The tabulated results show the average deterioration in 9 to 13 months of 43 samples to be 18.8 percent. The average deterioration of 38 samples during the first three or four months being 4 percent per month, while the average deterioration of 32 samples after the first three or four months was 2.4 percent per month.

PHARMACODYNAMIC LABORATORY,
H. K. MULFORD CO.,
July 28, 1918.

TABLETS FOR THE DISINFECTION OF DRINKING WATER.*

BY BERNARD FANTUS.[1]

For the disinfection of small quantities of drinking water, such as those that might be gathered and carried by rapidly moving troops, tablets constitute by far the most satisfactory form for use. Hence the study of these becomes of special importance in war time. To be ideal, such tablets should be small, prompt and reliable in action, perfectly harmless, and leave the water free from offensive odor or taste, and finally be relatively inexpensive. This study was undertaken to determine the nearest approach to the ideal.

Chlorine, by far the most potent disinfectant, is at the same time the most harmless, as in exercising its disinfecting action, it is changed to chloride ions. While liquefied chlorine is the most satisfactory form in which to use this agent for water disinfection on the large scale—the city of Chicago for instance, adding to its drinking water from three to five pounds of liquefied chlorine per million gallons of water—it is, of course, out of the question for the purpose under consideration.

Lime, in the form of chlorinated lime, is probably the most convenient and cheapest vehicle for chlorine; and this is, no doubt, the reason why the health department of the city of Chicago took up, in 1916, the question of preparation of chlorinated lime tablets. I am indebted to Dr. D. O. Tonney, the Director of the Municipal Laboratories, for permission to publish the data obtained by Mr. Jay Kaplan in this inquiry.

TABLET TRITURATES OF CHLORINATED LIME.

"The tablets were prepared as follows: Chlorinated lime containing not less than thirty percent of available chlorine is moistened slightly in a mortar to make a thick paste. It is important to add the smallest amount of water which will give a suitable consistency to the mixture. Very often the market product is sufficiently moist without further treatment. A tablet triturate mold of vulcanite, having fifty perforations, 5 mm. in diameter and 3.5 mm. in depth is used. The perforated half of the mold is placed on a glass plate and the paste is pressed into the impressions with a spatula. The mold is then placed for from five to ten minutes in an oven at 40° to 50° C. The tablets are now carefully forced out by fitting the two parts of the mold together and applying slow pressure. The tablet triturates thus prepared are shaken into bottles and tightly stoppered. The tablets ordinarily weigh from 120 mg. to 140 mg., and contain from 30 to 40 mg., of available chlorine. For distribution they are put up in homeopathic vials, ten tablets to the vial. The vials are tightly stoppered and kept, if possible, in a dark, cool place. Under average conditions, the disinfectant retains its potency for

* Read before Scientific Section A. Ph. A., Chicago meeting, 1918. From the John McCormick Institute for Infectious Diseases. Aided by a grant from the Fenger Memorial Fund.

[1] Associate Professor of Therapeutics, Rush Medical College of Chicago.

about four weeks. The tablets are given out each summer by the Department of Health for the benefit of vacationists and motor tourists.

"*Directions for use:* Dissolve one tablet by crushing between the fingers in one quart of water in an ordinary mason jar, which should be sealed with an air-tight cap. The jar is then shaken and stored in a cool, dark place. This is the stock solution and under average conditions will last about one week, after which it should be renewed.

"To prepare water for drinking, take one teaspoonful of the stock solution to one 8-ounce glass of drinking water, allow it to stand for about five minutes, when it is ready for drinking and will be safe. If it is suspected that the water is heavily polluted, two teaspoonfuls of the stock solution should be used to each 8-ounce glass of water. If it is desired to make up a daily supply, ready for use, it can be done by adding four teaspoonfuls of the stock solution to each quart of water.

The following experimental notes were made by Mr. Jay Kaplan on the keeping qualities of these tablets:

On September 16, 1916, about two hundred chlorinated lime tablet triturates were made from a fresh can of chlorinated of lime and distilled water, to give the proper consistency, etc.

Filled about nineteen tubes containing ten tablets each and sealed by fusing the glass.

On September 18, 1916—analyzed one tube (sealed two days) by U. S. P. assay method: 4 tablets, weight 0.5706 Gm., required: 30.3 cc. N/10 $Na_2S_2O_8$ = 18.68% available chlorine.

Four months later, on January 15, 1917, another tube assayed 11.12% average, which represents a deterioration of about 40% Cl gas under pressure in tube. (Note: When opened tablets appeared to be moist and had lost their shape.)

Seven and one-half months later, on May 1, 1917, the contents of two tubes were assayed. Upon opening each tube under water, a loud report was heard and a distinct splash seen. No water was sucked into the tube. The gas was evidently under pressure. The tablets were moist and sticky, and did not retain their shape when removed from the tube.

Assay = 3.27% available chlorine in one tube
3.32% available chlorine in another tube
Average = 3.30% available chlorine, a deterioration of 82.5%.

We may therefore conclude that chlorinated lime tablets prepared by the tablet triturate process do not possess satisfactory keeping qualities.

COMPRESSED TABLETS OF CHLORINATED LIME.

On the assumption that the moisture employed in the preparation of the tablet triturates was responsible for the rapid deterioration of the tablets, just described, Mr. Eicher, of the School of Pharmacy of the University of Illinois, kindly prepared for me some tablets by means of compression, using the following formula:

Chlorinated lime, 30%, or proportionately larger amounts of weaker lime	0.59 Gm.
Sodium Chloride (granular)	10.00 Gm.

Divide into 100 tablets weighing about 105 mg. each, avoiding use of lubricant.

One of these tablets will disinfect one l. of moderately infected water within one hour in cool, or much sooner in hot weather.

These tablets, prepared on May 3, 1918, without special care as to drying, and kept in the dark, in a well stoppered bottle, were assayed from time to time.

May 6,	1918	5 tablets weighing 0.538 Gm. yielded 9.2 mg. available Cl.
June 15,	1918	5 tablets weighing 0.544 Gm. yielded 8.1 mg. available Cl.
July 8,	1918	5 tablets weighing 0.529 Gm. yielded 7.1 mg. available Cl.
Aug. 9,	1918	5 tablets weighing 0.536 Gm. yielded 6.5 mg. available Cl.

This is equivalent to a deterioration of about 10 percent per month; though the rate of deterioration is becoming less. Had the tablets been prepared from dried material, the deterioration would, no doubt, have been slower. Nevertheless, it must be admitted that chlorinated lime tablets are decidedly unstable. However, by the time the deterioration has reached 50 percent, which might be in the course of half a year, these tablets would still be as good as ever for disinfecting half the specified quantity of water.

COMPRESSED TABLETS OF HALAZONE.

Because of this unstability of chlorinated lime tablets, H. D. Dakin and E. K. Dunham[1] advocated, for the purpose under discussion, *p*-sulphondichloramino-benzoic acid ($Cl_2NO_2SC_6H_4COOH$), and proposed the name "Halazone" for it. This substance is prepared from a cheap waste product in the manufacture of saccharin, which latter is ortho-sulphamino-benzoic acid. The para-isomer, which is not sweet, when chlorinated, constitutes halazone. This substance, very sparingly soluble in water, has its solubility increased by alkalies, such as sodium carbonate or borax. Dakin and Dunham found that 1 : 300,000 sterilizes water in about 30 minutes, leaving the water fairly palatable. They propose the following formula for tablets:

Halazone	4.0 Gm.
Sodium Carbonate (dried)	4.0 Gm.
Sodium Chloride	92.0 Gm.

The material should be carefully dried and mixed, the alkali being added last, and made into 100 mg. tablets, without use of lubricant.

One such tablet is capable of disinfecting one l. of water in 30 to 60 minutes.

The authors referred to report[2] that they found such tablets kept in amber-colored bottles at ordinary temperatures almost unchanged for five months, and that they should be serviceable for considerably more than a year. Having fed this substance to rabbits in doses of 100 to 200 mg. per day without observable symptoms, they consider it perfectly innocuous in the small amounts required for sterilization of water.

I have verified the claims of Dakin and Dunham in practically every respect. Have fed halazone to kittens and to rabbits in doses of 100 mg. per day for over 4 months without observable deleterious effect, either during life or on necropsy. This dose would approximate 7 Gm. daily for a man, and only 4 mg. are required to disinfect one l. of water.

Halazone tablets (which as well as the halazone used in my other experiments were kindly furnished me by The Abbott Laboratories of Chicago) showed the following results on assay from time to time.

Bottle opened May 6, 1918.
May 6, 5 tablets, weighing 0.550, yield 10.6 mg. available Cl.
July 8, 5 tablets, weighing 0.561, yield 10.6 mg. available Cl.
Aug. 9, 5 tablets, weighing 0.573, yield 10.6 mg. available Cl.

Therefore, there has been practically no deterioration in four months.

[1] *Brit. Med. Jour.*, Jan. 29, 1916, also May 26, 1917, p. 682.
[2] *Ibid.*, Dec. 15, 1917, p. 790.

The only disadvantage that halazone presents is its comparatively slow action. Using equivalent strengths of chlorinated lime and of halazone, (calculated on the basis of "active chlorine"), I found that halazone required almost twice as long as chlorinated lime for disinfection. This is in accordance with what might have been anticipated, in view of the fact that chlorine is the active agent in both, and that it is more readily given off from chlorinated lime than from halazone. The greater instability gives chlorinated lime a greater rapidity of action. However, even with chlorinated lime in the concentrations recommended, it may take 30 minutes to obtain complete disinfection. Now 30 minutes may seem quite a long time to a thirsty man.

COMBINATION WITH CITRIC ACID.

Some studies were therefore undertaken to find out whether it is possible to accelerate the action; and I succeeded in finding such an agent in citric or other organic acid. Citric acid enables a concentration of chlorinated lime or halazone to act within one to five minutes when, without the acid thirty or more minutes would have been required. As little as $^1/_{20}$ percent of citric acid enables chlorinated lime, $^1/_{20.000}$ N, to disinfect in less than five minutes; an equivalent amount of halazone, to act within ten minutes.

Another advantage of the action of citric acid in chlorine disinfection is improvement of the taste of the water thus disinfected. Nearly all of us are only too familiar with the disagreeable taste of chlorinated water. The addition of citric acid, even in very small amounts, improves the taste in two ways: it tends to disengage the chlorine from the compounds it has entered in with the constituents of the water, and it substitutes a pleasant degree of sourness for the flatness and offensiveness of taste of the chlorinated water. In this connection, I might point out that citric acid greatly improves the taste of Chicago water, which is not only chlorinated but which, at times, somehow becomes contaminated with the flavor of rotten fish. When used for this purpose, a little of a citric acid solution, say 5 or 10 percent, may be mixed with the water; the amount used being entirely governed by the taste.

Inasmuch as citric acid acts by driving off chlorine, it is obviously difficult to incorporate it in a tablet, at least one made in the ordinary way. In an experimental lot of citric acid-chlorinated lime tablets, made with fairly well dried material, all chlorine had practically disappeared within twenty-four hours. When, therefore, citric acid is used to accelerate the disinfectant action of chlorinated lime, or of halazone and to improve the taste of the product, it might be necessary to make use of a two-tablet system, unless some other acid and special method of preparation, which absolutely excludes moisture, make it possible to incorporate the two in one tablet. Here is a field for further research.

CONCLUSIONS.

1. Halazone is the best material at present available for the preparation of water disinfecting tablets.

2. Compressed tablets of chlorinated lime are less stable; though not so unstable as to be useless.

3. The tablet triturate process is not suitable for the preparation of chlorinated lime tablets.

4. Citric acid, even in very small amounts, renders the action of these tablets much more rapid and the disinfected water much more palatable; but seems unsuitable for incorporation in one tablet with the chlorine disinfectant.

DISCUSSION.

CHAIRMAN EDWARD KREMERS stated that the two-tablet idea in disinfection reminded him of an object of historical interest in the Historical Drug Store of the Wisconsin Historical Society, namely, a large container of tablets containing manganese dioxide and sodium chloride. When chlorine was to be generated, sulphuric acid was added to some of these tablets. The label on the container bears the name of Dr. E. R. Squibb, who devised this method, and was employed for the War needs of that period (about 1860).

F. E. STEWART: What microörganism was used in testing out the disinfecting power of these tablets?

BERNARD FANTUS: Typhoid organisms. We carried out the experiments not only in distilled water infected with typhoid organism, but also in tap water. The details of this part of the work will be published in the *Journal for Infectious Diseases.*

EDWARD S. THATCHER: May I ask Doctor Fantus whether he confined his attention to typhoid bacilli?

BERNARD FANTUS: When tap water was used there were other bacteria present. Hence, when the tap water was sterilized, a number of other organisms had also been destroyed.

L. F. KEBLER: As the important thing is to make the drinking water safe, it is necessary to avoid the use of too much of the disinfectants. I presume the taste would be the final deciding factor, but I have been wondering what would be the effect of too much of the disinfectants. An experience with too much copper sulphate for a like purpose came under my observation. This is a matter of importance.

H. C. HAMILTON: In my experience, I have found that it was more difficult to disinfect tap water than distilled water. The presence of chemicals cuts down the effect of the disinfectant.

Referring to the remarks of the last speaker, copper sulphate is effective for treating water containing vegetable growths, but not so efficient for killing bacteria.

BERNARD FANTUS: In the sterilization of tap water I found much greater variations than in the disinfection of infected distilled water. Some days it was more difficult to sterilize tap water than distilled water, on other days the reverse was true. This was due to the variations in the Chicago water supply.

F. E. STEWART: It is highly essential to ascertain how many bacteria are present in water, and whether a bacterial count was made to determine the number of the bacteria present in the drinking water.

BERNARD FANTUS: In the water disinfected in my experiments there were 30,000 to 90,000 bacteria per mil.

THE EVOLUTION OF CHEMICAL SYMBOLS.

BY INGO W. D. HACKH.

Evolution is progress, progress is the transition from the incomplete to the complete, an increase in value, either spiritual or material. The evolution of scientific knowledge illustrates best "how human knowledge grows" and progresses. To a student of any science its historical development will be of great benefit in understanding the ideas and conceptions involved. The development of chemical symbols, for example, offers a miniature history of chemistry and is an interesting topic in more than one respect.

In the dark epoch of the middle ages as the alchemists attempted to gain wealth and eternal life by the search for the philosopher's stone, man's position to the material world was entirely different. At that time man was still laboring