With strong solutions reacting there is here a tendency to produce nitrogen trichloride and nitrogen.

It is apparent that a solution of chloramine of only relatively low concentration can be prepared; that if stronger solution of bleach and of ammonia are used, the reaction must take place in the presence of considerable amounts of diluting water.

Experiments were undertaken to determine the stability of chloramine solutions of different strengths. Two methods of determining the velocity of the reaction: (1) the content of chloramine remaining in the solution after the lapse of each period of test, and (2) the total volume of nitrogen evolved in a gas burette at the end of each period.

The amount of nitrogen evolved is a function of the rate of disappearance of available chlorine, which finds expression in the equation:—

3 NH₂Cl=N₂+NH₄Cl+2 HCl.

A series of determinations was made of the rate of decomposition of chloramine solutions of different strengths.

DECOMPOSITION OF CHLORAMINE SOLUTIONS				
1- 1990	Available	Chlorine.	Available	Chlorine,
Hours.	Ppm.	Loss.	Ppm.	Loss.
Series -1 -2				
0	10.200	0	8,160	0
1 de ada	7.275	28.68	7,388	9.46
2	6.900	32.35	7,013	14.06
3	6.413	37.13	6,619	18.88
7	4.875	52.26	. 5,438	33.36
11	3.844	82.90	2,194	45.76
24	1.744	82.90	2,194	73.11
32.5	1.125	88.97	1,819	77.71
53.5	300	97.06	469	93.03
Series <u>—</u> 3—			-4-	
0	6,120	0	4,080	0
1	5,513	9.92	3,750	8.09
2	5,250	14.21	3,638	10.83
3	4,988	18.50	3,516	13.82
7	4,350	28.92	3,169	22.33
11	3,788	38.10	2,897	29.00
24	2,175	64.46	2,016	50.59
321/2	1.538	74.87	1,603	60.71
531/2	563 -	90.80	863	78.85
Series <u>-5</u>				_
0	3,060	0	2,040	0
1	2,775	9.31	1,875	8.09
2	2,700	11.76	1,844	9.61
3	2,625	14.22	1,813	11.13
7 10	2,391	21.86	1,706	16.37
11	2,231	27.09	1,638	19.71
24	1,688	44.84	1,350	33.82
321/2	1,397	54.35	1,194	41.47
531/2	853	72.12	863	57.69

The most concentrated solution used (10.2 grains available chlorine per liter, or .2877 normal) foamed vigorously at the start; the succeeding one less and so through the several series, with the velocity of the decomposition diminishing in each case as the period of experiment was prolonged, as indicated both by the volume of gas evolved and the concentration of available chlorine. A precipitation of calcium hydroxide varied in the series of reactions from very heavy in the first to relatively slight in the last.

From these data it is apparent why the application of chloramine should be made under such conditions that the concentration of the mixed reagents shall not exceed 1 part per million. A solution even of this low concentration should not be stored longer than 24 hours and is best made up as used. Not only do hydroxyl ions in solutions prepared from bleach and ammonia reduce the stability of chloramine; their reaction with bicarbonate ions in the treated water convert the latter to bivalent carbonate ions, and cause a copious precipitation of calcium carbonate. This has resulted in incrustation of feed pipe and of lines carrying the treated water from the point of applying chloramine.

Some experiments were carried on in preparing chloramine with dilute chlorine water and dilute ammonium compounds, NH₄CH, (NH₄)₂, CO₃, etc., with varying results. While it is theoretically possible that some chloramine might be formed under these conditions the diverse possibilities of reaction, indicated by Bray and Dowell (J. Am. Chem. Soc. 39, 905), offer little hope that direct addition of ammonia and liquid chlorine to a water can be so controlled and distribution of the sterilizing agent made so efficient as to insure the full chlorine equivalent in chloramine.

Oxidizing Power Not Increased

Rideal (J. Roy. San. Inst. 31, 33, 1910) found that when chlorine was introduced into sewage it was rapidly consumed, but that after free chlorine had entirely disappeared there persisted a strong germicidal power. The same results were obtained when bleaching powder was added to a water containing a small amount of ammonia. It seemed probable that the ammonia did not increase the oxidizing power of chlorine, since readily oxidizable organic matter in water absorbed much less chlorine from ammonia and hypochlorite than from hypochlorite alone. Furthermore the bleaching effect on dyestuffs indicated that ammonia and bleach together had only two per cent. of the oxidizing (bleaching) power of hypochlorite alone. While chloramine has little oxidizing value, it is still able to displace iodine from potassium iodide, giving the usual starch-iodide reaction; its chlorine can be precipitated by silver nitrate, and its ammonia equivalent determined with the strongly alkaline Nessler's reagent. Rideal showed that chloramine has a phenol coefficient of 6.6, three times that of chlorine.

According to Dakin (Proc. Roy. Soc. Lond., Series B. 89, B. 614, pp. 232-251) the germicidal value of hypochlorite in sewage is due to chloramine derivatives produced by the action of chlorine on amino acids and proteins. The proteins present in sewage contain amino groups which may react with chlorine to form substituted chloramines containing the NCl group. When chlorine or bleaching powder is added to sewage, there may occur a primary oxidation and a secondary formation of toxic chloramines from the reaction of amino bodies. When chloramine is added to sewage the initial rapid oxidation is eliminated, and the germicidal action begins at once. Dakin attributes the latter action to the chloramine group.

It is possible that proteins of living cells may so react, and that the killing of micro-organisms by hypochlorites is due to chemical changes of this character within the living cell, either by direct action of the germicide or by secondary products of similar nature.

Action of Chloramine on Crenothrix

The pronounced success of chloramine treatment in destruction of vegetative bacterial cells suggested its application to an especially troublesome water pest. Crenothrix is one of the "iron bacteria," so called because of their occurrence in iron-bearing waters. It belongs with the true bacteria (eubacteria). Its cylindrical cells are united in unbranched threads, enlarged toward the free end, covered with a thick sheath which becomes infiltrated with ferric hydroxide. Reproduction takes place by division of cells in three planes, with the formation of round gonidia. It is still in dispute whether the organism receives its energy from oxidation of ferrous to ferric iron (Winogradsky, Proc. Zool. Soc. Lond., 1913, Pt. 2, 430) or whether the separation of ferric hydroxide is an independent mechanical phenomenon not connected with the life processes of the cell. (Molisch and Ellis.)

It occurs in numerous sections of the State of Illinois in surface waters and in some well supplies, as at Freeport and Champaign-Urbana. In 1917, the latter supply was rendered unsightly and unfit for some domestic purposes by the development and decay of the organisms in the distribution system.

(Concluded on page 378)