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INVESTIGATIONS ON A LABORATORY-SCALE OZONE WATER PURIFIER

Special Report No. 96

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I. Abstract

Tests of an exploratory nature have been performed on the effectiveness against highly contaminated waters, of a laboratory scale ozone generator and water purification unit furnished by the Hydrozone Corporation of America.

This unit is capable of treating about two gallons of water per minute. The unit generated about 0.1 to 0.2 per cent ozone by volume in the air passing through it. Water saturated with this ozonated air contained an average of about 2 ppm ozone when first sampled. This residual ozone disappeared very rapidly from the water after it left the unit.

Sharp reductions in E. coli count were brought about by ozone treatment utilizing this unit, but complete sterility was not achieved when heavy suspensions were treated, even upon repeated or continued treatments of the same suspension. B. globigii spore suspensions were also reduced greatly in numbers, by continuous exposure to ozonated air as generated by this unit. The chlorine demand of heavy bacterial suspensions was reduced by ozone treatment.

II. Introduction

A. Object: The object of this work was to perform tests of an exploratory nature concerning the use of ozone as a decontaminating agent for highly contaminated waters.

B. Authority: This study was carried out under Project 4-11-05-04, Development of Materials and Methods for Decontamination in BW, activated 12 July 1946.

C. Acknowledgement: The laboratory scale ozone generator and purification unit used in the tests was furnished by the Hydrozone Corporation of America, 1 Montgomery Street, Jersey City, New Jersey. Technical assistance on many of the chemical and bacteriological tests was furnished by Dorothy M. Portner and Bernard F. Surkiewicz.

III. Experimental Methods and Presentation of Data

A. Description of Unit: These experiments utilized a laboratory scale ozone generator and water purification unit which was furnished by the Hydrozone Corporation of America. This unit is shown diagramatically in Figure I.

This laboratory unit is capable of treating 1 to 2 gallons of water per minute. According to directions, the water should enter the machine through a 1/2 inch pipe or a garden hose at a pressure of between 20 and 30 p.s.i. Actually, pressures of at least 24 p.s.i. were required for operation, and the unit seemed to operate best at pressures ranging from 30 to 50 p.s.i.

The water, upon entering the machine, passes through two Venturi type jets or aspirators where air containing ozone is pulled into the water stream. From there it passes through a mixing tank, a mechanical filter, and holding tank until it is discharged from the unit. Since these two tanks and the filter have a combined volume of 5 to 5 1/2 gallons, the water remains in enclosed tanks with the ozonized air for 2 to 3 minutes before it leaves the unit.

The ozone is generated by a high voltage (approximately 7,500 volts) discharge between aluminum electrodes separated by an air gap and by pyrex glass tubes. Air passes through a glass wool filter, a dehydrator, and then through four of these discharge tubes before it is drawn into the water stream passing through the aspirators.

The exact volume of ozonated air picked up by the water as it passes through the unit was unknown at the beginning of these tests since the aspirators had not been calibrated before they were installed in the machine. However, at the end of the experiments the machine was partially dismantled and the air flow through the aspirators was measured at 2.67 and 5.13 liters per minute when water passed the aspirators at 27 and at 43 p.s.i., respectively.

FIGURE I

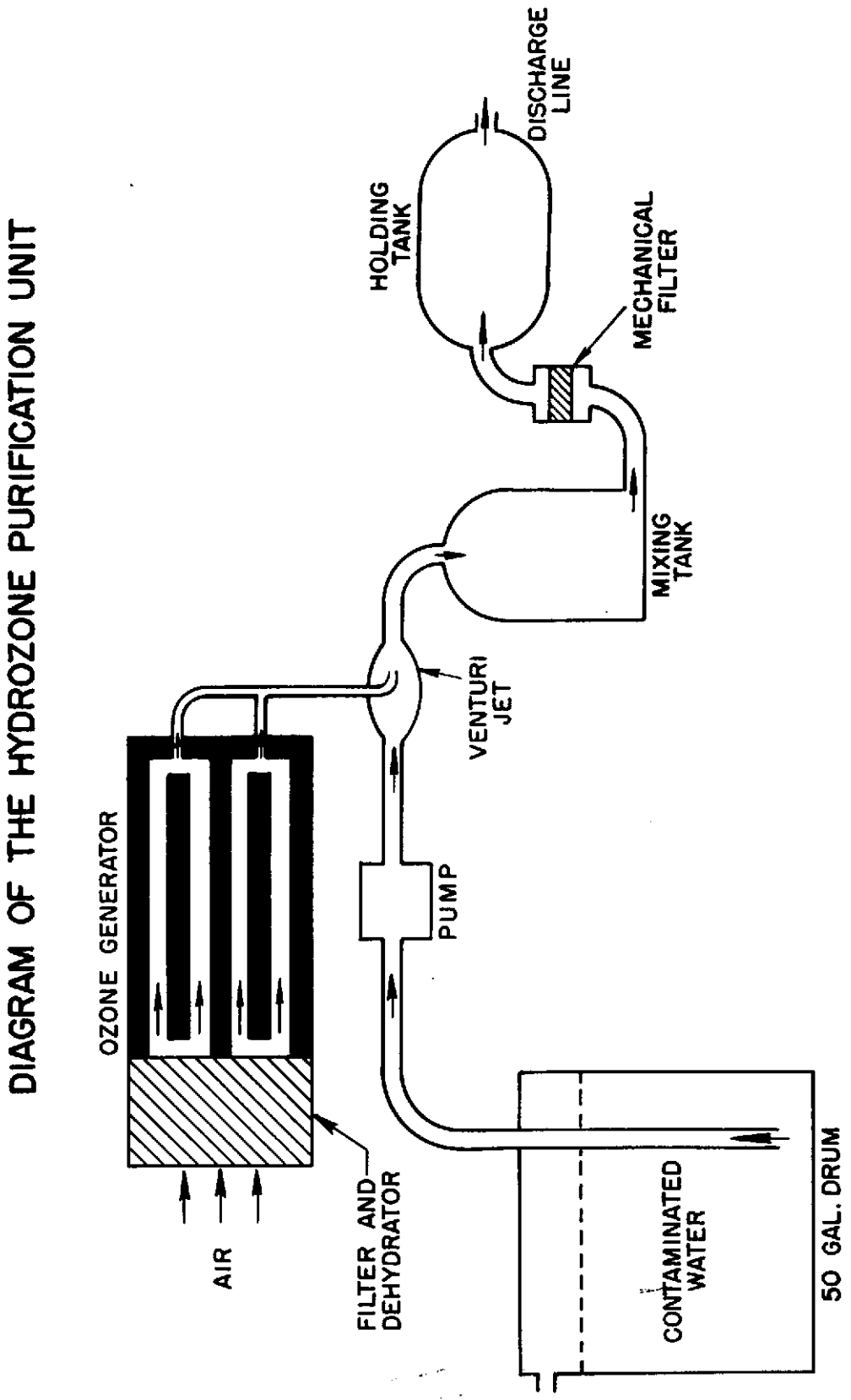

DIAGRAM OF THE HYDROZONE PURIFICATION UNIT

B. Amount of Ozone Generated in Air: Chemical tests were made on the amount of ozone generated in the air as it passed through these tubes by drawing air through the four discharge tubes and then through a Vigreaux type gas analysis bubbler at a rate of 0.8 liters per minute for exactly one minute. The bubbler was filled with 25 ml of a solution of KI and acetic acid. Ozone contacting this mixture quantitatively releases I_2, which can be determined volumetrically. Substantially all the ozone was removed by passage through a single bubbler since no significant amount was recovered from a second bubbler when two were placed in series. The data obtained are tabulated below:

Table I

OZONE CONCENTRATION IN AIR

(Ozonated air drawn thru 25 ml acidified KI solution in adsorption bubblers at 0.8 L/M for one minute)

Date of Test	Ml Standard Thio Required	Miligrams O_3 per liter of Air	Ozone in Air % by Volume
29 April	67.72	1.85	0.09
30 April	111.15	3.04	0.15
30 April	133.19	3.66	0.18
4 May	85.23	2.34	0.11
	Average	2.72	0.13

The amount of ozone present in the air varied considerably from test to test. While the air flow through the generator remained constant in all these tests, other factors were uncontrolled such as the length of time that the machine had been running and the temperature and humidity of the room air. These apparently caused significant differences in the amount of ozone generated.

C. Saturation Concentration of Ozone in Water: An attempt was made to determine the maximum amount of ozone which would be found in water saturated

with the ozonated air produced by this unit. This was done by modifying slightly the tests described in the preceding paragraph. Air was drawn through the discharge tubes and then through a bubbler at a rate of 0.8 liters a minute, exactly as in the previous tests, except that the bubbler contained only distilled water. After 10 minutes of constant bubbling to saturate the water, the flow of air was stopped. Acetic acid and crystals of KI were added immediately to the 25 ml of water in the bubbler. The iodine liberated by the dissolved ozone was then titrated with standard sodium thiosulfate solution. The results obtained are shown below:

Table II

SATURATION CONCENTRATION OF OZONE IN DISTILLED WATER

(Ozonated air drawn thru 25 ml distilled water in adsorption bubblers at 0.8 L/min for 10 minutes)

Date of Test	Ml Standard Thio Required	Concentration of Ozone in Water (p.p.m.)
29 April	5.33	4.0
30 April	0.79	0.7
30 April	1.40	1.2
Average	2.51	2.0

Again the amounts picked up were not constant, which was not surprising since the ozone in the air was not constant as shown above. The average amount picked up (2.0 p.p.m.) compares favorably with that which might be expected to be inequilibrium with air containing from 0.1 to 0.2 per cent ozone.*

For comparative purposes the exact amounts of 0.00092N sodium thiosulfate required to titrate the ozone picked up by 25 ml of KI solution in one case (Table I), and by 25 ml of distilled water in the other case (Table II)

*See Discussion, page 23.

are included in the data. Roughly 50 times as much thiosulfate was required in the tests where all the ozone was removed from the air by bubbling through KI solution as was required in the second tests in which distilled water was allowed to pick up as much ozone as it could by bubbling ozonated air through it.

Since 10 times the volume of air passed through the distilled water as did through the KI solution, these relative figures indicate that only about one part in 500 of the ozone bubbling through the distilled water remained dissolved in it.

D. Ozone Concentration and Residual Chlorine in Practical Trials: In certain of the biological trials described later in this report, ortho-tolidine color tests, and direct iodometric titrations were run for the determination of residual chlorine and dissolved ozone in the solution being treated.

The iodometric titration gives an accurate representation of the amount of residual chlorine in tap water, and of the amount of ozone dissolved in distilled, chlorine-free water as it is run through the machine. When tap water containing residual chlorine is run through the machine, however, the figures can be interpreted only as combined ozone and chlorine, and have to be expressed as equivalent amounts of chlorine.

The ortho-tolidine test, on the other hand, is a colorimetric test which has never been worked out carefully for ozone. It is by no means certain that the color standards developed for chlorine determinations gave accurate results with ozone. With this test, all that could be done was to follow the changes in 'Residual Chlorine' values as tap water passed through the machine. As the data in Table III show, the ortho-tolidine test was not satisfactory when the E. coli suspensions were examined, either before or after they had passed through the ozone generator, since they indicated almost no residual

[redacted]

Table III

CHEMICAL TESTS CONDUCTED DURING PRACTICAL TRIALS

WITH OZONE PURIFICATION UNIT

Trial No. 2

50 gallons of E. coli suspension run thru unit

All sampling done with 25 ml pipette

Treatment	Residual Cl_2 (or O_3 expressed as Cl_2) O.T. Color Test (ppm)	KI Titration (ppm)
Tap Water Control		
No Treatment	0.8	0.5
E. coli Suspension in Tap Water		
No Treatment - Control from Drum		
Before Test	-	0.4
At End of Test	0.15	0.25
Samples taken at indicated intervals as suspension was run through ozonizer		
First thru	<0.1	0
2 minutes	<0.1	<0.15
4 minutes	<0.1	0.2
6 minutes	<0.1	0.2
8 minutes	<0.1	0.2
Samples taken of suspension run through after ozone had been cut off for		
12 minutes	<0.1	0.25

[redacted]

chlorine in these suspensions, whereas small, but significant amounts were found with the iodometric titrations. In the later trials only the iodometric titrations were performed.

In the first of the practical trials, in which chemical determinations were run on the treated water as it left the unit, it was found that the amount of 'Residual Chlorine' in the water was decreased rather than increased as it passed through the machine. In other words, the amount of ozone picked up was not equivalent to the amount of chlorine that appeared to be lost during passage through the unit.

The residual chlorine present in the water as it left the tap dropped somewhat from 0.5 to 0.4 ppm as would be expected when it was placed in a 50 gallon stainless steel drum and a concentrated suspension of E. coli was added and mixed by bubbling air through the drum for a few minutes. After the suspension stood for the length of time needed to run the test, the residual chlorine dropped still more, to 0.25 ppm. This was determined upon the residue in the drum, and upon the effluent from the unit after the electrical discharge had been cut off so that only air, and no ozone was picked up by the water as it passed through the unit. The highest value for combined residual chlorine and ozone in the water as it left the unit during the operating trial, however, was 0.2 ppm. It was not apparent whether this represented chlorine or ozone, but it was evident that some residual chlorine was lost as the suspension passed through the unit, either by interaction with ozone, or possibly by loss to the air which was mixed with the water going through the unit.

A second trial was then run, in which the drum was cleaned and filled with distilled water, to which no suspension of organisms was added, and which of course contained no chlorine to interfere with the ozone determinations. As the data in Table IV show, not only were the initial ortho-tolidine and

Table IV

CHEMICAL TESTS CONDUCTED DURING PRACTICAL TRIALS

WITH OZONE PURIFICATION UNIT

Distilled Water Trial

50 gallons distilled water, no bacteria present, run through unit.

Treatment	Residual Cl_2 (or O_3 expressed as Cl_2) O.T. Color Test (ppm)	KI Titration (ppm)
Distilled Water Control No Treatment	0	0
Sampled at varying intervals upon leaving unit, by collecting in flasks, pipetting within one to two minutes to test flasks		
All Samples	0	0
Collected directly into graduate cylinder containing KI crystals and about 1/2 ml acetic acid	-	0.85 (Equivalent, 0.6 ppm O_3)

iodine tests negative as they should be with distilled water, but the samples taken from the machine at various intervals were also negative. Sampling was done by collecting water in an Ehrlenmeyer flask just as it emerged from the machine, and, within two minutes, pipetting out samples for the two tests. Towards the end of the run, crystals of KI and about 1/2 ml of acetic acid were placed in the bottom of the graduated cylinder and the 25 ml sample was collected directly into this as it left the unit. Sampled in this way, 0.6 ppm O_3 (equivalent to 0.85 ppm Cl_2) was found in the distilled water. Apparently the ozone had not yet dissolved in the water, or else the act of collecting the water in one flask, sucking it up into a pipette, and then allowing it to run out into another flask, caused it to be lost to the air. The water, as it left the unit, certainly had no lasting residual oxidizing property.

A third trial (Table V) was then conducted much as was the first, with an E. coli suspension in tap water passing through the unit. The main difference was that sampling was done immediately as the water left the unit, and it was allowed to run directly into a graduated cylinder containing KI crystals as had been done in the second trial with distilled water. In this case, an increase in the so-called residual chlorine was noted which could only represent ozone or ozone together with chlorine appearing in the water. The amounts were not great, less than were found in distilled water under similar conditions, but there was of course considerable organic matter present in the suspension being treated.

E. Effect of Ozone on Oxidizable Matter in Water: Concentrated suspensions (17.5 million organisms per ml) of E. coli in the broth in which they had been grown were treated directly with ozone by placing 25 ml of this suspension in the air bubbler and passing the ozonated air through this in the same manner as was done in the tests to determine ozone concentration (Sections

Table V

CHEMICAL TESTS CONDUCTED DURING PRACTICAL TRIALS

WITH OZONE PURIFICATION UNIT

Trial No. 3

50 gallons of E. coli suspension run through unit.

All sampling done by collecting in graduate cylinder containing KI and acetic acid.

Treatment	Residual Cl_2 (or O_3 expressed as Cl_2) KI Titration (ppm)
Tap Water from Drum	0.2
Tap Water Run thru Unit	
First thru	0
Several minutes later	0.35
E. coli suspension in Tap Water	
No Treatment - Control from Drum	
Before Test	0.15
End of Test	0.2
Samples taken at indicated intervals as suspension was run thru ozonizer	
First thru	0
6 minutes	0.4
11 minutes	0.25
16 minutes	0.45
21 minutes	0.45
30 minutes	0.45

III B and C). As in those tests, air containing approximately 0.1 per cent ozone was passed through this heavy suspension at the rate of 0.8 liters per minute for periods of 10 and 20 minutes. In the cases noted, a drop of olive oil was placed on top of the suspensions because they frothed badly as the air was drawn through. Chemical tests were performed following ozonation to determine what effect this had on the oxidizable matter present in the suspension. The chemical test chosen was chlorine demand, rather than biological oxygen demand, since the former test could be performed much more rapidly and would give immediate answers. Chlorine demand can be defined as the amount of chlorine (expressed in ppm) which must be added to a suspension to give a residual value of 0.1 ppm active chlorine on ortho-tolidine test after 15 minutes standing. The chlorine demand tests were actually performed on 1:50 dilutions of the suspensions, because of the high concentration and limited volume of the original suspensions. The values were then multiplied by 50 to give values for the actual suspension which had been treated with ozone. The drop in chlorine demand in the samples is recorded in Table VI.

F. Biological Tests; Practical Trials - Straight Runs: For most of the biological tests, 50 gallons of bacterial suspensions were prepared in a stainless steel drum. An outlet pipe running to the bottom of the drum, was connected to the ozone purification unit by means of a short section of garden hose. By admitting compressed air into the closed drum the suspension could be forced through the outlet pipe and then through the purification unit. The pressure at which this suspension was delivered to the unit was controlled by regulating the amount of compressed air admitted to the drum, and also by changing the height of the drum.

In the later tests, a pump was inserted between the drum and the purification unit, permitting the suspension to be passed through the unit

[redacted]

Table VI

CHANGES IN CHLORINE DEMAND OF HEAVY E. COLI

SUSPENSION FOLLOWING OZONATION

(25 ml of suspension in bubbler treated with ozonated air at rate of 0.8 L/min. for indicated times)

Treatment	Chlorine Demand (ppm)
None - Original Suspension	33.0
Sample A - Ozonized 10 minutes (olive oil present)	16.5
Sample B - Ozonized 20 minutes (olive oil present)	13.5
Sample C - Ozonized 10 minutes (no olive oil)	13.5

[redacted]

at pressures ranging up to 58 p.s.i. Bacterial counts were usually made on the suspension inside the drum both before and after the trial runs, and upon the effluent from the purification unit at various time intervals as the suspension ran through at approximately 2 gallons a minute. In several of the tests, the electrical discharge across the discharge tubes was cut off towards the end of the run, so that only air, and no ozone was mixed with the water. Counts made after all ozone could safely be assumed to have been flushed from the system, showed what drop in count could be attributed to mechanical effects alone, such as retention of bacteria on the filter inside the unit. All trials were conducted on quite concentrated suspensions. The data obtained are presented in tables VII, VIII and IX.

G. Biological Tests; Practical Trials - Recirculating Runs: Following the practical trials in which a drum full of bacterial suspension was passed through the ozone purification unit, and sampled at various intervals, an additional two trials were run in which the same suspension was passed through the unit several times, and sampled after each passage. The data collected in these two tests (Practical Trials 3 and 4) appear in Tables X and XI. In Trial No. 3, a very heavy suspension of E. coli was utilized. In the other trial, another attempt was made to utilize a heavy suspension in that 400 ml inoculum of an E. coli culture was added to 25 gallons of tap water. However, when a sample of this suspension was removed from the drum for plate counts, so few organisms were found that no accurate count could be made of the original suspension. Whether the organisms died off in the drum before the run, due perhaps to an unusually high residual chlorine in the tap water, or whether the culture had never grown properly, is unknown. In any case, a large amount of organic matter was present in these trials, though the coli count was not high.

[redacted]

Table VII

PRACTICAL BIOLOGICAL TRIALS WITH

OZONE PURIFICATION UNIT

Trial No. 1

Straight Run - 50 Gallons

Suspension: E. coli in Tap Water

Operating Pressure: 23 - 24 p.s.i.

Date: 27 April 1948

Sample	Bacterial Count per Ml
Untreated Suspension	4,100,000
Samples Leaving Unit - Ozone Treated	
First water through	1,500,000
3 minutes operation	3,000,000
6 minutes operation	2,600,000
9 minutes operation	2,700,000
Samples Leaving Unit After O_3 Generator was Shut Off for	
5 minutes	4,100,000
Control from Drum - After Trial	5,500,000

[redacted]

[redacted]

Table VIII

PRACTICAL BIOLOGICAL TRIALS WITH

OZONE PURIFICATION UNIT

Trial No. 2

Straight Run - 50 Gallons

Suspension: E. coli in Tap Water

Operating Pressure: 26 - 30 p.s.i.

Date: 28 April 1948

Sample	Bacterial Count per Ml
Untreated Suspension	1,700,000
Samples Leaving Unit - Ozone Treated	
First sample through	11,200
2 minutes operation	27,300
4 minutes operation	24,100
6 minutes operation	24,800
8 minutes operation	25,000
Samples Leaving Unit After O_3 Generator was Shut Off for	
10 minutes	355,000
13 minutes	310,000
Control from Drum - After Trial	510,000
Control from Hose - After Trial	625,000

Note: Chemical Tests on these solutions reported in Table III.

[redacted]

Table IX

PRACTICAL BIOLOGICAL TRIALS WITH

OZONE PURIFICATION UNIT

Trial No. 3

Straight Run - 50 Gallons

Suspension: E. coli in Tap Water

Operating Pressure: 58 p.s.i.

Date: 5 May 1948

Sample	Bacterial Count per Ml
Untreated Suspension	175,000
Samples Leaving Unit - Ozone Treated	
First sample through	6,600
6 minutes operation	7,800
11 minutes operation	5,700
16 minutes operation	1,400
21 minutes operation	750
30 minutes operation	2,000
Control from Drum - After Trial	19,300

Note: Chemical Tests on these solutions reported in Table V.

[redacted]

Table X

PRACTICAL BIOLOGICAL TRIALS WITH

OZONE PURIFICATION UNIT

Trial No. 4

Recirculating Run - 10 Gallons

(Entire Suspension Run Through Unit, Collected and Pumped Back Through Ozonizer Six Successive Times)

Suspension: E. coli in Distilled Water

Operating Pressure: 43 p.s.i.

Date: 6 May 1948

Sample	Bacterial Count per Ml
Untreated Suspension	3,000,000
Sample Leaving Unit - Ozone Treated	
1st passage through Ozonizer	2,300,000
2nd passage through Ozonizer	1,400,000
3rd passage through Ozonizer	225,000
Subsequent passages	(Contaminated with B. globigii)

[redacted]

Table XI

PRACTICAL BIOLOGICAL TRIALS WITH

OZONE PURIFICATION UNIT

Trial No. 5

Recirculating Run - 25 Gallons

(Entire Suspension Run Through Unit, Collected and Pumped Back Through Ozonizer Five Successive Times)

Suspension: E. coli in Tap Water

Operating Pressure: 37 p.s.i. (average flow 1.35 gallons/minute)

Date: 7 May 1948

Sample	Bacterial Count
Untreated Suspension	-
Sample Leaving Unit - Ozone Treated	
1st passage through Ozonizer	1,100
2nd passage through Ozonizer	300
3rd passage through Ozonizer	119
4th passage through Ozonizer	105
5th passage through Ozonizer	99

H. Biological Trials in Vigreaux Bubbler: Two trials were also performed, and reported in Table XII, in which small volumes of heavy bacterial suspensions were subjected to a continuous flow of ozonized air, by placing 25 ml of these suspensions in the same gas analysis bubblers described in the chemical tests, and drawing 0.8 liters of ozonized air through them each minute. At periodic intervals up to a half hour, the bubbling was stopped long enough to allow the removal of one ml of the suspension for plate counts. Both E. coli and B. globigii suspensions were so treated to give some idea of the comparative death rates of vegetative cells and spores. When the logarithm of the number of surviving organisms is plotted against time, as is done to establish the so-called death rate constants, it is evident that E. coli is being killed at a considerably faster rate than is the spore forming B. globigii. However, neither of the two organisms follow the usual logarithmic order of death in these trials, since the rate of killing is much faster initially than after several minutes have elapsed.

Table XII

BIOLOGICAL TRIALS IN VIGREAUX BUBBLER

(Ozonated Air Drawn through 25 ml of Bacterial Suspensions in Absorption Bubblers at 0.8 liters/minute for indicated times)

Exposure Time	Bacterial Count per Ml	
	E. coli Suspension	B. globigii Suspension
0 Min. (Original Suspension)	2,990,000	170,000
2 Min. Ozone passage	12,500	9,000
5 Min. Ozone passage	6,300	3,300
10 Min. Ozone passage	7,700	21*
30 Min. Ozone passage	27	4*

*Some E. coli contamination from previous run appearing.

IV. Discussion

The air leaving the discharge tubes of this laboratory unit contained between 0.09 and 0.18 per cent ozone by volume. This amount is lower than that reported in the literature for large commercial installations, which is given as about 1.0 per cent for the unit being built for Philadelphia[1] and between 0.5 and 1.0 per cent for the installation at Whiting, Indiana[2]. Storey[2] claims in the latter installation that "Higher concentrations are possible, but not economical". The voltages used in these large units, 13,350 to 16,500 volts at Whiting, are higher than the 7,500 volts discharge in the laboratory unit used in these experiments.

The amount of ozone imparted to the water is, of course, directly related to the concentration of ozone in the air with which the water is in contact.

The purification unit used in these tests produced between 1.9 and 3.7 mg. of ozone per liter of air passing through the discharge tubes. Water completely saturated with this ozonated air was found to contain between 0.7 and 4.0 ppm of ozone. Both figures were variable so that it is difficult to compare them, but they are in rather good agreement with the partition coefficient for ozone between water and air, as expressed in the literature.

On 30 April when two tests each, in a short period of time, were run on concentration in air and concentration in water, the partition coefficient averaged 0.274 at room temperature. This partition coefficient or ratio between the amount of ozone dissolved in water to the amount of ozone contained in the air, after equilibrium has been reached, is given as 0.381 at 19°C and as 0.270 at 27°C.[3] (The concentration units, ppm in water and milligrams per liter in air, are the same as those used in this report.) The 4.0 ppm of ozone found in water on the one test conducted on 29 April would seem to be unusually high for this unit.

These data on concentrations of ozone in water represent the maximum which can be expected in water which has been in contact with ozonated air of the strength generated by this unit.

Ozonated air of the strength reported for large installations could result in higher concentrations of ozone in water, but even here no more than 7 or 8 ppm in water would be expected. Hann[1] in his article mentions no higher concentration of ozone in water than 6.1 ppm.

The data obtained in this report, and the literature as well, indicate that ozone is lost from water very rapidly once the treated water leaves the holding tank in the purification unit. Hann[1] in discussing chemical tests for ozone in water states "Since an ozone residual dissipates very quickly, the sample must be tested as soon as withdrawn". In section III D. of this report, the difficulties in testing for residual ozone and the rapid drop in this value as water leaves the unit are discussed.

This failure of ozone-treated water to maintain a residual oxidizing capacity appears to be the reason why the American literature stresses the value of ozone treatment for removal of objectionable taste, odor, and color from water rather than its value in disinfection.

Quite significant reductions in E. coli count were obtained in the practical trials, considering the relatively small amount of ozone which can be imparted to water, and the fact that this acts for only the time that the treated water remains in the mixing and holding tanks, or approximately two minutes. The highly contaminated samples were not sterilized in the practical runs, but 30 to 40 per cent reduction was obtained in the first trial with an original contamination of 4 million organisms per ml, and 98 to 99 per cent reduction was obtained in the next two runs where the original contamination was lower, and the operating pressure and, hence, amount of ozonated air picked up was greater.

The initial rate of reduction appears to be greater than later rates of reduction, however, as indicated in the data obtained in the recirculating runs (Section III G.) and in the continuous bubbling trials (Section III F.) using B. globigii as well as E. coli as well as the test organisms.

These latter trials show that spore-forming organisms can be killed as well as the less resistant E. coli cells, but at a slower rate. Data were also accumulated (Section III E.), which showed that the oxidizable matter in very heavy suspensions was reduced about one-half, but not entirely removed, as measured by chlorine demand of the treated and untreated samples.

[redacted]

V. Conclusions

The Hydrozone laboratory unit as tested, failed to sterilize heavy E. coli suspensions when passed through the unit according to directions, or when the same suspension was repeatedly passed through the unit, or continuously exposed to the ozonated air generated by the unit. A great reduction in count was brought about by these treatments, however, and a B. globigii spore suspension was also sharply reduced in count upon continuous ozonation. Oxidizable matter in the water was also reduced but not eliminated by ozone treatment.

The treated air coming from this laboratory scale unit contained only about 10 to 20 per cent as much ozone as has been reported for large scale commercial installations. This naturally resulted in a lower concentration of ozone in water than could be obtained in larger units. However, even in larger units, the concentration of ozone which can be obtained in the treated water is limited, since the saturation concentration of ozone in water is directly related to its concentration in the air in contact with that water.

The chemical tests performed on the water treated in this laboratory scale unit, emphasized the findings reported in the literature, that ozone dissipates rapidly from treated water and that no residual oxidizing effect is found shortly after it has been discharged into the open.

VI. Recommendations

None.

[redacted]

[redacted]

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