

SANITARY ASPECTS OF THE SWIMMING POOL OF NORTH TEXAS  
STATE TEACHERS COLLEGE, DENTON, TEXAS

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TABLE OF CONTENTS

	Page
LIST OF TABLES . . . . .	iv
Chapter	
I. INTRODUCTION . . . . .	1
Historical Survey of Swimming Pools	
History and Operation of Local Pool	
Review of Literature	
The Problem	
II. BACTERIOLOGICAL ANALYSIS OF SWIMMING POOL	
WATER . . . . .	10
Quantitative Examination of Water	
Qualitative (Presumptive Test)	
Examination of Water	
Qualitative (Confirmed Test)	
Examination of Water	
Qualitative (Completed Test)	
Examination of Water	
Experimental Data	
III. SANITARY ASPECTS OF THE SWIMMING POOL OF	
NORTH TEXAS STATE TEACHERS COLLEGE. . . . .	20
Swimming Pool Standards	
Discussion	
Recommendations	
BIBLIOGRAPHY. . . . .	35

LIST OF TABLES

Table	Page
1. Number of Bacterial Colonies per Cubic Centimeter of Sample Found in the Quantitative (Total Plate Count) Examination of Swimming Pool Water. . . . .	24
2. Reactions Obtained in the Qualitative (Presumptive Test) Examination of Swimming Pool Water Showing the Absence of Presence of Lactose-Fermenting Organisms of the Colon-Aerogenes Group of Bacteria . . . . .	26
3. Reactions Obtained in the Qualitative (Confirmed Test) Examination of Swimming Pool Water Showing the Confirmation of the Presumptive Test for Lactose-Fermenting Organisms of the Colon-Aerogenes Group of Bacteria . . . . .	30
4. The Number of Gram Positive and Gram Negative Cocci and Rods Found in Each Area of the Swimming Pool . . . . .	31
5. Civilian Participation in the Swimming Pool Each Day of Each Week, May 3-30, 1943 . . . . .	32

## CHAPTER I

### INTRODUCTION

#### Historical Survey of Swimming Pools

A swimming pool is a body of water that is utilized for bathing and recreational purposes and is contained in a basin, tank, or natural depression in which the flow of water is controlled by artificial means. The term swimming pool does not, therefore, include bathing beaches, ponds or streams. <sup>1</sup>

The first educational institution in the United States to provide a swimming pool for the student body was Girard College. This institution was founded by Stephen Girard in the city of Philadelphia, Pennsylvania, in 1848. Five swimming pools were located at this college. An indoor pool was found in each of the four dormitories and there was one outdoor pool. The student body used these pools daily for a long period of time before the swimming pools were proved to be a health menace by the germ theory of disease.

Gallaudet College in Washington, D. C., constructed the second swimming pool for an educational

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<sup>1</sup> George C. Dunham, Military Preventive Medicine, p.375.

institution in 1881. Before 1900 Harvard, Princeton, Yale, and the University of Pennsylvania had erected pools in their institutions.

#### History and Operation of Local Pool

On August 21, 1923, North Texas State Teachers College purchased a half-block plot of land directly back of the old college ball park and converted this area into a recreation park and picnic ground for students and faculty members. The plot was enclosed with the athletic ground by an ornamental wire fence, and was later beautified with vines and shrubs.<sup>2</sup> By an order of the City Commission of Denton, Avenue B and Prairie Streets which separated these lots were closed.<sup>3</sup> The land was made suitable for use by filling ditches and leveling the entire surface.

The North Texas State Teachers College outdoor swimming pool was constructed in 1926 at a cost of \$26,000. It was located in that area of the recreation park which was formerly West Prairie Street but had been closed by the Denton City Commission.<sup>4</sup> The college pool is one hundred feet long and fifty feet wide, and in depth varies

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<sup>2</sup> Campus Chat, Vol. XXII, October 2, 1937.

<sup>3</sup> Minute Book, City of Denton, VII (1924), 160.

<sup>4</sup> Ibid.

from three and one-half to nine and one-half feet. A scum gutter is found on all sides of the pool. Each side of the pool is equipped with ladders except on the east end. At this end of the pool are located two three-meter diving boards and one nine-meter diving board.

Operating cost of the swimming pool is reasonably low since the City of Denton agreed in writing to furnish for the use of North Texas State Teachers College at Denton, in the County of Denton, State of Texas, an abundant supply of artesian water free of cost to the State of Texas. This transaction took place on October 10, 1889.<sup>5</sup> Each spring the pool receives its annual new coat of paint and minor repairs. The caretakers are composed of one foreman, a regularly paid yardman, and his crew of workers made up of college and high school boys, who receive college time wages.

One Senior Red Cross life guard is on duty at all times and at any hour when the total bathing load is too heavy another guard is employed. Not a single fatality has occurred in the pool and no major injuries have been reported in the operation of the pool. A small admission fee is charged to aid in covering the operating expenses.

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<sup>5</sup>Minute Book, City of Denton, 1 B, p. 377.

This college swimming pool opens in early May and closes in the latter part of August. Its daily schedule for the 1943 swimming season was from 9:00 A.M. until 7:30 P.M. A typical day for this season was as follows: pool opened at 9:00 A.M. for college swimming classes and remained open for civilian use until 11:30 A.M. At this time an Army unit took over the pool until noon. No swimming is allowed for two hours following the noon hour. Swimmers may enter the pool at 2:00 P.M. for a two hour and fifteen minute period. Again an Army unit entered the pool for a one hour period thus closing it for civilian use. After 5:15 P.M. the swimming pool was opened for the use of the public until 7:30 P.M. which was closing time. This schedule was followed each week day. On Saturday night the pool remained open until 10:00 P.M. and was open for a four hour period on Sunday afternoon from 2:00 until 6:00 P.M.

Any swimmer entering the North Texas State Teachers College swimming pool must have on file at the pool a physical examination certificate from a physician stating that the individual is free from contagious diseases and has no organic ailments such as faulty heart or diseased lungs. The certificate is good only for the year in which it was issued.



On entering the pool the swimmer takes a cold shower. No soap or hot water is required. A foot disinfectant is not used. No restrictions are made in regard to the types of swimming caps or suits used.

Each Friday night this outdoor swimming pool is drained completely. The cleaning crew scrubs the sides and bottom of the pool thoroughly with coarse brushes and this is followed by washing the surfaces with water. After the pool has drained completely of these washings a thin layer of copper sulphate is spread over the bottom of the pool before any water is admitted. The two pounds of copper sulphate used in this manner is sufficient to prevent the growth of algae markedly. It takes approximately twelve hours for the 280,000 gallon capacity of the pool to be reached. On the following Monday three pounds of calcium hypochlorite is added to the water, and on Wednesday three more pounds are added. No other disinfectant is added for the remainder of the week unless the residual chlorine content falls below 0.4 to 0.5 parts per million. Fresh water is added to the pool daily to keep up the desired level and to wash out the scum gutter.

In early usage the water was drained from the pool once a week. It was then left empty for twenty-four

hours and refilled the following day with fresh artesian water. There was no disinfectant used in the water and no infection was reported.<sup>7</sup>

A broad concrete walk leads from the south entrance of the Harriss Gymnasium, which serves as the dressing room for girls, to the swimming pool. The dressing room for boys is located below the bleachers at the east end of the pool. A walk from this dressing room to the outdoor showers connects with the other walk from the gymnasium. Immediately surrounding the pool one finds another concrete walk which connects to the ones mentioned above. These walks are washed daily with water to free them of foreign bodies which might cause injury and to remove dirt in order to lower the bacterial count of the pool water.

#### Review of Literature

Frostic (1934) said that crystal clear water is highly desirable in every pool, but clearness is not a guarantee in itself that the water is pure. The only safe way to determine the purity of water is by means of laboratory tests made depending upon the pool load and its distribution. A series of tests prove that human bodies, despite

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<sup>7</sup> Statement by Beulah A. Harriss, personal interview.

a thorough cleansing in the shower before entering the pool, continue to shed millions of bacteria after entering. The effectiveness of a sterilizer in controlling this rise in bacterial count can be determined only by tests.<sup>8</sup>

Mallmann (1928) observed a swimming pool during periods of marked pollution and made examinations for incidence of Bacillus coli and streptococci. Streptococcus incidence was variable, due to its growth in water. Streptococci indicated unsafe water. Bacillus coli does not necessarily indicate pollution, although its absence is an excellent index of safety.<sup>9</sup>

Winslow and Moxon (1928) made a survey of New Haven harbor in which the following general conclusions are presented. The total colony count at twenty degrees centigrade is not closely related to the colon count. The Bacillus coli varies at given points from day to day due to the effect of wind and tide on movement of sewage in the harbor. From data presented, the California standard of ten colon bacilli per cc. is far beyond the safety of

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<sup>8</sup> Fred W. Frostic, "Swimming Pools Require Rigid Sanitary Treatment," Nation's Schools, XIII (February, 1934), 60.

<sup>9</sup> W.L. Mallman, "Streptococcus as an Indicator of Swimming Pool Pollution," American Journal of Public Health, XVIII (June, 1928), 776.

the beaches studied. The standard four colon per 100 cc. suggested for indoor pools is too severe for natural sea water. A suggested standard of one colon bacillus per cc. with a maximum of ten per cc. is offered.<sup>10</sup>

France and Fuller (1940) made a quantitative comparison of the number of streptococci and of coliform organisms in a swimming pool of the recirculating type. Liquid chlorine was used as a germicidal agent and showed that the streptococci give a more accurate index of the use of the pool.<sup>11</sup>

The findings of Pasteur regarding the germ theory of disease in about 1860 proved to be a vital factor in the development of the modern swimming pool. Bacteriological studies of swimming pools were not made until nearly a quarter of a century after the theory of disease was formulated. Swimming pools and their administration were revolutionized after application of the germ theory of disease.

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C. Winslow and David Moxon, "Bacterial Pollution of Bathing Beach Waters in New Haven," American Journal of Hygiene, VIII (March, 1928), 229-310.

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Ralph L. France and James E. Fuller, "Coliform Bacteria and Streptococci in Swimming Pool Water," American Journal of Public Health, XXX (September, 1940), 1059-1062.

### The Problem

According to the literature there seems to be a scarcity of scientific studies upon artificial outdoor swimming pool water. The amount of actual bacteriological work accomplished is even smaller. This investigation was conducted in order to show that insanitary conditions may exist in the swimming pool at North Texas State Teachers College provided the proper precautions are not taken; and, in contrast that this pool can be sanitary and entirely safe when operated and used according to the necessary sanitary specifications. The problem has consisted mainly of the determination as to whether and when lactose-fermenting organisms of fecal origin and cocci bacteria of the possibly infectious types are actually present in the water of this pool; and, to interpret the information gained in such way as to make profitable recommendations for the further operation of and participation in the pool.

## CHAPTER II

### BACTERIOLOGICAL ANALYSIS OF SWIMMING POOL WATER

In order to gain an adequate idea of the sanitary conditions of the swimming pool on the North Texas State Teachers College campus, it was found necessary to make an investigation from a bacteriological standpoint. A bacterial analysis was made on the water three times weekly, no definite days being set aside to collect water samples. These examinations began at the opening of the 1943 swimming season, which was on the third day of May, and were continued through the first six weeks of the summer session, July 10.

The outdoor swimming pool is laid out in three distinct areas; therefore, a sample of water was necessarily taken from each. The pool divisions are referred to in this paper as deep, middle, and shallow. Depth of the water in the deep division is nine and one-half feet, the middle has an average depth of six feet, and the shallow is three and one-half feet in depth.

### Preparation of Sample Bottles

The six ounce screw-cap water sample bottle was thoroughly cleansed and allowed to dry completely. A parchment paper cap covered the neck and top of the bottle. The paper cap was tied securely in place with a piece of string. The bottle was then sterilized in the auto-clave at a pressure of fifteen pounds (120 degrees centigrade) for a period of thirty minutes. Due to the presence of the parchment paper cap, microorganisms were unable to contaminate the neck and cap of the bottle. Three sample bottles were prepared in this manner just prior to the collection of the water samples.

In sampling the water of the North Texas State Teachers College swimming pool, the cap of the sterile sample bottle was first carefully removed with the left hand. The bottle was then quickly plunged mouth downward to a depth of one foot below the surface of the water, then inverted. When filled the bottle was removed and stoppered. The bottle and the paper caps were then carefully replaced to avoid contamination of the contents. Care was taken to prevent the fingers touching the inside of the neck or cap. If this were not done contamination of the sample might occur and lead to erroneous results. When a current existed in the water, the mouth

of the sample bottle was directed against it to avoid the introduction of bacteria from the fingers. Each sample was analyzed immediately.

#### Quantitative Examination of Water

Method.--The quantitative microscopic bacterial count consists in placing a measured undiluted cubic centimeter of water sample in a Petri dish and mixing with sterile, melted agar. After the agar has solidified, the plates are inverted and incubated at a temperature of thirty-seven degrees centigrade for a twenty-four hour period. The colonies are counted and the result is expressed as the number of organisms per cubic centimeter of water.

Preparation of plates.--Three Petri dishes were prepared for each water sample. The plates used were sterilized in the hot air oven at 156-160 degrees centigrade for a period of one hour. One cubic centimeter pipettes necessary in the plating process were sterilized with the plates.

Bacto-tryptose agar.--This medium was used in the determination of the bacterial population or the total plate count of the swimming pool water. The formula is:

Bacto-tryptose.....	20.0 grams
Bacto-dextrose.....	1.0 grams



Sodium chloride..... 5.0 grams  
 Bacto-agar.....20.0 grams

In each of two one-liter sterile flasks was suspended twenty-three grams of the dehydrated medium in five hundred cubic centimeters of distilled water. The mixture was boiled until the medium was dissolved completely. The flasks were stoppered with sterile cotton stoppers and sterilized at fifteen pounds pressure (120 degrees centigrade) for twenty minutes. The final pH of the Bacto-tryptose agar was six and nine tenths. Later this sterile medium was poured into sterile Petri dishes and mixed thoroughly with the cubic centimeter of swimming pool water placed there for the total plate count.

Incubation of plates.--All plates were incubated at thirty-seven degrees centigrade for a period of twenty-four to forty-eight hours.

Counting of plates.--All plates were counted by the use of the Quebec Colony Counter which is manufactured by the Spencer Lens Company of Buffalo, New York. Three plates from each division of the swimming pool were counted by this method.

Qualitative (Presumptive Test) Examination of Water

Bacto-lactose peptone bile broth.--This medium in dehydrated form was used in making the presumptive test.

Its constituents are:

Bacto-peptone.....	10.0 grams
Bacto-lactose.....	10.0 grams
Bacto-oxgall.....	50.0 grams

In each of two one-liter sterile flasks was suspended thirty-five grams of the dehydrated culture medium into five hundred cubic centimeters of distilled water. Five cubic centimeters of this medium when dissolved was dispensed in ten cubic centimeter sterile test tubes containing inverted one cubic centimeter fermentation tubes. These were sterilized at fifteen pounds pressure (120 degrees centigrade) for twenty minutes. The final pH of the Bacto-lactose peptone bile broth was seven and three tenths.

Method.--The presumptive test consists in placing graduated amounts of sample water in a series of lactose-fermentation tubes each containing at least twice as much medium as sample. In this investigation four tubes containing five cubic centimeters of Bacto-lactose peptone bile broth were inoculated with one cubic centimeter of undiluted swimming pool water from each of the three divisions of the pool. These tubes were incubated at thirty-seven degrees centigrade for forty-eight hours.

The formation of ten per cent or more of gas in the inner tube in twenty-four hours at thirty-seven degrees

centigrade constitutes a positive presumptive test. This indicates presumptive evidence for the presence of members of the colon group. No gas formation after forty-eight hours of incubation constitutes a negative presumptive test and requires no further examination. This water may be considered satisfactory from the bacteriological standpoint.

#### Qualitative (Confirmed Test) Examination of Water

Bacto-endo agar.--This culture medium was used to confirm the presumptive test and also as a differential test for the genera in the colon-aerogenes group of bacteria.

Its formula is:

Bacto-peptone.....	10.0 grams
Bacto-lactose.....	10.0 grams
Dipotassium phosphate.....	3.5 grams
Bacto-agar.....	15.0 grams
Bacto-basic fuchsin (DF-5).....	0.5 grams
Sodium sulfite.....	2.5 grams

In each of two one-liter flasks was suspended twenty and seven tenths grams of the dehydrated medium in five hundred cubic centimeters of distilled water. The contents of the flasks were heated near boiling temperature in order to dissolve the medium completely. These were then sterilized in the autoclave at fifteen pounds pressure

(120 degrees centigrade) for fifteen minutes. After sterilization the medium was dispensed into sterile Petri dishes. The final pH of the Bacto-Endo agar was seven and five tenths.

Method.--The lactose-fermentation tubes of the previous test are utilized in the confirmed test. A loopful of the medium of a positive presumptive tube was streaked on a Bacto-Endo agar plate. After streaking the agar plates were incubated at thirty-seven degrees centigrade and examined at the end of twenty-four to forty-eight hours depending upon the reaction obtained.

The test is considered positive if typical colonies appear on the plates in the twenty-four to forty-eight hour period and negative if no typical colonies are found.

Typical colonies of the Escherichia group have the following characteristics: (1) well-isolated colonies two to three millimeters in diameter; (2) neighboring colonies with little tendency to run together; (3) colonies slightly raised, surface flat or slightly concave, rarely convex; (4) colonies dark, button-like, often concentrically ringed with coppery metallic sheen. Typical colonies of the Aerobacter group have the following characteristics:

(1) well-isolated colonies usually four to six millimeters or more in diameter; (2) neighboring colonies which run together quickly; (3) colonies considerably raised and markedly

convex, occasionally the center drops precipitately;  
 (4) coloration of colonies is light pink and they have a waterish appearance on the surfaces. Only the colonies of the Escherichia group are of sanitary significance in this investigation.

#### Qualitative (Completed Test) Examination of Water

The completed test reveals two significant facts:

(1) that the colonies appearing on a Bacto-Endo agar plate are capable of fermenting lactose with production of acid and gas, and (2) if the organisms transferred to an agar slant show the morphological characteristics of the members of the colon group. The agar slant culture from a typical colony on a Bacto-Endo agar plate, when studied microscopically from a Gram stain, showed the presence of Gram negative nonspore-forming rods. This was considered a positive test for the colon group of bacteria. The failure to show the presence of these rods together with the failure to ferment lactose, constituted a negative test.

Gram staining technique.-- The Gram staining technique used in the completed test requires the following solutions:

Gram I

Gentian or crystal violet..... 1 gram

Distilled water..... 100 cc.

## Gram II

Iodine..... 2 grams

Normal solution of NaOH.....10 cc.

After the iodine dissolves make volume to  
100 cc. with distilled water.

## Gram III

Safranine (two and five tenths per cent in  
ninety-five per cent alcohol)..... 10 cc.

Distilled water.....100 cc.

## Decolorizing agent

Alcohol (ninety-five per cent)..... 7 parts

Acetone..... 3 parts

Method.--Staining consists of: (1) preparing and fixing the film of organisms on a clean microscopic slide; (2) covering the film with Gram I solution and allowing the stain to act three minutes; (3) rinsing off the stain with distilled water, adding Gram II solution and letting this stain react before washing it off with distilled water; (4) destaining with acetone-alcohol mixture, adding it drop by drop until no color is seen in the drippings (generally less than ten seconds); (5) counter-staining for about thirty seconds with safranine, then wash off with distilled water and blot dry.

Organisms are divided into two classes by the reaction to the Gram staining technique. Gram positive

organisms are the ones that retain the purple stain of the gentian violet. Gram negative organisms refuse the purple stain and take up the pink color of the counterstain, safranine.

The above procedures of the presumptive, confirmed, and completed tests attempt to distinguish between fecal and non-fecal members of the colon-aerogenes group of bacteria. These tests are the same as those outlined by the American Public Health Association.

#### Experimental Data

The results for the quantitative, presumptive, confirmation and completed tests for each of the three areas of the North Texas State Teachers College swimming pool studied are given in Tables 1, 2, 3, and 4.

### CHAPTER III

#### SANITARY ASPECTS OF THE SWIMMING POOL OF NORTH TEXAS STATE TEACHERS COLLEGE

##### Swimming Pool Standards

It is generally agreed that swimming is one of the most popular and most beneficial sports; and, that unless precautions are taken this activity can become the source of many serious infections. It has been estimated that one swimmer may introduce as many as four thousand organisms into a pool; and, although the pool is initially filled with safe water, the presence of only a few swimmers can render it unsafe.

Infections are transmitted by one swimmer to another by way of various microorganisms which are transferred into the water in bodily secretions, discharges and from skin surfaces. Causal agents of intestinal diseases such as common diarrhea, the dysenteries, typhoid and paratyphoid fevers have been found in insanitary swimming pool water. Pathogenic organisms especially those affecting the nasal passages, sinuses, and



the throat have also been found in pool water. This medium is likewise an agency for the transmission of organisms causing eye, ear, and skin infections. Injuries received in diving and swimming may develop serious infections because of the presence of the proper infectious microorganisms.

In order to help prevent swimming pool infections the United States Public Health Service has set up the following swimming pool standards:

1. The total count shall not exceed 200 organisms per ml.
2. Not more than two of five samples collected on the same day nor more than three out of ten consecutive samples collected on different days shall show the presence of Bacillus coli in ten ml. of water.
3. Not more than twenty bathers shall be allowed per 1,000 gallons of fresh water added to the pool.

City and county health officials should require minimum standards containing the following requirements:

1. Each pool shall have a conscientious and capable operator who is familiar with swimming pool sanitation and resuscitation methods and who will maintain the pool in such manner that a silver dollar on the bottom of the pool can be seen by persons standing on the walkway.
2. A residual of two tenths to five tenths ppm. of free chlorine shall be maintained in the water of the pool.
3. Bathers shall take showers before entering the pool.
4. A foot bath containing a five tenths per cent solution of chlorine shall be maintained for bathers to walk through on entering the pool. This will minimize the spread of foot infections.
5. A notice shall be posted in a conspicuous place

in the bath house warning bathers against spitting in the pool. Scum gutters should be provided for this.

6. Cross-connections will not be allowed in the piping arrangement of the pool.

In localities where bacteriological laboratory facilities are available, daily bacteriological checks should be made on the pool.<sup>1</sup>

The following regulations for bathers are typical of those used in the operation of the ordinary swimming pool:

1. The orders, instructions, or requests of the pool attendants will be complied with by all bathers.

2. A limited number of bathers will be allowed within the pool enclosure at one time; number of bathers determined by size of pool.

3. All bathers will take a shower bath with warm water and soap before entering the pool enclosure. Bathing suits will not be worn in the shower bath. The soap will be rinsed off with warm water and the bathing suit put on without drying the body. Each bather will place both feet in a foot bath before entering and when leaving the shower bath.

4. All bathers visiting the toilets will take a warm water and soap shower bath in the same manner as directed in part 3, before re-entering the pool.

5. Expectoration, blowing the nose or spouting of water from the mouth into the pool is forbidden.

6. No article of food will be carried into the bathhouses or the pool enclosure.

7. Smoking within the pool enclosure or shower bathroom is forbidden.

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Texas State Department of Education, The Production, Treatment and Distribution of Water, (December, 1937), p. 90.

8. No person who has a cold or sores, ulcers or other skin diseases, discharges from the ears, or is wearing a bandage of any kind, or is otherwise sick will be permitted to enter the pool enclosure.

9. No person reported by the doctor as having, or as being a carrier of an infectious disease will be permitted in the pool enclosure.

10. No person other than the bathers who have complied with these regulations, except pool attendants, will be allowed within the pool enclosure. (Note): Exception is made in the case of the parents or those in charge of children using the pool. 2

#### Discussion

The data given in Table 1 show that in the total plate count of the North Texas State Teachers College swimming pool water the highest number of bacterial colonies appeared in the latter part of May and showed a marked decrease after July 11. It was on this date that chlorine was first used in the water for the 1943 swimming season. It was used regularly, however, from then on. There is a variation in the number of bacterial colonies appearing on the Bactotryptose agar from the lowest average count of three colonies found on July 16, in a sample from the deep section of the pool, to the highest average count of two hundred and fifty-nine colonies observed on May 27, in a sample taken from the shallow portion.

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George C. Dunham, Military Preventive Medicine, p.407.

TABLE 1

NUMBER OF BACTERIAL COLONIES PER CUBIC CENTIMETER OF  
SAMPLE FOUND IN THE QUANTITATIVE (TOTAL PLATE  
COUNT) EXAMINATION OF SWIMMING POOL WATER

Date	Deep Area Samples				Middle Area Samples				Shallow Area Samples			
	1	2	3	Ave.	1	2	3	Ave.	1	2	3	Ave.
May												
4	60	28	41	43	76	37	43	52	90	61	47	66
6	193	71	86	116	211	87	112	137	93	201	78	124
8	44	63	52	52	21	76	30	42	27	31	18	35
11	84	103	44	44	130	107	61	99	81	35	72	63
13	46	89	23	43	32	84	21	49	58	19	41	39
15	25	16	24	22	60	4	10	25	12	30	16	20
18	93	57	88	79	81	93	108	94	181	88	109	93
20	173	91	158	141	192	128	153	158	169	203	184	185
22	68	122	109	99	91	173	158	141	142	111	103	119
25	248	191	179	206	203	217	197	208	227	236	201	221
27	256	271	218	248	258	274	221	254	286	233	257	259
29	198	153	186	146	101	141	163	135	130	151	118	133
June												
1	158	172	141	157	119	148	121	163	149	137	108	131
3	207	188	176	190	218	204	193	205	213	194	202	203
5	194	169	173	179	137	180	164	160	129	173	185	162
8	151	109	149	139	126	145	129	133	107	160	128	132
11	148	99	116	121	156	79	123	119	103	98	126	109
13	17	21	11	16	9	22	19	17	24	39	23	28
16	3	0	5	3	6	10	2	6	3	6	2	4
18	2	5	5	4	7	4	5	5	1	9	2	4
19	8	14	0	7	20	8	6	11	10	4	3	6
22	20	12	9	14	8	0	12	7	13	21	16	17
24	14	0	10	8	14	18	7	13	4	8	3	5
26	7	3	0	3	9	5	7	7	1	12	2	5
30	16	4	23	14	10	2	3	5	11	6	7	8
July												
1	26	30	10	22	3	9	17	9	8	3	7	6
3	90	22	72	57	28	22	40	30	71	60	33	53
6	4	11	8	8	7	9	13	10	17	8	19	15
8	12	3	21	12	16	24	3	14	19	7	14	17
10	42	70	6	39	19	24	16	19	8	14	19	14

The latter count was made on Thursday, the day before the pool was cleaned for the week, and at this time no chlorine was being used.

In Table 2 it is observed that all of the samples on the above date, May 27, gave positive presumptive tests. Five of the presumptive tests were confirmed on Bacto-Endo agar. This indicated that fecal organisms of the colon-aerogenes group were in the pool on this date, and that the water was unsafe for swimming. The low count of three colonies was made from a water sample taken in the middle of the week after chlorination of the swimming pool water had been in progress over a period of five days. No positive presumptive reactions were obtained.

In results from ninety total plate counts it is observed that twenty-three of these show counts above two hundred, and twenty-one above one hundred and seventy colonies per plate. The percentage for these total plate counts ranges from fifty-one and one tenth per cent for the former down to forty-eight and nine tenths per cent for the latter. A bacterial count of over two hundred colonies per cubic centimeter indicates that the water is unsafe. This is because of greater possibilities for the presence of pathogenic organisms. Precautions must be taken in treatment and operation of the pool when the count runs too high in order to prevent a case or an epidemic of an infectious disease.

TABLE 2

REACTIONS OBTAINED IN THE QUALITATIVE (PRESUMPTIVE TEST)  
 EXAMINATION OF SWIMMING POOL WATER SHOWING THE  
 ABSENCE OR PRESENCE OF LACTOSE-FERMENTING  
 ORGANISMS OF THE COLON-AEROGENES  
 GROUP OF BACTERIA

Date	Deep Area Samples				Middle Area Samples				Shallow Area Samples			
	1	2	3	4	1	2	3	4	1	2	3	4
May												
4	*	-	*	*	*	*	*	*	*	*	-	-
6	*	*	-	-	*	*	*	*	-	*	*	*
8	-	-	-	*	-	*	*	-	-	-	-	-
11	*	-	-	-	*	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-	-	*
15	-	-	-	-	-	-	-	-	*	-	*	-
18	*	-	-	*	*	*	*	*	*	*	-	-
20	*	*	-	-	*	*	*	*	*	*	*	*
22	*	*	*	-	*	*	*	*	*	-	*	*
25	*	*	*	*	*	*	*	*	*	*	*	*
27	*	*	*	*	*	*	*	*	*	*	*	*
29	-	-	-	*	-	*	-	-	-	-	-	-
June												
1	-	-	*	-	-	-	-	-	*	*	-	-
3	*	*	*	-	*	*	*	*	*	*	-	*
5	-	-	*	*	*	-	-	-	-	*	*	-
8	-	-	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-	-	-
13	*	*	*	*	-	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-	-	-
22	-	-	-	-	-	-	-	-	-	-	-	-
24	-	-	-	-	-	-	-	-	-	-	-	-
26	-	-	-	-	-	-	-	-	-	-	-	-
30	-	-	-	-	-	-	-	-	-	-	-	-
July												
1	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-	-

(-) Negative Reaction

(\*) Positive Reaction

Civilian participation in the pool during the latter part of May and early June was on the average high. Due to the fact that any number of the men might enter the pool during the designated hour for their swimming, no record is available of the number of swims taken by the Army and Navy personnel. Therefore, the total attendance record was much higher than is indicated in Table 5. Upon the improvement of operating procedures and the addition of chlorine the number of colonies decreased greatly, even though the attendance gained. Therefore it may be concluded that maintaining a residual of free chlorine of at least four tenths to five tenths parts per million is sufficient to retain a low total plate count and to control the growth of lactose-fermenting organisms of the colon-aerogenes group as well as the various cocci of the infectious types.

As the number of bacterial organisms increased per cubic centimeter, the number of positive presumptive tests also increased. Table 2 indicates that variations were obtained in the occurrence of lactose-fermenting bacilli in the three areas of the pool. More positive presumptive reactions occurred in the middle and shallow divisions. Since most of the swimming is in these two areas, a higher concentration of organisms from the swimmers is expected. This, no doubt, accounts for the greater number of

positive reactions in the Bacto-lactose peptone bile broth.

Of the three hundred and sixty presumptive tests made ninety-nine or twenty-seven and five tenths per cent of the individual examinations gave positive presumptive reactions. A positive reaction indicated the presumed presence of lactose-fermenting organisms. With this high percentage obtained swimming could have proved more detrimental than beneficial to the health of the swimmer. The majority of the seventy-two and five tenths per cent of the negative presumptive tests were from samples collected and examined after the beginning of the use of chlorine in the month of June. This practice evidently made for a more sanitary environment for swimmers.

With more ultra-violet rays of the sun entering the water, the addition of chlorine, and greater regularity in draining and cleaning the pool, lactose-fermenting bacilli and bacteria of the cocci group were seemingly controlled. The sanitary conditions of the pool in the latter part of June and the first part of July exhibit a marked contrast with the insanitary conditions that prevailed in May and the earlier part of June.

Of the confirmation tests made on Bacto-Endo agar thirty-four and seven tenths per cent of the positive presumptives previously determined were positive for the lactose-fermenting organisms. Dark button-like colonies with



a coppery metallic sheen, characteristic of the organisms belonging to the Escherichia group, were formed on the surface of the agar. These bacteria are the ones of significance in regard to the sanitation of swimming pool water. As shown in Table 3, the remaining sixty-five and three tenths per cent were organisms of a different group, and therefore reacted negatively to the confirmation test. These organisms which are of the Aerobacter group developed large pink watery colonies. From May 18 until May 27, a period of ten days, seventeen positive confirmation tests were obtained. Bad weather conditions which resulted in large quantities of rain and many high winds no doubt helped to account for the marked water contamination. Since only a small amount of bactericidal sunlight was available, and no chlorine was being used, an abundant growth of algae, bacteria and fungi developed. The majority of the positive confirmation tests occurred in the month of May. Negative reactions for the colon-aerogenes group of bacteria were found in June and July at which time the water was presumed and later confirmed safe. No unfavorable weather conditions occurred and good sanitary operational procedures were being administered regularly to the pool during this period.

TABLE 3

REACTIONS OBTAINED IN THE QUALITATIVE (CONFIRMED TEST)  
 EXAMINATION OF SWIMMING POOL WATER SHOWING THE  
 CONFIRMATION OF THE PRESUMPTIVE TEST FOR  
 LACTOSE-FERMENTING ORGANISMS OF THE  
 COLON-AEROGENES GROUP OF BACTERIA

Date	Deep Area Samples				Middle Area Samples				Shallow Area Samples			
	1	2	3	4	1	2	3	4	1	2	3	4
May												
4			-	-	-	*	-	-	*	*		
6	-	-			*	*	*	-		-		*
8				*		*	*					
11	-				-							
13									*			
15												
18	-			*	-		*	-	-	-		
20	-	-			*	*	-	*	-	*	*	*
22	-	-			-	-	-	*	*			
25	-	-	-		-	*	*	*	*			
27	*	-	*	-	-	*	*	-	*	*	*	-
29				-	-	-			*	*		-
June												
1			-						-			
3	-	*	-		-	-	*	*	-	*		*
5												
8				-	-					-	-	
11												
13	-	-	-	-								
16												
18												
19												
22												
24												
26												
30												
July												
1												
3												
6												
8												
10												

(-) Negative Reaction

(\*) Positive Reaction

Bacterial colonies from the Bacto-Endo agar plates, which gave positive confirmed results, were stained by the Gram technique and observed under the oil immersion lens. Of the forty Gram stains recorded in Table 4 twenty-two and five tenths per cent of the organisms have the morphological characteristics of lactose-fermenting bacilli, fifteen per cent are in chain-like formation resembling streptococci, and thirty-five per cent are in grape-like clusters indicating the staphylococci group. The remaining twenty-seven

TABLE 4

THE NUMBER OF GRAM POSITIVE AND GRAM NEGATIVE COCCI AND RODS FOUND IN EACH AREA OF THE SWIMMING POOL

Areas in the pool	Gram positive and Gram negative							
	Cocci				Rods			
	Cocci in chains		Cocci in grape-like clusters		Short rods		Long rods	
	G <sup>+</sup>	G <sup>-</sup>	G <sup>+</sup>	G <sup>-</sup>	G <sup>+</sup>	G <sup>-</sup>	G <sup>+</sup>	G <sup>-</sup>
Deep	3	0	4	0	1	4	3	0
Middle	1	1	4	0	0	3	3	0
Shallow	1	0	6	0	1	2	2	1

and five tenths per cent are seemingly organisms of no particular sanitary significance. The conclusion is that lactose-fermenting organisms of fecal origin and cocci bacteria of possibly infectious types were actually present in the pool thus rendering the water unsafe. The pool is

entirely safe when operated and used according to the necessary sanitary specifications, but is unsafe if the proper precautions are not observed.

Table 5 shows the daily civilian attendance from 9:00 A. M. to 6:30 P.M. in the swimming pool of North Texas State Teachers College from May 3 through May 30, 1943.

TABLE 5

CIVILIAN PARTICIPATION IN THE SWIMMING POOL  
EACH DAY OF EACH WEEK, MAY 3-30, 1943

Day of the week	Week				Month total on each day	Average total per day
	May 3-9*	May 10-16	May 17-23	May 24-30		
Monday	287	16	107	74	484	121
Tuesday	298	95	111	109	613	153
Wednesday	216	109	120	128	573	143
Thursday	74	25	1	35	135	34
Friday	91	23	25	174	318	80
Saturday	10	72	3	10	95	24
Sunday	..	96	34	20	150	50
Totals	976	441	401	530	2,368	86

\*Pool was not open on May 9.

On Tuesday, May 4, the highest number of swimmers were reported for the month. Two hundred and ninety-eight individuals entered the pool besides the Army and Navy personnel. Only three persons went swimming on May 22. This was because the pool was not filled during the morning period and that unfavorable weather followed in the afternoon. No records were kept of the number of swims taken at

any time by the Army and Navy men. Any member of either military unit had the privilege of using the pool during the period designated for his group. Monday, Tuesday, and Wednesday proved to be the most popular days for the use of the pool over the period of time the attendance record was investigated. The factor contributing toward usage on these days was most likely the obvious prevalence of more sanitary conditions.

#### Recommendations

In terms of the preceding information and the swimming pool standards set up by the United States Public Health Service the following recommendations are made:

1. That regular bi-weekly bacteriological and chemical analyses of the pool water be made from the quantitative and qualitative standpoint.
2. That the water be changed twice weekly to help reduce bacterial, fungal and algal growth thus lessening the infections caused by these organisms.
3. That rigid enforcement of the rules and regulations of the pool be made to aid in maintaining sanitary conditions, safety, and controlling the overcrowded bathing capacity.
4. That swimmers be required to take soap and hot water showers, wear clean bathing suits and caps, and use a good standard foot disinfectant before entering the pool.

5. That onlookers be prohibited from contaminating walks and pool with foreign objects and dirt.

6. It is also recommended that encouragement for intelligent cooperation of administrators, instructors, swimmers and operative employees be made to insure a safe and sanitary swimming pool for North Texas State Teachers College.

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