B. WELCHII IN THE CHICAGO WATER SUPPLY.

ARTHUR E. GORMAN, FRANK E. GREER AND H. J. HLAVACEK,
DEPARTMENT OF PUBLIC WORKS AND DEPARTMENT
OF HEALTH, CHICAGO.

The proposition of eliminating all gas forming organisms in a public water supply while unquestionably desirable from the health officer's view point may make treatment by chlorine very offensive to the consuming public. This fact is most pointedly emphasized in Chicago where bacillus welchii and other resistant gas formers appear seasonally in the public water supply but apparently have little if any public health significance other than to mask the results of the presumptive tests from B. coli and, therefore, require the use of more chlorine than would be considered necessary if the time and temperature effect of this chemical and organisms of the B. coli group were better understood. The sudden appearance of these chlorine resistant organisms at about the time the ice fields in Lake Michigan off Chicago were breaking up this winter suggested to the authors the possibility of a relationship between these factors, which has been studied and may be of interest to this group.

The public water supply of the city of Chicago is obtained through six intake cribs located in Lake Michigan opposite the city at points from two to four miles from shore. The only treatment which the lake water receives before being delivered from the pumps directly into the distribution system is for disinfection, using chlorine. This chemical in solution is applied in the suction wells at each of the ten pumping stations. At one of the cribs, the Two-Mile, the water is pre-chlorinated.

The period of contact between the chlorine and the water before the latter enters the mains for public consumption is very short. The minimum period is 16 seconds, while the maximum is about two minutes. The average period of contact is about three-quarters of a minute. On account of this short period of contact there

are times, when in order to deliver a safe water it is necessary to add chlorine in amounts which cause distinct tastes in the water. These periods are fortunately relatively short in duration, occurring usually for a few days only and following strong southerly winds.

The quantity of chlorine used for disinfecting Chicago's water supply is considerably more than would be necessary if it were not for this brief period of contact between the sterilizing agent and the water to be disinfected. The average daily chlorine dosage per million gallons of water pumped was 3.61 pounds in 1924 and 3.3 pounds in 1925. The maximum dosages for brief periods may be as high as 6 pounds per million gallons at certain stations. The minimum is as low as 1¾ pound, depending upon the quality of the lake water. It will be seen, therefore, that the problem of disinfecting the public water supply in Chicago is a difficult one if a safe water is to be assured without rendering the water objectionable to drink.

In spite of these relatively large amounts of chlorine there are periods of the year when, based on the results of presumptive tests for organisms of the B. coli group, the chlorinated water in Chicago would not meet recognized standards. This is due to the existence of relatively large numbers of non-confirming spore formers, some of which may be normal to the lake waters. Experience has shown that these resistant forms are apparently of little public health significance and that to endeavor to eliminate them by the use of increased amounts of chlorine is not justifiable. Difficulty with these organisms invariably follows storm periods on the lake when, due to the violent wave action light flaky sediment on the bottom of the lake is brought into suspension in the water. This condition is particularly prevalent in the late winter and early spring months when strong northerly winds are most frequent.

On account of the large amount of filling material deposited along the lake front, in connection with park improvement projects, and the formation in the winter of huge ice banks along the water edge this winter, it was decided to study the effect of the movement of ice

fields on the presence of those gas forming organisms in the lake water. It was thought that with the separation of these huge ice cakes from the shore line and their drifting into the lake in the vicinity of the cribs there might be a marked increase in the development of spore formers in the lake water, since laboratory examination of shore ice had indicated the presence of large numbers of B. welchii and other resistant organisms in the ice.

Samples were, therefore, collected over three periods, viz: February 24 to March 16, when the waters in the vicinity of the cribs were more or less filled with floating ice or ice fields; second, from March 18 to April 1, when the waters of the lake were open and moderately choppy, and third, from April 1 to April 16, when the lake waters were open but highly turbid (for Lake Michigan) due to the influence of strong winds.

The samples were collected from the routine sampling points in the tunnel system from which the daily bacterial and turbidity samples of the unchlorinated water supply are obtained. The results are tabulated in the three accompanying tables and are given on the basis of the number of B. welchii per 100 c. c. of sample, although the amount of water actually used in the analysis was 20 c. c. The samples were analyzed in the water analysis laboratory of the Bureau of Laboratories and Research, Chicago Department of Health. The method used is the sulphite-glucose-iron medium, as published by Wilson & Blair.[1] The colonies counted in this media are black. This is because of the production of iron sulphide around the colonies, which indicates the presence of a hydrogen sulphide producer that can break down ferric sulphite into the black ferric sulphide. In water practically the only organisms present that produces these black colonies are B. welchii and fecal streptococci. There is a marked difference in the size of the black colonies produced by these organisms, the B. welchii producing large colonies and the fecal streptococci small ones. In the plate made with the sample of raw water examined in the laboratory practically all of the black colonies produced were of the large B. welchii type. The significance

[1] Wilson & Blair: J. Patti and Bact (1924) XXVII P. 119.

of the presence of numbers of B. welchii in water is in much debate, but it is thought that in such water as the public supply of Chicago they may display indications of fecal contamination.

In the accompanying tables the direction and velocity of the wind, the condition of the lake and the average turbidity of the water for the days samples were collected are given for reference purposes. It was thought advisable to give the turbidity of the Two-mile crib waters as well as the average turbidity of the water from all cribs, because this structure is located but two miles from shore and water entering this intake is not considered representative of that from other cribs. Furthermore, the water supplied from this inlet is pre-chlorinated at the crib, so that the results of samples collected are hardly comparable as those from the other sources.

The results from various sampling points in the tunnel system have been grouped by the crib served, with averages compiled for each crib. The 68th Street crib is not included, as it was out of service during this period.

While it is realized that these studies were made over too brief a period to permit of a detailed analysis of conditions, it is thought that they do bring out factors which are of interest to water works and health officials. It will be noted that in general the average results by groups for each of the three periods are quite uniform, with those in the second period lowest and those in the third or period of greatest turbidity, highest. It appears that the most important factor relating to B. welchii contamination of the waters in the vicinity of the intakes are those influences causing high turbidities, such as violent wave action due to strong and prolonged winds. The average results show no marked variations between the North and South side groups. The best results are reported from the Four-Mile crib, which is the most distant from shore and in whose vicinity the waters are usually the least turbid. During the period when ice fields were prevalent in the lake waters the average turbidity was slightly lower than during the second period of open water, although the average velocity of the wind

was higher. The presence of B. welchii in the water during the ice period was considerably higher than in the second period or the first one of open waters. Considering the amount of dirt which becomes enmeshed in the ice banks along the shore there is the suggestion that floating ice fields may be an influencing factor contributing to the high B. welchii contamination of the water, but this is considered by no means as important as the influence of those factors affecting the turbidity of the water, such has violent wave action due to winds.

TABLE I.

B. Welchii Per 100 C. C.—Period February 24 to March 16 Inclusive.

Date	Feb. 24	Feb. 25	Feb. 26	Mar. 1	Mar. 4	Mar. 5	Mar. 8	Mar. 10	Mar. 15	Mar 16	Period
Wind direction	SW.	W.	NW.	W.	NE-NW.	SE.	NW.	NE.	NW.	SW.	.....
Wind Vel. mi./hr.	13.2	20.2	13.9	22.2	12.9	11.6	17.5	9.2	12.9	14.4	14.8
Lake Surface	Fl. Ice	Fl. Ice	Ice Fi.	Fl. Ice	Ice Fi.	Ice Fi.	Ice Fi.	Ice Fi.	Fl. Ice	Fl. Ice	.....
Lake Condition	Choppy	Choppy	Rough	Choppy	Calm	Calm	Calm	Calm	Choppy	Choppy	.....
Average Turbidity P. P. M. Two-Mile Cr.	11.7	10	11.7	6.7	8.3	11.7	6.0	4.3	10	6.7	8.7
Average Turbidity Other Cribs.	12.3	11.6	12.1	6.5	11.0	11.2	6.2	6.1	9.0	6.8	9.3
Mayfair R-1	..	70	20	50	50	0	0	5	10	10	23.9
Lakeview R-1	35	10	25	40	25	15	15	0	10	35	21.0
Lakeview R-2	40	5	50	30	10	25	0	0	5	65	23.0
Wilson Avenue Crib	37	28	32	40	28	13	5	2	8	37	23.0
Springfield R1	25	20	15	20	55	20	10	15	10	15	20.5
Central Pk. R1	40	50	10	15	75	55	0	0	15	20	28.0
Chicago R-3	30	20	40	10	55	10	10	0	20	5	20.0
Carter Harrison Crib	32	30	22	15	62	28	7	5	15	13	22.9
Chicago R-1	40	30	90	35	95	10	10	10	5	20	34.5
Chicago R-2	25	0	10	10	50	10	5	0	0	25	13.5
22nd St. R-1	10	15	..	20	50	20	0	0	15	30	17.8
*Two Mile Crib	25	15	50	22	65	13	5	3	7	25	23.0
Harrison St.	75	90	..	..	10	5	5	0	45	55	35.6
14th St.	10	25	..	15	....	25	0	0	25	0	12.5
Four Mile Crib	43	58	..	15	10	15	3	0	35	28	23.1
68th St. R-3	10	20	..	15	40	30	5	0	10	5	15.0
Roseland R1	10	15	..	50	115	30	20	0	30	5	30.5
Dunne Crib	10	18	..	33	78	30	13	0	20	5	23.0
Average all Cribs	28	31	35	26	53	20	6	2	15	22	**22.8

* Water pre-chlorinated at crib at rate of 2. to 3.0 lbs. per M. G.
** Calculated from grand total.

TABLE II.

B. Welchii Per 100 C. C.—Period March 18 to 30 Inclusive.

Date	Mar. 18	Mar. 22	Mar. 23	Mar. 24	Mar. 25	Mar. 27	Mar. 30	Period
Wind direction	NE.	SE.	W.	S.	NE.	NW.	NE.	.....
Wind Velocity	10.9	7.2	10.8	15.4	14.7	10.0	26.3	13.6
Lake Surface	Open	Open	Open	Open	Open	Open	Open	.....
Lake Condition	Choppy	Choppy	Calm	Choppy	Choppy	Choppy	Rough	.....
Average Turbidity P. P.M. Two-Mile Cr	10	10	5	8.3	10.	4.3	8.3	8.0
Average Turbidity P. P. M. Other Cribs	9	8.5	6.9	5.8	8.1	4.7	7.3	7.2
Mayfair R-1	5	20	35	20	0	10	0	12.9
Lakeview R-1	0	35	10	15	25	50	5	20.0
Lakeview R-2	20	25	15	20	80	15	5	25.7
Wilson Avenue Crib	8	27	20	18	35	25	3	19.4
Springfield R-1	30	20	15	25	0	0	35	17.9
Central Pk. R-1	90	40	30	10	5	5	20	28.6
Chicago R-3	10	20	0	10	35	30	15	17.1
Carter Harrison Crib	43	27	15	15	13	12	23	21.1
Chicago R-1	20	5	0	5	0	30	55	16.4
Chicago R-2	20	10	25	10	40	0	95	28.6
22nd St. R-1	0	5	5	0	30	15	5	8.5
*Two Mile Crib	13	7	10	5	23	15	52	17.9
Harrison St.	0	10	5	20	15	5	25	11.4
14th St.	0	0	0	0	40	..	5	6.4
Four Mile Crib	0	5	3	10	28	5	15	9.1
68th St.	15	80	10	10	15	40	5	25.0
Roseland R-1	10	0	15	15	0	5	15	8.6
Dunne Crib	13	40	13	13	8	23	10	17.1
Average all Cribs	17	21	13	12	22	16	*22.0	*17.5

* Water pre-chlorinated at crib at rate of 2 to 3.0 lbs. per M. G.
** Calculated from grand total.

TABLE III.

B. Welchii Per 100 C. C.—Period April 1 to 16 Inclusive.

Date	Apr. 1	Apr. 5	Apr. 6	Apr. 7	Apr. 8	Apr. 9	Apr. 12	Apr. 14	Apr. 15	Apr. 16	Period
Wind direction	W.	NE.	SE.	NE.	N.	W.	NE.	NE.	SW.	NW.	.....
Wind vel. mi./hr.	28.0	11	10	18	18	7	14	22	13	20	16.1
Lake surface	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	.....
Lake condition	Rough	Rough	Choppy	Rough	Rough	Choppy	Rough	Rough	Choppy	Choppy	.....
Average Turbidity P. P. M. Two-Mile Cr.	30	20	30	15	17.5	17.5	37.5	35	45	30	27.8
Average Turbidity P. P. M. Other Cribs	15.1	16.9	17	14.2	16.2	21.7	21.2	29.5	21.8	23.7	19.7
Mayfair R-1	90	70	35	40	85	30	70	145	65	145	77.5
Lakeview R-1	125	75	50	30	60	45	40	65	45	45	58.0
Lakeview R-2	135	...	40	35	35	0	50	90	70	40	55.0
Wilson Avenue Crib	117	73	42	35	60	25	53	100	60	77	63.5
Springfield R-1	165	15	65	40	55	110	100	35	20	55	66.0
Central Pk. R-1	110	75	75	...	10	125	100	135	5	...	79.
Chicago R-3	135	25	40	110	40	120	110	195	120	120	101.5
Carter Harrison Crib	137	38	60	75	35	118	103	122	48	58	79.4
Chicago R-1	155	55	115	30	100	130	105	80	30	50	85.0
Chicago R-2	110	35	45	50	20	30	130	100	145	35	70.0
22nd St. R-1	125	55	45	125	100	85	35	35	20	160	78.5
*Two Mile Crib	130	48	68	68	73	82	90	72	65	82	77.8
Harrison St.	110	170	50	35	50	65	120	20	165	30	81.5
14th St.	65	70	35	35	30	55	55	80	55	15	49.5
Four Mile Crib	88	120	43	35	40	60	88	50	110	23	65.7
68th St. R-3	40	60	100	80	35	65	20	120	85	55	66.0
Roseland R-1	120	75	85	85	120	60	25	75	25	270	94.0
Dunne Crib	80	68	93	83	78	63	23	93	55	163	79.9
Average all Cribs	115	65	61	58	57	70	74	90	66	85	**75.2

* Water pre-chlorinated at crib at rate of 2 to 3.0 lbs. per M. G.
** Calculated from grand total.