an inch in diameter, and give a peculiar taste to the water.

They are too small to be removed by ordinary filters, and remain in suspension for several weeks, although the vessels containing the water are undisturbed.

This clay is derived from a thin belt crossing the River Schuylkill above the city of Reading, and is seldom brought down by the stream except at such times as the margin of the river is covered with melting snow or ice.

Results of the Examination of WATER from the River Schuylkill.

Table F.

Charles M. Cresson, M.D., 417 Walnut Street, Philadelphia.

ANALYSES OF WATER FROM FAIRMOUNT FOREBAY.

Analysis made by	Prof. Boyé, 1842.	S. C. Phillips. 1870.	C. M. Cresson, M.D. Feb. 9, 1872.	Jan. 6, 1873.	Mar. 29, 1873.	Jan. 22, 1874.	Jan. 19, 1875.
	POUNDS IN 1,000,000 U. S. GALLONS.						
Analysis Number,	. . . .	. . . . .	329	512	548	1025	1414
Sediment,	. . .	. . .	274.28	. . .	339.00	. . .	. . .
Solid Matter upon Evaporation to Dryness,	585.9	652.41	899.10	1067.10	606.20	817.31	998.57
Inorganic Matter,	580.7	615.70	675.00	891.40	. . .	. . .	722.85
Organic Matter, by ignition,	5.1	36.71	224.10	175.70	. . .	. . .	275.72
Silica ($Si\ O_3$),	56.4	42.56	. . .	357.70	73.40	15.12	92.85
Alumina ($Al_2\ O_3$),	. . .	. . .	. . .	. . .	. . .	29.01	7.28
Oxide of Iron ($Fe_2\ O_3$),	. . .	. . .	. . .	. . .	. . .	37.40	8.43
Silica, Alumina and Oxide of Iron,	. . .	. . .	78.30	. . .	. . .	. . .	. . .
Alumina and Oxide of Iron,	11.0	13.34	. . .	27.70	98.80	. . .	. . .
Lime (Ca O),	175.2	141.83	86.40	61.88	142.91	56.14	135.20
Magnesia (Mg O),	31.4	38.75	21.38	97.40	43.10	52.61	76.11
Sulphuric Acid, free (SO_3),	. . .	. . .	None.	None.	None.	None.	None.
" " in combination,	44.8	91.01	169.53	91.11	94.20	210.00	168.57
Chlorine, free (Cl),	. . .	. . .	None.	None.	None.	None.	None.
" in combination,	13.3	42.44	37.18	110.00	125.70	114.28	71.42
Potash (KO),	. . .	33.28	85.27 (Potash and Soda)	Residue not determined.	Residue not determined.	Residue not determined.	Residue not determined.
Soda (Na O),	62.1	67.03					
Ammonia, free (NH_3),	. . .	. . .	0.99	1.67	0.70	0.75	1.21
" albumenoid,	. . .	. . .	0.66	2.51	1.80	2.13	3.06
Nitrogen from Nitrates and Nitrites,	. . .	. . .	10.27	Not determined.	5.80	4.68	24.28
Sewage,	. . .	. . .	6.65	25.17	18.80	21.25	30.60

Note.—The Sulphuric Acid in all of the Tables is expressed as Sulphuric Anhydride. The Residues entered as Soda and Potash consist chiefly of Soda.