MUNICIPAL DEPARTMENT

THE CHEMICAL AND BACTERIAL EXAMINATION OF WATER.*

By Percy F. Frankland, Ph D., B Sc., Lond., F R. S., *Professor of Chemistry in Mason University College, Birmingham.*

The bacterial purification which takes place in the different layers of the sand filter is, perhaps, most instructively exhibited in the following results, which were obtained by Reinsch at the Altona Waterworks (see Table A).

TABLE A—Number of Micro-Organisms Found in One Cubic Centimetre of Water.

Date.	Raw Water.	No. 1 pipe 30mm. below layer of slime.	No. 2 pipe 6mm. below layer of slime.	No. 3 pipe 16mm. below layer of slime.	No. 4 pipe 43mm. below layer of slime.	No. 5 pipe 60mm. below layer of slime.	No. 6 pipe 70mm. below level of slime.	No. 7 pipe* 50mm. below level of slime.	No. 8 pipe† 150mm. below level of slime.	The water drawn from the delivery pipe of the whole filter.
June 16.....	28,881	3,596	2,976	824	446	314	306	304	1,280	2,212
" 21.....	52,328	1,860	752	321	244	152	140	160	592	624
" 26.....	60,310	1,994	216	163	40	48	48	62	143	164
July 2	36,320	1,876	446	176	44	46	48	44	86	98
" 5	36,810	Liquefied	1,148	281	56	34	28	28	80	96
" 17‡	13,824		2,946	386	102	122	108	116	208	236
" 20	34,224		4,960	242	124	24	22	—	60	58
" 24	11,840		3,472	102	7	11	10	13	11	12

* This pipe was placed at the boundary between the sand and gravel layers.
† This pipe was placed in the layer of stones of about the size of a walnut.
‡ The filter was cleaned on July 12, in which operation 30mm. of sand were removed from the surface, so that no further samples were obtainable from No. 1 pipe, whilst No. 2 pipe, instead of being 6mm. beneath the surface slime, was now only 30mm below. Even when samples were taken five days later (on July 17th), although the number of micro-organisms in the raw water was considerably smaller than on the previous occasion, the disturbance is reflected in all the samples collected on that day by an increase in the number of bacteria present.

Another important fact connected with waterworks filtration which has been revealed by the bacteriological method of examination is that a new sand filter, or a sand filter which has just been scraped, possesses but very little power of removing bacteria. In this connection I may refer to the following results which have been obtained in the laboratory of the Massachusetts Board of Health.

	Percentage Removal of Bacteria.
First three days	25
Second three days	70
Second week	96
Third week	98

A particularly striking example of the comparative inefficiency of a sand filter which had just been started after scraping came under my personal notice in connection with the waterworks of a large city only a few weeks ago, and is exhibited by the following figures:

Filtration works at X.	Unfiltered water. No. of bacteria in one cubic centimetre.	Filtered water.	Rate.	Age of bed.
				Days.
Jan., 1898	639	78	3·6in.	36
Feb., 1898	3,042	57	4·9in.	17
Mar., 1898	2,1	59	5·3in.	18
Ap., 1898	1,300	528	3·1in.	1

It will be observed that in April, when the bed had only just been started, the efficiency of the filtration was much less than on any of the other occasions, although the rate was the slowest.

This comparative inefficiency of a new sand filter revealed by bacteriological examination, shows how necessary it is that the practice should be adopted of running to waste the filtrate until the sand has acquired the power of retaining the micro-organisms in the water, a practice which is at present, I regret to say, but little adopted by waterworks engineers.

From the facts which I have brought before you, it is obvious that the only available method of ascertaining whether filtration is being efficiently carried out is by submitting the water before and after filtration to bacteriological examination. It is, moreover, essential that the performance of each individual filter bed should be submitted to this bacteriological control. Unfortunately, it is too frequently the case, especially at old waterworks, that separate samples cannot be obtained of the filtered water from each separate bed, but only an average sample from the general filter-well of a group of beds, and it is evident that the examination of such average samples is of very much less value, as it does not enable the delinquencies of a particular filter bed to be detected. It will, however, be generally found that existing works can be modified by some simple and inexpensive contrivance so as to permit of samples from each bed being obtained, whilst in all new works ample provision for this purpose should be made.

As an example of the unsatisfactory nature of an examination made of the mixed water from several beds, I may cite the following instance, in which I was able to examine the water coming from no less than six beds:

Filter beds yielding mixed water.	Age of bed	Unfiltered water supplying beds.	Filtered water from beds.
No. 1.....	3 days	1,230	66
No. 2.....	1 "		
No. 3	15 "		
No. 4	14 "		
No. 5.....	10 "		
No. 6....	7 "		

Thus the average efficiency of the six beds, as measured by the number of bacteria present in the mixed filtrate, was good, yet it is practically certain that No. 2 bed, which had only been in operation a single day, must have been working with very indifferent efficiency.

Just as the bacteriological examination has enabled us to ascertain the real value of artificial purification processes, so also by its means we can discover whether natural purification processes are operating with efficiency or not. Thus the safety of deep-well water depends upon the exhaustive filtration to which it has been subjected in the porous strata of the earth, and if the water gaining access to such a well has already been thus filtered, it should be almost entirely free from bacteria, and this in the case of properly constructed wells is found actually to be the case. It is desirable, therefore, that wells should be frequently submitted to the control of bacteriological examination, and this control is especially necessary after heavy rains, as it is at such times that there is the greatest possibility of the ingress of surface water taking place.

In the following table are recorded the results which I have obtained in the bacteriological examination of a number of deep-well waters, some of which I have had under periodical observation since 1886:

Series of Deep Wells in the Chalk Under Periodical Observation.

Works at	Number of bacteria in one cubic centimetre of water. 1892.	1896.	1897.	1898.
A. No. 1 well	16	—	14	—
A. No. 2 well	13	—	19 5	—
A. No. 3 well	4	—	24	—
B. well.....	76	—	43 46	—
C. No. 1 well	11	13	75	32
C. No. 2 well	21	10	31	—
D. No. 1 well	21	—	115 9	—
D. No. 2 well	—	—	—	4
E. No. 1 well	44	—	8 50	4
E. No. 2 well	54	—	10	—
F. No. 1 well	18	—	9 18 7	—
F. No. 2 well	74	—	80 20	14

It is unnecessary for me to further enlarge upon the great advantages which are to be derived from the use of the bacteriological method for ascertaining the efficiency of purification processes, whether natural or artificial, but it is very necessary that I should point out that the results obtained in such an investigation will only be of value if the samples have been collected in the proper manner and with the exercise of sufficient judgment. Indeed, there are a number of details which unless rigidly adhered to may lead to the most erroneous results being arrived at. The water must invariably be collected in sterilized bottles and submitted to examination with the greatest possible dispatch, whilst during any unavoidable delay the samples should be packed in ice to prevent multiplication of the bacteria. Much discredit has already been brought upon the method through inattention to such details by persons who might have been expected to be better informed.

* From a paper presented to the British Association of Waterworks Engineers.