REPORT

OF

Analyses of Ohio River Water

WITH A

SUPPLEMENTARY REPORT OF ANALYSES OF CISTERN WATER, DETERMINING THE PRESENCE OF SEWAGE AND OTHER IMPURITIES.

BY

C. R. STUNTZ, A.M., M.D.,

PROFESSOR OF CHEMISTRY.

WITH

THE REPORT OF THE SANITARY COMMITTEE

ON THE

PUBLIC WATER SUPPLY.

BY ORDER OF THE BOARD OF HEALTH.

A. J. MILES, M.D., Health Officer.

CINCINNATI:
PRESS OF ROBERT CLARKE & Co.
1881.

MEMBERS OF THE BOARD OF HEALTH OF CINCINNATI.

HON. CHAS. JACOB, JR., MAYOR, EX-OFFICIO PRESIDENT.

CHAS. F. KLAYER,
L. R. BRAMBLE, M.D.,
C. F. HORNBERGER,
CHARLES BLEICHART,
DANIEL METZ,
JOSEPH SEITER.

REPORT OF THE SANITARY COMMITTEE

ON THE

PUBLIC WATER SUPPLY.

To The Board of Health of Cincinnati:

Gentlemen—By a resolution of your Board, adopted September 7, 1880, the Sanitary Committee and Health Officer were directed to make an examination of the water supply of the city.

In accordance with this resolution, to enable them to render a more definite and complete report they employed Professor C. R. Stuntz to make analyses of the water supply of the city, and of other waters which have been considered available for public use.

Your Committee having completed this work, beg leave to submit the following report, together with the very valuable report of the chemist, Professor Stuntz.

This report takes into consideration a wide range of topics of great interest, both from their scientific value and their connection with the public welfare.

There has been for years a growing suspicion that the sewage of the city, accumulated from the rapidly increasing population, facing the river from the pumping works to Columbia, has contaminated the river water supply, and fears have been felt that this water brought to the homes of the people for daily consumption may become a means of injury to the public health. The attention of the public has been called to this subject from time to time.

The former health officer, Dr. T. C. Minor, in his last annual report, says that there is undoubtedly sewage in the river water supply. The Trustees of the Water Works have evidently for a long time been impressed with the same belief, for, several years ago, the city under their influence, purchased up the river, twelve miles from Main street, a hill property containing a ravine suitable for an elevated reservoir. This property, known as the Markley Farm, since its purchase, has been constantly placed before the public by the managers of the Water Works, as the proper point from which to obtain the river water supply.

The Sanitary Committee, in consideration of this state of public feeling, decided that it was the duty of the Board of Health to determine positively if there be sewage in the water of the river at the pumping works, and also to determine the comparative value of this water in relation to other known and available waters. They also had under discussion the sanitary condition of the population who are so placed as to be affected by the city's sewage, either along the lines of the sewers or on the river front below the points at which it discharges, and the health of the marine population who take their whole water supply from the river itself; and decided to determine the effect of the city's sewage on the river, and on the ground water drawn from the river below the city, and likewise on the spring and shallow well water which is used within the city's limits.

It will be noted with interest that the water at Markley Farm is proven to be of good quality, and that it compares favorably with the water of other cities, but it may become bad after a sudden flood. It ranks well with the Croton water of New York, and with the supply of Boston and Philadelphia.

The analyses of water at the pumping works establish the unwelcome fact that the sewage of the city is beginning to contaminate the river water supply. All of the analyses, made at the same time, show an increase of sewage at the pumping works beyond the amount determined in the water at Markley Farm.

The evidence of analyses of the Eden Park catch basin is gratifying, but should not furnish to the Water Works management an argument for throwing the drainage of the street-car track and of Park avenue into the people's supply of drinking water.

Your attention is especially called to the sample of filtered water accompanying this report, obtained from the Dayton, Ky., sand-beach, and to the comparative analyses, which show that, at this sand-beach, there can be obtained an ample supply of filtered water, which, so far as one set of experiments can determine, is substantially as good as that at Markley Farm, with the advantage of being always clear.

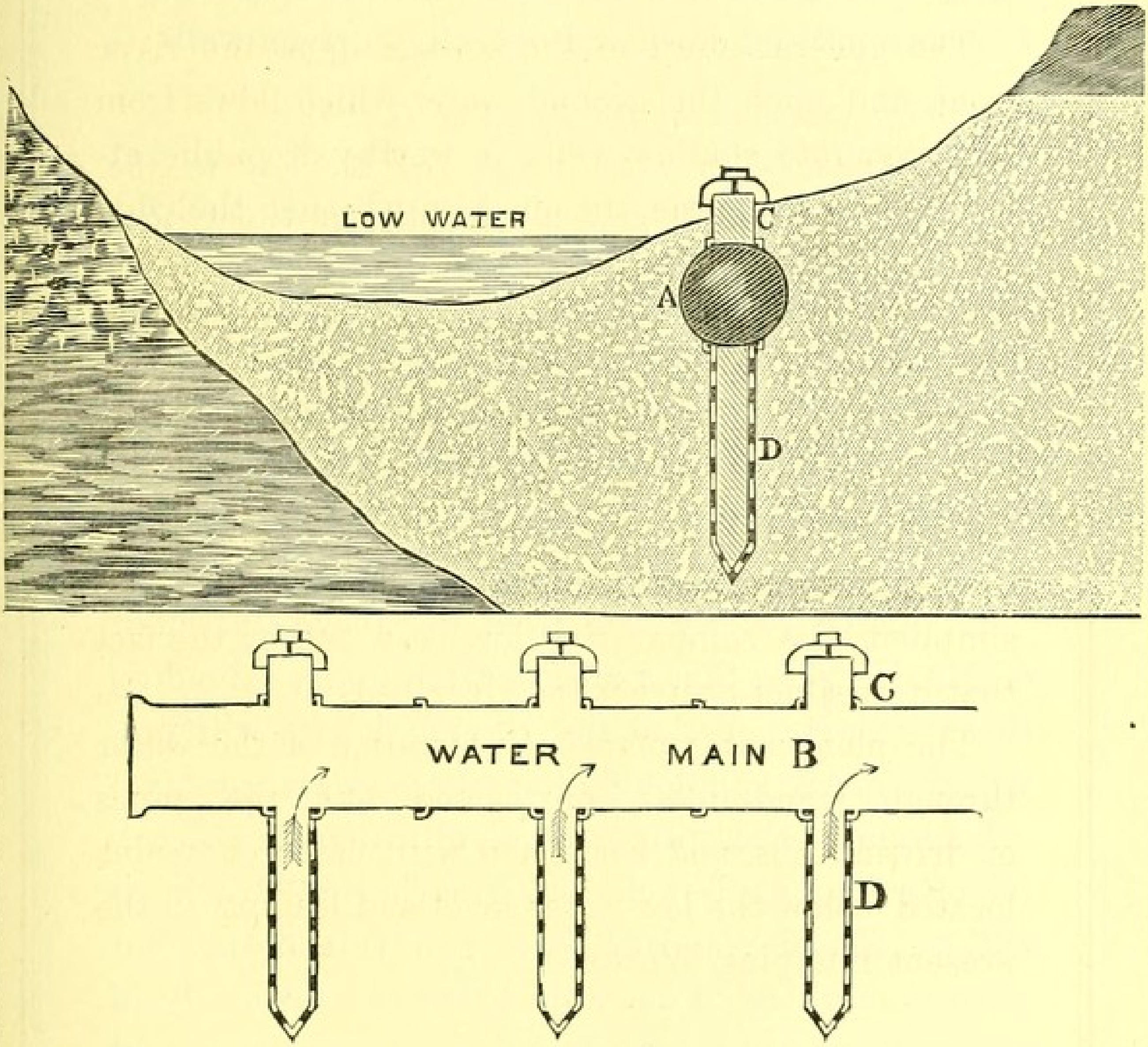
The general effect of the sewage upon the river front, and upon the ground water which flows from the river into shallow wells, is worthy of public attention. It suggests the question whether the Ohio river should not be secured from sewage contamination, by the joint legislation of the several States which control its banks.

Your Committee, in the process of obtaining the filtered water from the Dayton sand-beach, had brought to their attention a plan of filtration which seems practicable, and which commends itself by its simplicity, its comparative low cost, and by the fact that it does not obstruct the river bed.

The plan contemplates the filtration of the water through stand-pipes, constructed like the pipes of driven wells, and connected with cast-iron mains located below the low-water level and leading to the present Pumping Works.

Sectional Drawing of the Ohio River Bed.

(Showing the location of a Water Main and Stand-pipes for filtration.)



Description of Drawing.—**A.** **A.** are end and side views of a cast-iron water main; **C. C.** are vertical pipes, connected to **A.** and **B.** by T's, and capped water-tight at the upper end; **D. D.** are continuations of openings **C. C.** by perforated cast-iron pipes, into which are placed brass strainers to keep out the sand. Multiply the pipes to the desired amount.

The practicability of this plan of filtration has been demonstrated by the action of driven wells at various points along the river banks. We give in confirmation, the statement of a man of large experience in putting down and operating driven wells:

" *Sanitary Committee of the Board of Health:*

" GENTLEMEN—The water supply of the city to the amount of 50,000,000 gallons each day of twenty-four hours can be filtered on the Dayton, Ky., sand-beach by employing one hundred and sixteen (116) stand-pipes, as represented in the diagram, each twenty (20) inches in diameter, and having a vertical length of twenty (20) feet of straining surface, when the pipes are placed twenty to twenty-five feet apart.

[Signed] " J. A. YINGLING."

It will be readily seen from the above statement of Mr. Yingling that a single water main, extending three thousand feet to the Dayton Ferry, will provide for more than double the present water supply.

There are other processes of filtration in successful operation at Lowell and Manchester, Mass.; at Ottawa, Canada; and at Toledo, in this State: but your Committee is not able to report favorably of any of them, in consequence of their great cost and the amount of obstruction they would necessarily produce in the river bed.

The improvement of the water supply temporarily, pending the delay necessary to the procuring of better water from the sand-beach, or at some other point, is possible by the plan of settling and aeration, already carried out to a limited extent by Mr. Moore, Superintendent of the Water Works.

If the use, in the Eden Reservoir, of one settling basin and one dam for aeration, removes the sewage in amount up to *twenty per cent.*, as proven by the analyses of Prof. Stuntz, it would seem possible by multiplication of cascades and reservoirs in which the water is carried to the top of the hill and alternately settled and dashed into spray many times over granite rocks to furnish a water much clearer and purer than we now have.

The natural conditions of the Eden Park Reservoir, on account of the surrounding hills, is well adapted for the carrying out of this plan of aeration, without great cost to the city.

The supplementary report on cistern water which we also transmit with that on the general water supply, is of especial interest to inhabitants of suburban residences as well as to all who use rain-water in cisterns.

This water, it is probable, is generally overrated in purity and wholesomeness, and the possible contamination by surface drainage and by badly constructed privies is in many cases entirely overlooked.

A few rules in the management of cisterns are to be derived from the report:

1. Cisterns should be repeatedly and thoroughly cleansed, and especially those receiving water from roofs of dwellings.

2. The drainage *away* from the cistern should be perfect.

3. The cistern should be located as far from the privy vault as possible, and care should be taken that the matter in the privy vaults be kept constantly below the level of the bottom of the cistern.

4. Cistern water should be drawn by means of buckets, chain pumps, or such other means as will introduce plenty of fresh air into the water.

Respectfully submitted,

CHARLES F. KLAYER, *Chairman.*
L. R. BRAMBLE, M. D.
JOSEPH SEITER.

Sanitary Committee.

A. J. MILES, M. D., *Health Officer.*

CINCINNATI, January 10, 1881.

REPORTS

OF

ANALYSES OF OHIO RIVER WATER.

A. J. MILES, M. D., *Health Officer of Cincinnati.*

DEAR SIR—The water supply of Cincinnati comes from four sources each of which furnishes a kind of water differing in properties and general character from all the rest.

First. The most important of these sources of supply is the Ohio river, the water from which is taken at the pumping works and distributed through the mains to all points in the city. In the same class also falls the supply which is taken directly from the river at various points by the marine population, and which only differs from the water at the works in the important fact that it may contain more sewage.

Second. Ground water obtained from springs issuing from the hill sides or from shallow wells which are carried down to water bearing strata in the earth. All the waters from these sources have fallen in the form of rain or snow upon the adjacent upland and filtered through the soil to the point of collection, and they therefore contain in solution the soluble matters with which they have been in contact.

Third. Deep well water. Wells for procuring this water are sunk from five hundred to eighteen hundred feet deep. Water from these sources has fallen upon the earth at some distant point, and having been carried further through the earth than the water of the second class they have become saturated with soluble matters. The deep wells when extending below twelve hundred feet are true artesian wells. They all are characterized by the presence of sulphur.

Fourth. Water of underground cisterns which are filled by rain or melted snow which has fallen on the roofs of dwellings.

It has not been possible in the time to which I was restricted by the Sanitary Committee to determine completely all questions of interest in reference to these several kinds of water.

I have the honor to report the completion of that part of the analyses which determines the relative character of the river at the several most important points, and which determines the amount of sewage, and total soluble ingredients in the Ohio river water supply. My report also contains analyses of the water of one spring, two shallow wells, one deep well, and a supplementary report on cistern water.

The analyses of the Ohio river water supply contemplate general comparisons of public interest as follows:

1. A comparison of the water drawn from the river at the Pumping Works with that in Eden Reservoir, with the water at Markley Farm, and also with that of the river below the general outflow of the sewage of the city.

2. A comparison of water filtered through the sand of the river beach near Dayton, Kentucky, with the other waters under examination.

3. The general condition of the Ohio river water in comparison with the water supply of other cities.

The basis of comparison of drinking waters is the amount of foreign organic and mineral ingredients considered especially with reference to the presence of sewage.

In the following tables of numerical results the amount of ammonia and chlorine indicate the comparative amount of sewage present, and the residues the amount of solid matter that will be left upon evaporation.

The free ammonia indicates the comparative amount of nitrogenous organic matter, that has recently been subjected to putrifactive decomposition, and the so called albumenoid ammonia the comparative amount of nitrogenous organic matter waiting in the water for the action of decomposing agents.

SCALE FOR INTERPRETATION OF THE NUMBERS UNDER THE HEAD OF AMMONIA.

Less than .0100 superior	drinking	water.
.0100 to .0150 good	"	"
.0150 to .0200 not good	"	"
.0200 to .0250 bad	"	"
More than .0250 very bad	"	"

At a distance from the sea and in the absence of other natural sources of common salt, waters containing chlorine above a certain amount, receive this element from the liquid excrement of animals. Its presence in considerable amount becomes an important index of the amount of sewage.

To interpret the indications of sewage under chlorine, compare the amount of this element with that found in the Markley Farm water collected at the same date, and also with that found at the mouth of Eggleston avenue sewer. Useful indications will be obtained by comparing the ammonia of the analyses with that of Eggleston avenue sewer.

The residues and tables of hardness, the latter of which is estimated in degrees on the basis of the U. S. gallon, are both of industrial interest indicating the amount of solid deposit upon evaporation of the waters.

The collections of water were made as follows:

1. Eden reservoir, in the catch basin two rods from the extremities of its horns.

2. At the Pumping Works, sixty feet from the front of the breakwater.

3. In mid-river at Fleming's Landing, Storrs.
4. Opposite ravine at Markley Farm, one third across the river.

These four collections were taken one foot below the surface.

The water from the Sand Beach was obtained by driving a pipe well near Dayton, Kentucky, on the premises of Thomas G. Smith. It was located twenty-one feet above low water mark, about ten rods from the crest of the high bank and about fifteen rods from the water at low water mark. The pipe was driven to the depth of twenty-six feet—about the level of the bottom of the river—and the water rose in it to the level of the river.

The collections made from September 17th to October 16th represent the same conditions of water. The river had been very low for some weeks. Those made from November 1st to the 13th were made after a rise that increased the water from two to three volumes.

The collections at about the date December 4th were made when the river was from eighteen (18) to twenty-two (22) feet above low water and filled with silt and other loose material carried into it by the heavy rain that cleansed the streets. The driven well was inaccessible from high water and could not be reached until December 14th. These samples of water were probably the worst in appearance that could be collected from the river, yet the indications are that those of November 9th contained the most sewage.

The collections from the river bottom were made from the water carried from the river to Eden Reservoir, and were taken from the water issuing from the pipes.

The river-bottom water from Sedamsville was collected at a point eight feet below low-water mark on the Ohio side.

Numerical Results of the Analysis.

TABLE NO. I.—Ohio River Water.

PARTS BY WEIGHT IN 100,000 OF WATER.

Hardness Gr. of $CaCO_3$. in U. S. Gal.

1880. Date.	1880. Anal't	Locality.	Ammonia. Free Ammonia.	Ammonia. Albumenoid Ammonia.	Residues Dried at 212° F. Inorganic Solids.	Residues Dried at 212° F. Organic and Volatile.	Residues Dried at 212° F. Total Solids.	Chlorine.	Hardness.	Temp. Deg. F. Water.	Temp. Deg. F. Air.
Sept. 17	Stuntz.	Bonte's Well, Dayton, Ky	......	......	......	.....	......	......	39.1	....	....
" 17	"	Bellevue Well, Bricky'd	......	.... .	....	......	......	.....	32.5	....	....
" 17	"	Pumping Works.........	.0047	.0218	6.96	2.82	9.78	.62	6.3	67	74
" 17	"	Eden Reservoir.........	.0045	.0214	11.22	3.16	14.38	.75	6.8	74	76
" 17	"	Storrs	.0132	.0150	9.16	3.96	13.12	.70	5.8	64	74
" 18	"	Markley Farm.........	.0016	.0121	8,20	2.94	11.14	.22	5.3	67	82
" 28	"	Sand Beach	.0083	.0099	7.76	2.58	10.34	.27	7.4	68	71
Oct. 4	"	Sand Beach............	.0099	.0087	8.96	4.64	13.60	.22	7.4	68	70
" 16	"	Storrs	.0118	.0236	9.16	3.96	13.12	.77	5.7	67	74
Nov. 1	"	Sand Beach	.0054	.0075	9.32	2.60	11.92	.25	7.3	56	47
" 1	"	Pumping Works........	.0050	.0156	11.14	4.66	15.80	1.33	8.3	50	49
" 1	"	Storrs....................	.0180	.0198	11.10	2.70	13.80	1.16	8.5	50	49
" 1	"	Eden Reservoir.........	.0231	.0200	11.68	2.18	13.86	.91	9.2	50	49
" 3	"	Markley Farm..........	.0015	.0024	13.16	2.54	15.70	.39	8.2	50	59
" 9	"	Sand Beach	.0040	.0244	7.82	1.70	9.52	.30	7.0	56	54
" 9	"	Markley Farm..........	.0042	.0628	12.44	3.32	15.76	.83	6.0	43	54
Dec. 3	"	Pumping Works........	.0076	.1366	11.06	6.80	17.86	.44	6.8	45	35
" 4	"	Storrs......................	.0262	.1200	13.84	4.02	17.86	.34	4.7	36	40
" 4	"	Eden Reservoir	.0209	.0728	10.38	3.20	13.58	.64	7.4	35	39
" 4	"	Markley Farm..........	.0080	.0420	16.38	2.72	19.10	.43	4.6	35	45
" 14	"	Sand Beach	.0031	.0170	11.00	2.38	13.38	.41	7.9	56	44

TABLE II.—EDEN RESERVOIR.

1880. Date.	Locality.	Ammonia. Free Ammonia.	Ammonia. Albuminoid Ammonia.	Residues Dried at 212° F. Inorganic Solids.	Residues Dried at 212° F. Organic and Volatile.	Residues Dried at 212° F. Total Solids.	Chlorine.	Hardness.	Temp. Deg. F. Water.	Temp. Deg. F. Air.
Sept. 17..	....	.0045	.0214	11.22	3.16	14.38	.75	6.8	74	76
Nov. 1...	....	.0231	.0200	11.68	2.18	13.86	.91	9.2	50	49
Dec. 4...	....	.0209	.0728	10.38	3.20	13.58	.64	7.4	35	39

TABLE III.—PUMPING WORKS.

Sept. 17..	....	.0047	.0218	6.96	2.82	9.78	.62	6.3	67	74
Nov. 1...	....	.0050	.0156	11.14	4.66	15.80	1.33	8.3	50	49
Dec. 3....	....	.0076	.1366	11.06	6.80	17.86	.44	6.8	45	35

TABLE IV.—SAND BEACH.

Sept. 28..	....	.0083	.0099	7.76	2.58	10.34	.27	7.4	68	71
Oct. 4 ...	....	.0099	.0087	8.96	4.64	13.60	.22	7.4	68	70
Nov. 1...	....	.0054	.0075	9.32	2.60	11.92	.25	7.3	56	47
Nov. 9...	....	.0040	.0244	7.82	1.70	9.52	.30	7.0	56	54
Dec. 14 ..	....	.0031	.0170	11.00	2.38	13.38	.41	7.9	56	44

TABLE V.—MARKLEY FARM.

Sept. 18..	....	.0016	.0121	8.20	2.94	11.14	.22	5.3	67	82
Nov. 3...	....	.0015	.0024	13.16	2.54	15.70	.39	8.2	50	59
Nov. 9...	....	.0042	.0628	12.44	3.32	15.76	.83	6.0	43	54
Dec. 4....	....	.0080	.0420	16.38	2.72	19.10	.43	4.6	35	45

TABLE VI.—EGGELESTON AVENUE SEWER.

Sept. 25.	Mouth of Sewer....	.0546	.0529	8.32	4.00	12.32	1.87	12.85	50	55
Dec. 2 ...	Mouth of Sewer	.2000	.2148	19.05	6.16	25.21	7.48	7.10	32	33

TABLE VII.—River Bottom at Pumping Works and Sedamsville.

Dec. 28...	Pumping Works......	.0125	.0424	9.26	3.24	12.50	.40	6.96	......	......
Dec. 28...	Sedamsville..........	.0230	.0882	10.38	3.19	13.57	.46	7.31	......	....

TABLE VIII.—Wells.

Nov. 13...	[60 feet deep Sedamsville Q. sand	.4415	.0634	41.66	5.96	47.62	4.04	50.40	56	45
Nov. 13...	[750 feet deep Sedamsville Artes'n	.0225	.2274	74.54	12.00	86.54	10.02	60.20	54	45
Dec. 13..	Mill Creek Gaff Dist.	.0250	.0210	45.04	10.32	55.36	3.37	59.25	53	42
Dec. 28...	Sedamsville Q. sand	.3888	.1200	....	....	....	....	....	52	35

TABLE IX.—Spring.

Oct. 15....	Under G.S. Hospital	.0010	.0084	80.66	33.60	114.26	10.67	68.60	60	70

TABLE X.—Cistern.

Sept. 30..	No. 1, Walnut Hills.	.0041	.1234	1.52	1.16	2.68	.55	7.41	......	......
Sept. 30..	No, 2, Walnut Hills.	.2745	.0555	3.12	1.60	4.72	2.76	6.40	......	......
Nov. 3...	No. 3, Walnut Hills.	.0207	.1177	2.72	1.76	4.48	1.97	8.39	......	....
Dec. 24 ..	No. 4, Country.........	.0038	.0159	4.64	3.32	7.91	Trace	4.34	.....	......
Dec. 24 ..	No. 5, Country.........	.0202	.3600	2.28	1.82	4.10	Trace	2.76	......	......

TABLE XI.—Water Supply of Other Cities.

1872 March 7.	Croton, N. Y. City*.	.0118	.0118	....	....	6.04	.26	....	......	......
....	L. Katrine, Glasgow	.0003	.0079	....	....	2.83	.45	....	......	......
....	Thames, Lond'n S.†	.0010	.0060	....	....	26.42	1.70	16.50	......	......
Jan., 1880	Mystic R.,Bos'n, M.‡	.0080	.0220	....	....	10.00	....	....	......	......
Jan., 1872	F. Pond, Cam., M.‡	.0075	.0180	....	....	13.00	1.38	....	......	......
1873	Fairmount, Phil'a.*	.0158	.0189	....	....	11.80	.95	....	......	......

* Health Report of Philadelphia, 1874. Cresson.

† Hand-book of Water Analysis. Wanklyn.

‡ Massachusetts Report of Health, Lunacy and Charity, 1879. Nichols. Average of two giving about medium quality.

The numerical expression of the comparative amount of sewage may also be made by the method suggested by Wanklyn, which consists in multiplying the so-called albumenoid ammonia by ten (10) for the entire sewage. In the following tables this amount is computed in avoirdupois pounds to the million United States gallons:

Table for Comparison of Total Sewage.

Pounds of Sewage in 1,000,000 Gallons of Water.

Date. 1880.	Dayton Sand Beach.	Markley Farm.	Pumping Works.	Eden Reservoir.	Lower River, Storrs.	Eggleston Avenue Sewer.	Croton, New York.	Loch. Katrine, Glasgow.	Thames, London, Supply.	Fresh Pond, Cambridge, Mass.	Mystic River, Boston, Mass.	Fairmount, Philadelphia.
Sept. 17 to Oct. 16...	.82	1.00	1.81	1.78	1.96	4.41	.98	.65	.50	1.50	1.83	1.58
Nov. 1 to Nov. 3...	.62	2.00	1.30	1.66	1.65	....	....	....	....	....	....	......
Nov. 9.....	2.03	5.23	....	....	....	....	....	....	....	....	....	......
Dec. 2 to Dec. 14..	1.41	3.50	11.39	6.07	10.00	17.91	....	....	....	....	....	......

From River Bottom—December 28. Pumping Works, 3.53; Sedamsville, 7.35.

General Average—Dayton, Sand Beach, 1.35; Markley Farm, 2.17; Pumping Works, 4.18; Eden Reservoir, 3.17; Lower River, Storrs, 5.94.

DEDUCTIONS FROM THE TABLES.

It must be borne in mind that the averages here given express the amount of sewage somewhat higher than it is on the average through the year. They are based upon one good condition of water, and upon others that reach from bad to the worst. The water from September 17th to October 16th gives about the average condition of the several specimens for the year.

Waters exposed to atmospheric air contain naturally about one pound to one and one-half of sewage to the million gallons.

On this basis we have the general conditions of comparison:

Croton water, New York City......	.98	lbs. sewage	to the	1,000,000	gal.
Loch Katrine, Glasgow...............	.66	"	"	"	"
Thames, London supply...............	.50	"	"	"	"
Mystic River, Boston, Mass.........	1.83	"	"	"	"
Fresh Pond, Cambridge, Mass.....	1.50	"	"	"	"
Fairmount, Philadelphia............	1 58	"	"	"	"

1st. General Condition of Ohio River Water.

Dayton Sand Beach (filt'd-water)	.82	lbs. sewage	to the	1,000,000	gal.
Markley Farm..............................	1.00	"	"	"	"
Pumping Works........................	1.81	"	"	"	"
Eden Reservoir........................	1.78	"	"	"	"
Storrs..	1.96	"	"	"	"
Eggleston Avenue sewer............	4.41	"	"	"	"

2d. Worst Condition.

Dayton Sand Beach..................	2.03	lbs. sewage	to the	1,000,000	gal.
Markley Farm..........................	5.23	"	"	"	"
Pumping Works........................	11.39	"	"	"	"
Eden Reservoir........................	6.07	"	"	"	"
Storrs..	10.00	"	"	"	"
Eggleston Avenue sewer............	17.91	"	"	"	"

3d. General Average from Analyses.

Dayton Sand Beach..................	1.35	lbs. sewage	to the	1,000,000	gal.
Markley Farm..........................	2.17	"	"	"	"
Pumping Works........................	4.18	"	"	"	"
Eden Reservoir........................	3.17	"	"	"	"
Storrs and Lower River..............	5.94	"	"	"	"
Eggleston Avenue sewer............	11.16	"	"	"	"

4. The amount of increase of sewage in coming from Markley Farm to the Pumping Works is over fifty (50) per cent.

5. The increase from the Pumping Works to the points below the out-flow of the city sewage is a little over forty (40) per cent.

6. The effect of the settling basin of Eden Reservoir and of the dam for aerating the water, on the amount of sewage is a general reduction of it, up to about twenty (20) per cent.

There is no evidence from the analyses that the drainage from the street car track and from Park Avenue, which is carried into the catch-basin, causes any increase in the amount of organic impurity in the catch-basin. The one case in which the sewage of the catch-basin exceeds that of the Pumping Works is probably caused by falling leaves.

7. The filtered water of the Dayton, Kentucky, Sand Beach contains less sewage than the water at Markley Farm under the same conditions, and shows less increase of sewage from a sudden flood. This water will be always clear from mud and other suspended matter.

I transmit a sample of it with that of water from other localities for comparison.

The filtered water of this sand beach, on the testimony of the experiments made at your order, is the best available for the water supply of the city.

I have made full analysis of three wells and determined the hardness of two others. They are all on or near the river bank :

1st. Bonte's well is at the rope works, Dayton, Ky., about eighty (80) rods from the river. It is about sixty (60) feet deep, in a gravel formation. The water rises and falls in it with the river.

2d. The Bellevue brickyard well is about twenty (20) rods from the river. It is a driven well.

3d. The Sedamsville quicksand well is on the river bank, is sixty (60) feet deep and its water rises and falls with the river.

The Sedamsville artesian well is near the quicksand well. It is dug to about sixty (60) feet and then a pipe is carried down from that depth to about 750 feet. When the river is high the water flows from the pipe. The water contains sulphur and salt.

5th. The Millcreek well supplies the Gaff distillery. The water rises and falls in it with the river.

	Hardness.	Sewage to 1,000,000 Gals.
Bonte's well	39.1	......
Bellevue brickyard well	32.5	......
Sedamsville quicksand well	50.4	5.28
Sedamsville artesian well	60.2	19.96
Millcreek Gaff distillery well	59.25	1.75

The hardness and the amount of mineral ingredients in these several specimens of water show that they are not river water, but what is called upland surface water. I have not been able to determine satisfactorily the source of the large amount of sewage in the Sedamsville wells.

The large amount of chlorine in each of the wells, fully examined, is unpleasantly suggestive of an impure source.

I have analyzed one spring in the city. It is the one that issues under the pavement of the Good Samaritan Hospital.

This is shown to be good water with a large amount of mineral salts in solution. It contains of sewage .70 lbs to the 1,000,000 gallons. Yet if all the chlorine in it is derived from sewage—a supposition justified by the geological formation—a simple calculation will show that at some previous time 1-50 of its water has been obtained the liquid excrement of animals. It has probably been transformed to the condition of good water by aeration and oxidation. No one knows at what time accident may prevent oxidation and the water again become the cause of disease.

All of which is respectfully submitted.

C. R. Stuntz,
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January 10, 1881.

SUPPLEMENTARY REPORT

OF

ANALYSES OF CISTERN WATER,

TO DETERMINE THE

Presence of Sewage and other Impurities.

BY

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BY ORDER OF THE BOARD OF HEALTH:

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CISTERN WATER.

To most persons the type of good drinking water and of water good for culinary purposes, is that which falls upon the roof from the clouds in the form of rain or snow, and which is collected in lime cemented cisterns under ground.

On theoretical grounds, in which are considered the formation of snow and rain by condensation of moisture from the clouds, neglecting the sources of contamination, water collecting from the roofs should compare favorably with the chemically pure distilled water of the laboratory. The high estimation in which cistern water is held generally, is probably caused by the theory of its pure source.

But it must not be forgotten that the atmosphere near the surface of the earth is pervaded with soluble gases through which the rain and snow must fall, and that the roofs of habitable dwellings upon which they are collected are perforated with chimneys, which vomit into the air constantly, the gases, smoke, soot, and dust that is carried up from the fires, and living occupants below.

Many houses, in addition to the chimneys, have ventilating pipes, to living rooms, heated by indirect radiation, pipes to drains leading to sewers, and the waste pipe itself of the inside improved water-closet, piercing the roof, and each contributing to load the air above it with fetid gases, and deleterious solids carried up by the draught.

The atmosphere abounds in organic dust, so light as to be carried on its currents, and in organic germs, which await the stimulating action of water, and of heat, to produce in them corruptive decomposition, or to cause them to spring into deleterious life. This infectious matter is collected on the roofs, by the lateral currents, to the ascending columns of warm air from the chimneys, and ventilating pipes, and is washed bodily into the cisterns below.

On these other theoretical considerations, it becomes a question as to what rank the contents of the house cistern should hold among potable waters.

Dr. Frankland ranks it "suspicious water." Dr. Herman Hager says, "Rain water, when entirely pure, is drinkable, but not good drinking water. Cold snow water is unhealthy."

The examinations of cistern water have not, to my knowledge, furnished the facts from which can be determined the character of a given specimen, or on which the analyst can either authoritively commend or condemn it. He has either to be guided by the general principles of water analysis, or to compare the results from examinations of suspected waters with those obtained from water known to be good.

The following table contains the numerical results of some analyses made at the order of the health officer of Cincinnati.

Each of the specimens was collected from an underground cistern, cemented with lime, and filled from the roof of a dwelling-house.

Except No. 5, each was tinged with the color of soot, and No. 4 contained a remarkable amount of this substance.

All were neutral to sensitive litmus paper, and all when cold, were without odor.

Cistern No. 1 was eight feet from a privy vault, filled with fecal matter to the surface of the earth. The surface of the water in the cistern was about four feet below the surface of the ground. The water was viscid, tinged with soot, and yellowish by transmitted light. The premises about the cistern were tidy. Persons drinking the water freely were not sick, but at the same time did not have the appearance of persons in good condition.

No. 2 was about eight feet from the vault described under No. 1, and about twelve feet from the vault on the adjoining premises. Its water was yellowish-brown by transmitted light, and somewhat viscous. The surface of the ground about the cistern was in a very untidy condition. Of the parties who had been drinking the water, one was sick with typhoid fever, and the others were looking badly.

Cistern No. 3 was also eight feet from a privy vault, and was described by the sanitary policeman who collected the water, as in the same general condition as cistern No. 1.

Cistern No. 4 was fed from the shingle roof of a country dwelling. It was surrounded by deep gravel drainage, and at a distance from any surface sources of contamination. It was thoroughly aerated and in constant use. It had been cleaned within the year. Its waters were analyzed to furnish a standard of comparison for the others.

Cistern No. 5 contains five hundred barrels of water. It is on a gravel terrace sixty feet deep, and is in a condition which excludes the possibility of contamination by sewage, unless it be by back-flow of the waste pipe from an inside water closet. Its water was collected in the expectation of finding the best possible specimen of cistern water.

After the analysis, it was found to have been twelve years without cleaning. It had been kept closed during that time, the water being drawn from it by a pump.

I also found that it swarms with water beetles.

The people drinking it were subject to malarial fever more than their neighbors.

The following scale, for the interpretation of the numbers under ammonia, is partly taken from the analysis of known waters, and partly from published tables.

SCALE FOR AMMONIA.

Less than .0100,	Superior Drinking Water.	
.0100 to .0150,	Good "	"
.0150 to .0200,	Not Good "	"
.0200 to .0250,	Bad "	"
More than .0250.	Very Bad "	"

Table of Analysis of Cistern Water.

1880. DATE	1880. ANAL'T	LOCALITY.	Free Ammonia.	Albuminoid Ammonia.	Inorganic Solids.	Organic and Volatile Solids.	Total Solids.	Chlorine.	Hardness.
Sept. 30	Stuntz.	No. 1, Walnut Hills...	.0041	.1234	1.52	1.16	2.68	.55	7.41
"	"	No. 2, Walnut Hills...	.2745	.0555	3.12	1.60	4.72	2.76	6.40
Nov. 3	"	No. 3, Walnut Hills...	.0207	.1177	2.72	1.76	4.48	1.97	8.39
Dec. 24	"	No. 4, Country	.0038	.0159	4.64	3.32	7.96	Trace 000	4.34
"	"	No. 5, Country	.0202	.3600	2.28	1.82	4.10	Trace 000	2.76
Sept. 25	"	Eggleston Ave. Sewer	.0546	.0529	8.32	4.00	12.32	1.87	12.85
Dec. 2	"	Eggleston Ave. Sewer	.2000	.2148	19.05	6.16	25.21	7.48	7.10

DEDUCTIONS.

1. The total solids of cistern water should not exceed four to five parts, by weight in 100,000 parts, by weight of water.

2. The hardness in grains per gallon should correspond closely to the amount of inorganic solids.

3. Chlorine, beyond the merest trace unless explained, should be taken as an indication of the presence of excrement of animals.

OBSERVATIONS.

1. Cisterns Nos. 1, 2 and 3 are evidently contaminated with human excrement. It will be noted that their hardness is excessive, in proportion to the inorganic solids.

Cistern No. 2 would seem to justify the inference, that bad water becomes an active agent of disease, when thrown into active decomposition by the introduction of foreign materials.

The decomposing agents were probably introduced with the filth which abounded at the surface of the ground about the cistern curb.

Cisterns Nos. 1 and 3 were probably kept from fermentation and from being positive agents of disease, by the care of good housewives, who kept the premises neat.

Cistern No. 5, from the ammonia determination, ranks with Nos. 1 and 3, but the absence of chlorine excludes the idea of excrement. It is believed to have become foul entirely from organic matter in a fine state, which was drawn to the roof by lateral currents to the chimneys, washed down from the roof, and collected at the bottom of water not sufficient aerated to cause its full decomposition. It will be noted that its total solids, in solution fall low.

The water of Eggleston Avenue sewer, here given probably at its best and worst, was analyzed to give a standard of comparison, as to presence of impurity.

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JANUARY 10, 1881.