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The Sanitary-Chemical and Bacteriological Examination of Natural Ice

AN ADDRESS

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THE SANITARY—CHEMICAL AND BACTERIOLOGICAL EXAMINATION OF NATURAL ICE.

By Edward Bartow, Director Illinois State Water Survey.

DURING the past two or three years the Illinois State Water Survey has been called upon to make some sanitary examinations of natural ice. In a few cases we have received, with the ice, samples of the water from which the ice was harvested. The comparative analyses are especially interesting. I wish every much that there were more analyses to place before you, but the data obtained are enough to warrant some interesting conclusions.

The analyses made have been arranged in two tables. The first table shows the data obtained by the analyses of the specimens of ice. The second table shows a comparison of the analyses of some specimens of ice with the analyses of the water from which the ice was harvested.

The determinations made are the ordinary determinations of chemical and bacteriological analysis, including turbidity, color, odor, residue, chlorine, oxygen consumed, nitrogen as free ammonia, albuminoid ammonia, nitrites and nitrates, alkalinity, the number of bacteria and gas formers. Some of these tests are of little significance in ice analysis but others have a decided value.

Turbidity refers to the insoluble matter in suspension. It may be dangerous or harmless. Even if harmless it renders a water or an ice less attractive than a clear water. In only one ice did the turbidity exceed five parts per million and in the one which is reported as greater there is so small a residue that one must conclude that there may have been an error in the work.

Color refers to colored substances in solution. It is due usually to an extract of vegetable matter. Color is usually harmless, but a colored water or ice arouses suspicion and people will not use it. The color of all of the samples was very low; and in no case would it be detected in an ordinary drinking glass.

Odor is a descriptive term and is reported as aromatic, earthy, vegetable, etc. Only one of the samples was reported as having a noticeable aromatic odor. Only one of the samples was reported as having a noticeable odor.

"Residue" comprises the solid matter left on evaporating the water. It includes both organic and inorganic constituents. Unless the quantity is excessive, it does not injure the water for domestic use. Five hundred parts per million is a usual allowance in a drinking water. Ice should have very little residue. The highest residue found in the ice examined was 34 parts per million, but in most cases it was less than 10, which is the equivalent of distilled water.

"Chlorine" refers to the quantity of chlorine in combination with

TABLE I.—ANALYSES OF ICE.

Lab. No.	Source.	Turbidity.	Color.	Odor.	Residue.	Chlorine.	Oxygen Cons.	Nitrogen as— Free Amm.	Alb. Amm.	Nitrites.	Nitrates.	Alkalinity.	Bacteria per cc.	Gas Formers. 10 cc.	1. cc.	.1 cc.	Indol.
21045	Rock River, Sterling	5	0	0	23	1.	.8	.062	.076	.004	.200	12	330	1 –	2 –	2 –	–
21770	Sturgeon Bay, New Boston	..	..	...	...	...	...	....	....	....	....	....	10	1 –	2 –	2 –	–
21771	Lake Rice, Galesburg	..	..	...	...	...	...	....	....	....	....	....	125	1 –	1 – 1 +	2 –	–
22925	Sylvan Island Pool, Moline	2	0	0	11	.0	5.6	.154	.364	.000	.000	1	3	1 –	2 –	2 –	–
22924	Pool, 24th Street, Moline	3	0	0	9	.1	6.0	.166	.360	.000	.000	2	8	1 +	2 –	2 –	–
22926	Sylvan Island Pool, Moline	2	0	0	10	.1	2.6	.096	.128	.000	.000	3	6	1 –	2 –	2 –	–
21842	Lake Rice, Galesburg	5	0	0	7	3.	1.8	.112	.200	.000	.160	6	20	1 –	2 –	2 –	–
22058	———, Quincy	10	0	0	12	2.	1.7	.040	.090	.003	.000	4	Liq.	1 –	2 –	2 –	–
22165	———, Chester	0	0	3A	14	3.	.2	.118	.098	.000	.040	0	6	1 –	2 –	2 –	–
22962	———, New Boston	2	0	0	9	.2	.9	.040	.082	.000	.160	1	7	1 +	2 –	2 –	+
22963	Lake Rice, Galesburg	3	0	0	10	.2	1.5	.118	.156	.000	.040	1	16	1 –	1 + 1 –	2 –	+
22990	Illinois River, Spring Valley	4	0	1E	6	.1	.9	.118	.122	.000	.120	1	234	1 –	2 –	2 –	–
23004	Rock River, Dixon	2	0	1	34	.8	1.8	.096	.104	.002	.200	4	22	1 –	2 –	2 –	–
23005	Spring Creek, Kankakee	2	0	1E	27	.8	.9	.090	.094	.000	.080	4	6	1 –	1 + 1 –	2 –	–
23039	———, Galesburg	2	0	1E	7	.4	.7	.094	.068	.004	.000	2	6	1 –	2 –	2 –	–
23040	Quincy Bay, Quincy	2	4	0	8	.6	1.5	.118	.206	.000	.040	2	17	1 –	2 –	2 –	–
23176	———, Mendota	1	2	2W	5	2.2	2.5	.166	.140	.001	.000	2	17	1 –	2 –	2 –	–
23340	Quincy Bay, Quincy	0	0	0	31	.5	1.2	.150	.182	.002	.280	6	45	1 –	2 –	2 –	–
23517	Cedar River, Cedar Falls, Ia.	1	2	1	17	1.	.9	.080	.104	.000	.16	4	65	1 +	2 –	2 –	–

ANALYSES OF ICE—*Continued.*

Lab. No.	Source.	Turbidity.	Color.	Odor.	Residue.	Chlorine.	Oxygen Cons.	Nitrogen as Free Amm.	Nitrogen as Alb. Amm.	Nitrogen as No. 2.	Nitrogen as No. 3.	Alkalinity.	Bacteria per cc. Gel.	Bacteria per cc. Agar.	Gas Formers. 10 cc.	Gas Formers. 1. cc.	Gas Formers. .1 cc.	Gas Formers. Indol.
24107	Ice, Pontiac....................	5	0	2V	10	1.6	1.8	.088	.186	.000	.36	0	50	4	1 –	2 –	2 –	–
24770	Ice, La Salle....................	0	0	0	19	0.	1.1	.128	.058	.000	.60	4	32	3	1 –	2 –	2 –	–
24791	Ice, Mendota..................	2	0	0	27	1.	1.0	.052	.124	.000	.24	4	20	15	1 –	2 –	2 –	–
24866	Ice, Kankakee..................	5	0	1E	24	1.	1.3	.150	.204	.000	.12	20	60	50	1 –	1+1 –	2 –	–
24973	Ice, Pana.....................	0	0	0	33	1.	.9	.428	.048	.003	.80	10	1	0	1 –	2 –	2 –	–
24988	Ice, Momence..................	0	0	0	33	1.	.9	.040	.068	.000	.12	8	7	7	1 –	2 –	2 –	–
25347	Ice, Quincy Bay, Quincy........	0	5	0	3	3.2	.8	.048	.020	.010	.20	2	120	20	1 –	2 –	2 –	–
25443	Ice, Pekin.....................	2	5	0	9	1.	1.2	.064	.078	.000	.044	2	106	7	1 –	2 –	2 –	–

TABLE II.—ANALYSES OF WATER AND OF ICE FROM THAT WATER

Lab. No.	Source.	Turbidity.	Color.	Odor.	Residue.	Chlorine.	Oxygen Cons.	Nitrogen as— Free Amm.	Alb. Amm.	No. 2.	No. 3.	Alkalinity.	Bacteria per cc.	10 cc.	1. cc.	.1 cc.	Indol.
21769	Lake Rice, ⅛ mile east of Galesburg	..	..	...	...	...	...	....	....	....	....	....	12000	1+	2+	2+	+
21771	Ice, Lake Rice, ½ mile east of Galesburg	..	..	...	...	...	...	....	....	....	....	....	125	1−	1 −1+	2−	−
22921	**Pool opposite channel, Moline**	8	50	1E	183	2.4	9.1	.072	.152	.004	.680	144	520	1+	2+	2−	+
22925	Ice, Moline Ice Co., Moline	2	0	0	11	.0	5.6	.154	.364	.000	.000	1	3	1−	2−	2−	−
22922	Pool opposite Moline Ice Company's plant, Moline	7	50	1E	194	2.3	7.9	.080	.150	.004	.680	144	675	1+	2+	2+	+
22926	Ice from Sylvan Ice Company, Moline	2	0	0	10	.1	2.6	.096	.128	.000	.000	3	6	1−	2−	2−	−
22961	Lake Rice, east of Galesburg	7	20	1E	277	3.	4.6	.274	.310	.005	1.12	180	1400	1+	2+	2−	+
22963	Ice, Lake Rice, Galesburg	3	0	0	10	.2	1.5	.118	.156	.000	.040	1	16	1	1±1−	2−	+
23002	Rock River, Dixon	..	..	...	...	...	...	....	....	....	....	....	4060	1+	2+	2+	+
23004	**Ice, Rock River, Dixon**	2	0	1	34	.8	1.8	.096	.104	.002	.200	4	22	1−	2−	2−	−

metals; for example, sodium chloride (common salt). Chlorine is a constant and considerable constituent of sewage. Unless present because of the presence of salt wells, or the nearness to the sea, etc., its presence in a water is a cause for suspicion. The chlorine in the ice examined never exceeded 3 parts per million. It usually could be determined with difficulty, and could well be reported as "trace."

The "alkalinity" refers to the soluble carbonates or hydrates, and helps to determine the value of a water for household uses. There should be a very low alkalinity in an ice, as was found to be the case in the specimens examined.

While they indicate very well the purity of the ice from a physical and chemical standpoint, the tests for turbidity, color, odor, residue, chlorine and alkalinity are of no significance with respect to the hygienic condition of the water.

In Table 2 are shown analyses of ice and the water from which the ice was taken. A consideration of the degree of purification effected by freezing is quite interesting, from both a chemical and bacteriological standpoint.

The turbidity, although not high in the original water, is practically eliminated.

The high color in most of the samples was also eliminated, in two of the cases being reduced from 50 to 0.

The residue was reduced from 183 to 11, 194 to 10 and 197 to 10 respectively.

The chlorine was reduced from 2.4 to 0, 2.3 to 1 and 3 to .2; the alkalinity from 134 to 1, 144 to 3, 180 to 1.

The oxygen consumed was reduced, and, in most cases, free and albuminoid ammonia, nitrites and nitrates were greatly reduced.

Where comparisons of the number of bacteria were made, the purification was very striking. In one case, with 12,000 bacteria in the raw water, there were but 125 in the ice; 520 were reduced to 3, 675 to 6, 1,400 to 16, and 4,060 to 22, in every case practically 99% reduction. Gas-forming bacteria were also greatly reduced.

In the purification of water by freezing both suspended matter and soluble substances are removed. The removal of the suspended matter is explained by the fact that water in freezing solidifies on top. The formation of the coating of ice protects the water from disturbance and enables the particles heavier than water to sink to the bottom. Also in the normal formation of the crystalline ice there is no room for solids between the crystals. This accounts for the decrease in the turbidity and bacteria.

For the removal of soluble substances we must seek another explanation. Let us compare the solubility of the ice with the solubility of soluble substances. Ice is soluble in water at 4 degrees Centigrade

(39.2 degrees Fahrenheit) when the water is at its maximum density, but insoluble in water at 0 degrees Centigrade (32 degrees Fahrenheit). The substances occurring in river and pond waters are, as a rule, soluble to a much greater extent than is their concentration in the rivers and ponds. For example, the least soluble of the common substances occurring in pond waters is calcium bicarbonate. This at 0 degrees Centigrade has a solubility of 700 parts per million. In most of the streams of the United States we find less than 200 parts per million of residue and hence much less than that amount of any one compound. Before very much calcium carbonate would be taken from the water by the ice, there must be a concentration several times the ordinary concentration in the water. The same is true of other salts. Magnesium carbonate is soluble 1,300 parts per million. Calcium sulphate is soluble to the extent of 2,050 parts per million. Magnesium sulphate is soluble to the extent of 257,000 parts per million. Of the salts of sodium, sodium chloride (common salt) is soluble to the extent of 55,000 parts per million. Other salts, sodium carbonate is soluble to 70,000 parts per million, and sodium bicarbonate to 79,000 parts per million. None of these exist in the rivers and streams of the United States to an extent greater than 200 parts per million. Only in sea water do we find these salts present in sufficient quantities, so that on cooling to zero degrees are they taken out with the ice. Sea water contains 3½ per cent of salts. The water obtained from the melted ice from sea water is said to be fresh. This, however, has a bitter taste, since but four-fifths of the salts present are removed.

Nature certainly does its share toward furnishing a pure natural ice. If reasonable precautions are taken so that no ice is obtained from grossly polluted ponds or rivers and the surface of the ice is protected, there need be no difficulty in placing a pure ice on the market. This, I believe, is the aim of this Association, and it can not be too highly commended.

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