ON THE NECESSITY FOR THE SYSTEMATIC INSPECTION OF WELLS IN CITIES AND TOWNS.

BY DURAND WOODMAN, PH. D.

In presenting the following analytical data obtained from an examination of wells in Newark, N. J., it may be remarked that the case under consideration is not a special one, but illustrates conditions which not only exist to-day in many cities and towns, but which are constantly reappearing whenever a new centre of population forms, and are always a fit subject for more stringent and systematic sanitary regulation than that to which they are usually subjected.

Newark presents the usual case of the growth of a city where the water supply from wells has long been superseded by an aqueduct service, except among the small minority who still persist in the use of wells, either through force of habit and old association, motives of economy, convenience, or sometimes among the poor, inability to have the city water close at hand, and occasionally through distrust of the aqueduct supply.

Many wells in a town become unfit for use before the introduction of a general system of water distribution, and sickness caused by them, or the impending danger of epidemics lead to the agitation which results in a change. But after the new supply is provided all interest in wells subsides; each well owner continues to use well water as long as he pleases, or until the family physician insists on its discontinuance. When a particular season develops an epidemic the Board of Health is aroused and many old wells are examined and closed; many more remain to cause future trouble.

An examination of over thirty wells in Newark, selected in as many different localities as possible, disclosed some very astonishing cases of badly contaminated water in daily use.

Referring to the tabular statement of analytical results, the first sample taken for comparison is water from the Passaic River, opposite the outlet of the Millbrook sewer, which, if not as bad as that much defiled river can furnish, is at least very much worse than any water ever drawn from a faucet in the city.

The first well water examined contained nearly twice as much free ammonia (.049 parts per 100,000) as this river sample, and had almost as bad an odor after standing a few hours. The second well, No. 224, a street pump only a block distant from the preceding, contains but .005 parts per 100,000 *total* ammonia, and would be rated a good water, while third, No. 227, is again an aggravated case. Free ammonia, .068 parts per 100,000.

Continuing, it will be found that fifteen out of thirty-two here tabulated are unfit for use, being contaminated in several instances to an extent which makes it seem almost impossible that they should be found tolerable.

Only one of the fifteen No. 297 contains less free ammonia than the sewer outlet sample. Of two of the fifteen it was stated by those living on the premises that the water was unfit to drink; but nothing had been done to prevent water being drawn from them by any one who chose to do so.

No. 245 containing .068 parts per 100,000 free ammonia and other conditions corresponding (see Table) was said to be "used only in hot weather."

FREE AND ALBUMINOID AMMONIA.

Referring to the table, it will be noticed that all the waters are characterized by a large proportion of free ammonia, which in No. 326 reaches the extreme figure 0.74 parts per 100,000, and in a well concerning which no warning was given by those on the premises.

The albuminoid ammonia is, in one case only, higher than in the sewer outlet sample or 0.05 parts per 100,000 in No. 284. This water was filled with minute green particles of a species of algae, imparting a greenish tinge to the entire mass.

CHLORINE.

It is well known that the value of the chlorine determination is relative only and taken alone, without a knowledge of the quantity natural to waters of the locality in question, is likely to be very misleading.

A comparison of results in the chlorine column shows the want of uniform agreement between the evidence furnished by the amounts of chlorine and of ammonia.

The lowest chlorine is in No. 278, a water which at least would be called doubtful judged by the ammonia determinations, while in No. 358 a well on high ground with an abundant supply of water from the sandstone rock three times as much chlorine is found. (2.63.)

The same well also contains more chlorine than the river sample from opposite the sewer outlet.

No. 227, a very bad water, irrespective of chlorine, contains 5.07 parts per 100,000.

No. 271, in which free ammonia is only .003 and albuminoid ammonia only .007 parts per 100,000, contains 9.36 parts chlorine per 100,000 or nearly twice as much.

No. 290, an offensively bad water, is comparatively low in chlorine (3.22 parts per 100,000), while No. 281, a comparatively good water, contains nearly twice as much. (5.82 parts.)

No. 245, a very bad water, contains 4.38 parts per 100,000 chlorine, while No. 326 containing over ten times as much free ammonia, contains only 2.5 as much chlorine. (11.40)

Again, the first three wells, which are in the same neighborhood, yield almost precisely the same quantities of chlorine, while the ammonia varies from a very low figure in No. 224 to .049 in No. 217.

From these results it appears that a large proportion of chlorine is a normal characteristic of much of the water from wells in the level and lower part of the city, and also that it varies greatly. This level consists of gravel or "drift" and is about 30 feet above mean tide. An estimation of the chlorine contained in it gave the following result:

1,360 grams taken at a depth of seventeen feet and away from any source of contamination yielded 4.17 grams chlorine.

$$\frac{4.17 \times 100}{1360} = 0.306 \text{ per cent.}$$

or from ten to fifteen times as much as found ordinarily in earth at points distant from tidal ways. (The average of 21 determinations, U. S. Agricultural Report, 1885, p. 175, is 0.02 per cent.).

TEMPERATURE.

The temperature observations were made as a means of judging approximately, in cases when direct observation was impossible, as to whether the well was very shallow or affected to any great extent by surface drainage.

The temperature of deep seated springs corresponds very closely with the mean annual temperature of the locality, which, in the case of Newark, N. J., is 50.52° F.

In about two-thirds of the observations recorded the approximation to this figure is very close.

That of No. 358 observed at the end of the Summer (Sept. 10th) is 51.5° or one degree higher than the mean annual temperature.

The lowest recorded temperature 48° happens to be in a very shallow well, No 276, but this well is nothing more than the outflow of a vigorous spring which rises to within ten feet of the surface. (Observation made May 16th.)

DISTANCES FROM CONTAMINATING SOURCES.

Even among people otherwise well informed the notions as to safe distance between a well and a cesspool or privy vault seem to be vague to the extent of allowing them to take great risks.

In most of the cases here given in the column of distances between wells and vaults, probably no special thought or anxiety was ever expended. Each one has looked out for himself according to his own ideas, regardless of neighbors. Eight and ten feet are among the most striking figures giving evidence of the popular confidence in the filtering and purifying influences of limited thicknesses of earth, while the analytical results show to what extent such confidence is misplaced.

The question so frequently asked of the chemist, "How far distant from cesspool and privy vault must a well be placed to be safe?" is of course one that does not admit of a general answer;

for the kind of soil, rock, etc., in which the well is sunk, the direction in which drainage tends, and other variable conditions necessarily make each case a subject for special inquiry.

NEED OF INSPECTION.

The conditions shown to exist by the foregoing seem in some instances almost incredible and prove without argument the necessity for systematic inspection to prevent the existence of wells in such a state as those described, many of which like the one previously referred to, are reserved for use in Summer weather.

Boards of Health of cities and towns should have complete lists of the wells in actual or possible use, an analysis of each sufficient to determine the character of the water, with particulars as to location and surroundings.

Annual inspection would result in closing such as were found to be approaching the limits of safety, while those showing no deterioration could remain in use.

In accordance with the results of such inspection well owners should be given a preliminary notice that the further use of the well is dangerous, naming a time limit, at the expiration of which, if not closed by the owner, it will be closed by authority of the Board of Health, at the same time posting a notice on the well house or pump stating that the water is unsafe to drink.

This allows opportunity for new arrangements to be made, if any are necessary, and prevents the ill feeling and opposition which summary proceedings always engender.

From one point of view, viz : the average conditions of proximity to sources of contamination, it would seem that the closing of all the wells herein described would be the only safe plan, and without proper inspection it most certainly would ; but in some cases wells receive an abundant supply of deep spring water coming from considerable and safe distances through strata of the underlying rock, and such wells overflow, so to speak, through the adjacent soil instead of acting as centers of local drainage.

All these questions, however, would be decided from the records of inspection and proper action taken accordingly. When it is considered to what extent an epidemic may be spread through the medium of bad wells before the means are discovered, nothing need be said to emphasize the risk and danger of allowing the existence of even one well such as nearly fifty per cent. of those described have been shown to be.

No.	Date.	Temperature F.	Approximate Depth.	Distance from Privy Vaults.	Color or Appearance	Odor.
215	Apr. 28	....	......	....	Brown	Soapy.
217	" 29	49°	33 ft.	40 ft.	Slight Opalescence	Soapy.
224	" 29	....	......	....	Clear.	....
227	May 2	49°	......	25 ft. 27 "	"	Offensive on standing.
229	" 2	55°	40 ft.	25 "	"	....
232	" 3	49°	30 "	15 "	"	....
237	" 4	55°	50 "	35 " 75 "	"	....
245	" 11	50°	40 "	25 "	"	....
247	" 13	50°	?	25 "	Opalescent.	....
260	" 12	50°	30 "	17 "	Clear.	....
268	" 14	51°	40 "	32 "	"	....
271	" 16	51°	......	25 " 25 " 30 "	Good.	....
273	" 16	54°	.....	20 " 25 "	"	....
276	" 16	48°	18 ft.	30 "	Yellowish. (Iron.)	....
278	" 16	58°	28 "	18 "	Clear.	....
281	June 18	54°	30 "	25 "	"	....
284	" 20	54°	......	8 "	Greenish Yellow.	Offensive on standing.
287	" 20	53°	......	30 " 35 "	Clear.	....
290	" 21	56°	......	25 "	Clear.	Offensive on standing.
293	" 21	53°	33 ft.	25 " 30 "	Turbid.	....
297	" 21	53°	35 "	(6) 40-80 "	Excellent.	Earthy.
318	" 22	52°	......	....	"	....
320	" 22	53°	......	45 ft.	"	....
323	" 27	54°	......	....	"	....
326	" 27	57°	... .	10 ft. 25 " 30 "	"	....
330	" 28	52°	25 ft.	40 "	Yellowish Opalescence	Offensive on standing.
333	" 28	52.5	30 "	......	Clear	....
336	" 28	56°	.. ...	25 ft.	"	....
340	" 29	55°	35 ft.	20 "	"	....
357	July 29	54.5	......	30 "	"	Offensive.
358	Sept. 10	51.5	55 ft.	30 "	"	....
423	....	....	70 " piped.	Water-tight 30 ft. Sewer.	"	....

Parts per 100,000.

Ammonia. Free.	Ammonia. Album-enoid.	Chlorine.	Hardness.	Remarks.
0.026	**0.045**	**1.90**	**2.44**	**Passaic River,** opposite outlet to Millbrook Sewer. Tide going out.
.049	.008	5.20	17.90	Chain and Buckets.
Total	0.005	5.50	.....	Wooden pump. Edge of sidewalk.
0.030	.008	5.07	26.81	Pump.
.005	.004	10.53	21.40	
.001	.009	9.09	19.20	
.032	.010	12.24	16.00	
.068	.004	4.38	10.67	"Only used in hot weather."
.192	.010	10.54	18.07	
.038	.008	11.20	37.32	
.004	.003	5.85	13.06	"Used in Summer."
.003	.007	9.36	5.69	Wooden pump.
.011	.007	.....	.....	Pump 150 ft. from Morris Canal.
.005	.008	5.12	16.73	
.008	.007	0.88	5.54	
.002	.009	5.82	15.16	Wooden pump.
.027	.050	19.75	49.50	" "
.074	.017	17.05	13.44	" "
.055	.024	3.22	12.00	Pump. Said to be unfit to drink.
.062	.007	5.34	10.67	Brick lined well.
.017	.017	18.36	26.53	
.001	.005	3.88	11.90	Pump.
.005	.004	6.95	8.62	Wooden pump.
.148	.009	7.31	16.66	
.739	.016	11.40	19.35	Pump.
.325	.008	8.70	9.73	
.002	.013	.....	.....	Wooden pump.
.002	.005	3.73	15.13	Pump.
.002	.019	6.44	11.90	
.7306	.002	12.00	8.33	Pump.
.0002	.012	2.63	.....	
.0036	.012	15.00	23.00	Iron pump.