BACTERIAL SURVEY OF THE SOURCES OF DRINKING WATER OF TRINIDAD, TEXAS, WITH SPECIAL REFERENCE TO SANITATION

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CHAPTER I

INTRODUCTION

The primary purpose of a bacterial analysis of water is to determine the potability of that water. Typhoid fever, dysentery, and other diseases of intestinal origin may be transmitted by waters polluted by wastes of human origin. Since the isolation of the small number of disease producers is very unreliable although not entirely impossible, the safety of the water supply is determined by testing for organisms that are present in large numbers and are associated with the pathogens. The common organisms of the intestinal tract of man most closely associated with the intestinal pathogens are those of the coliform group. Non-pathogenic soil bacteria having similar morphology and physiological activities are classified in one general group called the Colon-Aerogenes group. An absence of the Colon-Aerogenes group indicates an absence of the intestinal pathogens. By testing for this group an indirect test for the pathogens is also made.

Trinidad, though a rather old town, was of no particular significance to the industrial life of Texas before 1924. At that time it was chosen as the site for the Texas Power and Light Company's generating plant which is now the largest in the state. This plant caused a growth in the town which has been rather slowly followed by municipal improvements. The old residential section was located on each side of the railroad while the Texas Power and Light Company's plant was located some two miles to the south. Since it was necessary for the plant's employees to have living quarters provided for them and their families, the company built two groups of houses to care for the situation. These were built on the land adjoining the plant proper, and wells were dug to supply them with water. There were four of these wells connected to a common storage tank from which the houses obtained their water.

Later, houses were built between the original town and the plant villages. Since electrical power was then available, these houses were supplied with water from wells using electric pumps instead of the rope and buckets of those wells already in use. When the Lone Star Gas Company installed its plant and built houses for its employees, it also dug a well to supply them water.

Until some five years ago, each property owner was thus responsible for his own water supply. At that time the town dug a well, equipped it with an electric pump, and began supplying water to many of the houses where rope and bucket wells, hand pumps, and other unsatisfactory water supplies had been in use.

At the present time the city well supplies approximately seventy-five houses and stores, the Texas Power and Light Company wells about thirty houses, the gas plant well about eight houses, and some thirty-one privately owned wells the remaining houses of town. The only building in town using a source of drinking water other than a well is the drugstore which has an underground cistern equipped with an electric pump.

Even though there has been no indication that the respective water systems might be unsatisfactory, it was a matter of speculation that some of these might prove unsatisfactory if they were carefully studied. For this reason the survey was made.

Review of Literature

Leach and Leach (1924) made a report on the potability of the water from the forty-six wells installed in 1907 to supply Manila with pure water. The high incidence of typhoid fever resulted in the survey beginning in 1922. Of the forty-six wells, the water from only twenty-six percent was potable, forty-five and six-tenths percent contaminated by leaky casings, by pumps allowing leakage of surface water into wells, or by priming the pumps with contaminated water. Even in the cases where water was taken from wells classed as potable, the unsanitary handling by water carriers often resulted in contamination.[1]

Nicoll, Holmquist, and Bedell (1926) reported that between 1903 and 1925 some thousand cases of typhoid fever and over one hundred deaths were recorded and traced to polluted wells in the eastern states. There were nine such outbreaks in New York state alone during this period. Though large sums of money were spent by towns and cities to provide sanitary water supplies, these same towns and cities allowed their citizens to use individual wells of doubtful and unsatisfactory sanitary qualities.[2]

A Kansas State Board of Health member (1928) gave a case of contamination of a city well by leakage from a nearby swimming pool. Abandoned and forgotten test holes allowed wastes from the earth's surface to enter the underground streams and contaminate the water supplies quite frequently. Occasionally an abandoned well was used for the disposal of sewage, and the contamination of a water supply would be the result.[3]

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[1] C. N. Leach and F. D. Leach, "The Artesian Well as a Potential Source of Danger," The American Journal of Public Health, Vol. XIV (October, 1924), pp. 827-831.

[2] M. Nicoll, Jr., C. A. Holmquist, and A. S. Bedell, "Public Health Aspects of Cross Connections and Dual Water Supplies," The American Journal of Public Health, Vol. XVI (April, 1926), pp. 355-363.

[3] "Impure Wells and Springs," The Literary Digest, Vol. XCIX (November 17, 1928), pp. 79-81.

Gershenfeld (1933) discussed the development of the use of bacterial analysis to determine the potability of water. Until 1871, the time of the demonstration of the presence of bacteria in water, an analysis of water was confined to its color, odor, taste, and mineral constituents. Water is now known to carry such diseases as cholera, typhoid fever, paratyphoid fever, dysentery, and other intestinal infections; therefore, the greatest danger in a water supply is pollution from human sources. The importance of the bacterial analysis of water has increased with this understanding of the relation of bacteria to water supplies.[4]

Prescott and Horwood (1935) devoted a chapter of Sedgwick's Principles of Sanitary Science and Public Health to the discussion of epidemics which were traced to polluted water supplies. Two of these epidemics were traced to polluted wells. The first, an epidemic of Asiatic cholera, was traced to the Broad Street (London) pump. Contamination of the water of the well was by leakage from a cesspool located only a few feet from the well and being used by a person having Asiatic cholera. The other case was an epidemic of typhoid fever in Caterham and Red Hill (England), which was traced to an infected ground water supply. The infection came from a worker who had been suffering from typhoid

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[4] L. Gershenfeld, Bacteriology and Sanitary Science, p. 429.

fever at the time he was going down into the well and helping remove chalk rock from it.[5]

Whitley (1937), in a survey of seventy-two representative wells of Denton County, Texas, found fifty-five percent unsanitary, twenty-seven percent sanitary, and eighteen percent doubtful.[6]

Suckling (1943), a water engineer in England, reported a number of means of pollution of wells and water supplies that have been traced in England and Wales. Two wells supplying a city of a population of over twenty thousand were pure most of the year. They were located near a river which overflowed its banks two or three times a year, thus causing the water to become impure.[7]

Another case showed colon bacteria in the water of a well which was the sole source of supply to a town. A survey located a manure-littered, poorly drained stable yard in the vicinity of the well. After the yard had been well-drained, the top soil removed, and an impervious layer of

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[5] S. C. Prescott and M. P. Horwood, Sedgwick's Principles of Sanitary Science and Public Health, pp. 131, 145.

[6] M. D. Whitley, "Bacterial Survey of Representative Denton County Wells with Special Reference to Sanitation," (Unpublished thesis, Department of Biology, North Texas State Teachers College, 1937), p. 55.

[7] E. V. Suckling, The Examination of Water and Water Supplies, p. 51.

cement made to cover it, the water from the well was free of colon bacteria.[8]

An outbreak of typhoid fever in a small town in Essex was traced to a well where the water became turbid following a heavy rainfall. The pollution was coming from a drain from an isolation hospital, where there had been a case of typhoid fever some weeks prior to the outbreak. The pipe was defective at a point close to the stream of water supplying the well.[9]

At New Herrington, Denham, an outbreak of typhoid fever was traced to a well the underground stream of which was contaminated three-fourths of a mile away by wastes from a farmhouse and other farm buildings. Pollution of another well was traced to the boots of men who had descended into the well to work.[10]

In 1905 the County Asylum near Cambridge, England, had a number of typhoid fever cases which were traced to its well. A crude system of broad irrigation was used for sewage disposal. Since the soil was loamy and covered chalk, it was possible for the impurities to drain through the chalk into the well.[11]

Barnes (1944) found thirty-two percent of twenty-five

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[8] _Ibid._, p. 52. [9] _Ibid._, pp. 54-55. [10] _Ibid._, pp. 56. [11] _Ibid._, pp. 58-60.

wells tested unsanitary and sixty-eight percent sanitary in a survey of wells in and near Canyon, Texas.[12]

The Problem

A bacterial analysis of the water from thirty-six sources of consumption by the white population of Trinidad, Henderson County, Texas, was made to determine the potability of each of these in regard to infection from typhoid or related organisms. The survey included monthly examinations of each source from November 1, 1943 through April 13, 1944 for the total number of bacteria per milliliter in the water and the presence of Colon-Aerogenes bacteria following the initial compiling of sources, means of obtaining the water, number of houses supplied, and other information which might prove valuable in case of revealed contamination. An attempt has been made to explain the findings in total counts and Colon-Aerogenes bacteria with reference to sanitary conditions as to well construction, means of obtaining water, and the general care of the well. The wells were classified as satisfactory, doubtful, or unsatisfactory sources of sanitary or potable water after all the available information was duly considered.

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[12]Adele Barnes, "Bacterial Survey of Representative Wells of Canyon, Texas, with Special Emphasis on Sanitation," (Unpublished thesis, Department of Biology, North Texas State Teachers College, 1944), p. 38.

CHAPTER II

FIELD WORK

The field work consisted of all procedures done outside the laboratory. The source of water for each house was determined, and those having sources not already located were recorded. When all the sources were located and the laboratory materials were ready for the experimental work to be done, samples of water were collected from each source, and the information concerning the sanitary condition of each was obtained. In later months collecting the samples was all that was done unless the experimental results were such that further investigation of the source was necessary.

The samples were collected in glass bottles of two hundred and fifty milliliter capacity fitted with plastic screw caps. The bottles were capped, wrapped in newspaper, and sterilized in a hot-air oven for an hour at a temperature of one hundred and seventy degrees centigrade.[1]

Immediately preceding the collection of a sample, the paper covering was removed from the bottle. In cases where

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[1]American Public Health Association and American Water Works Association, <u>Standard Methods for the Examination of Water and Sewage</u>, p. 206.

the water was taken from pumps and faucets, the water was allowed to run for three to five minutes to wash out the pump and pipes, thereby insuring as near a representative sample as possible. In the rope and bucket type well the sample was collected from the bucket only after the bucket had been rinsed and filled a second time. Experimental work was done on these samples within six hours after collection.[2]

A comparison and study was made of the number of houses supplied by each source, the method of obtaining the water, the depth of each source, and the means of purification if one were in use. All the sources were wells with the exception of Number 14 which is an underground cistern for storing rainwater. Only two of the sources used a means of purification. The method of obtaining the water was largely by means of an electric pump though several used the rope and bucket method and one used a hand pump. The wells varied from eighteen feet to two hundred feet in depth with only one more than forty feet. Practically all were well constructed and properly repaired from time to time. The number of houses served by each source varied from one to seventy-five. The table on the following page gives the foregoing information with reference to each source.

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[2]*Ibid.*, p. 207.

TABLE 1

INFORMATION ON SOURCES OF DRINKING WATER
OF TRINIDAD, HENDERSON COUNTY, TEXAS

Source	Houses Supplied	Obtained by	Depth	Purification
Number 1	2	Rope and bucket	20'	None
Number 2	1	Electric pump	22'	None
Number 3	1	Rope and bucket	30'	None
Number 4	1	Electric pump	25'	None
Number 5	2	Electric pump	25'	None
Number 6	1	Electric pump	25'	None
Number 7	1	Rope and bucket	20'	None
Number 8	1	Electric pump	25'	None
Number 9	75	Electric pump	30'	None
Number 10	1	Electric pump	23'	None
Number 11	1	Electric pump	23'	None
Number 12	2	Electric pump	25'	None
Number 13	4	Electric pump	35'	None
Number 14	1	Electric pump	15'	Activated charcoal
Number 15	1	Electric pump	20'	None
Number 16	8	Electric pump	200'	None
Number 17	1	Electric pump	25'	None
Number 18	1	Rope and bucket	35'	None
Number 19	1	Hand pump	23'	None
Number 20	1	Electric pump	28'	None
Number 21	1	Electric pump	20'	None
Number 22	1	Rope and bucket	30'	None
Number 23	2	Electric pump	25'	None
Number 24	12	Electric pump	30'	None
Number 25	8	Electric pump	40'	None
Number 26	1	Electric pump	25'	None
Number 27	1	Rope and bucket	40'	None
Number 28	1	Electric pump	40'	None
Number 29	1	Electric pump	38'	None
Number 30	1	Electric pump	40'	None
Number 31	2	Electric pump	30'	None
Number 32	1	Electric pump	30'	None
Number 33	30	Electric pump	30-40'	Chlorination
Number 34	1	Electric pump	30'	None
Number 35	1	Rope and bucket	18'	None
Number 36	1	Electric pump	27'	None

CHAPTER III

EXPERIMENTAL WORK

Total Plate Count.--Each sample bottle was thoroughly shaken, and one milliliter of the sample was transferred by means of a sterile one milliliter pipette to each of three sterile Petri dishes. About fifteen milliliters of agar, which had been sterilized at fifteen pounds pressure at one hundred and twenty degrees centigrade for fifteen minutes and cooled to about forty-five or fifty degrees centigrade previously, were poured into each Petri dish. The dishes were rotated to mix the water and agar thoroughly so that the bacteria would be distributed uniformly throughout the agar. After the agar solidified, the dishes were inverted and put into the incubator where they remained for twenty-four hours at a temperature of thirty-seven degrees centigrade.[1]

At the end of the twenty-four hours the colonies of bacteria were counted with the aid of a magnifying glass having a magnification of three diameters. The average

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[1]American Public Health Association and American Water Works Association, Standard Methods for the Examination of Water and Sewage, p. 208.

count of the three plates was determined, and this number was recorded as the total plate count in bacteria per milliliter of the sample of water for the month.[2]

Presumptive Test.--Lactose broth was used in the presumptive test to determine the presence of lactose fermenting organisms in the water. The solution was made from the dehydrated medium and water. The solution was tubed in fermentation tubes and sterilized in the autoclave. One-tenth milliliter of each sample of water was transferred by means of sterile pipettes to each of five fermentation tubes containing lactose broth. The tubes were incubated at thirty-seven degrees centigrade for twenty-four hours and checked for fermentation. Negative tubes were returned for another twenty-four hours of incubation, after which the final presumptive test readings were made. Tubes containing as much as a ten percent column of gas in the inverted vial were recorded positive while all others were considered negative. Negative fermentation tubes were discarded, but confirmation tests were run on all positive fermentation tubes.[3]

Confirmation Test.--The purpose of the confirmation test is to verify the presence of lactose fermenting organisms indicated by the positive presumptive test and to differentiate between the Colon and the Aerogenes bacteria. Endo's

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[2]*Ibid.*, p. 209. [3]*Ibid.*, pp. 211-212.

agar was used as the culture medium with eosin methylene blue medium used occasionally as a check. The media were prepared, sterilized in the autoclave, cooled, poured into sterile Petri dishes in about fifteen milliliter portions, and allowed to solidify.[4]

Material from each of the positive fermentation tubes was streaked on the surface of a plate of medium by means of a sterile inoculating needle. The plates were then inverted and incubated at thirty-seven degrees centigrade for twenty-four hours and then examined for the presence of bacterial growth. Small, flat, copper-colored colonies which produced a reddening of the agar were recorded as positive for the Colon group. Large, pink, watery colonies were considered positive for the Aerogenes group. The morphology of the organisms of these colonies was determined by preparing Gram stains of growth from the colonies on slides and later examining microscopically with oil immersion. The presence of short, Gram negative rods verified the results of the confirmation test.[5]

Observations and Results.--The results of the various tests on each source are given in the tables on the following pages. They are grouped according to similarities in means of obtaining the water.

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[4]*Ibid.*, p. 212. [5]*Ibid.*, p. 213.

TABLE 2

SOURCE NUMBER 2

Month	Total Plate Count	Presumptive Test					Confirmation Test									
							I		II		III		IV		V	
		I	II	III	IV	V	C	A	C	A	C	A	C	A	C	A
November	69	-	-	-	-	-										
December	81	-	-	-	-	-										
January	67	-	-	-	-	-										
February	168	-	+	-	-	+			-	-					-	-
March	261	-	-	-	-	-										
April	255	-	-	-	-	-										

TABLE 3

SOURCE NUMBER 4

Month	Total Plate Count	Presumptive Test					Confirmation Test									
							I		II		III		IV		V	
		I	II	III	IV	V	C	A	C	A	C	A	C	A	C	A
November	27	-	-	-	-	-										
December	29	-	-	-	-	-										
January	19	-	-	-	-	-										
February	43	-	-	-	-	-										
March	54	-	-	-	-	-										
April	58	-	-	-	-	-										

TABLE 4

SOURCE NUMBER 5

Month	Total Plate Count	Presumptive Test					Confirmation Test									
							I		II		III		IV		V	
		I	II	III	IV	V	C	A	C	A	C	A	C	A	C	A
November	25	-	-	-	-	-										
December	15	-	-	-	-	-										
January	27	-	-	-	-	-										
February	65	+	+	+	-	-	-	-	-	-	-	-				
March	85	-	-	-	-	-										
April	39	-	-	-	-	-										

TABLE 5

SOURCE NUMBER 6

Month	Total Plate Count	Presumptive Test					Confirmation Test									
							I		II		III		IV		V	
		I	II	III	IV	V	C	A	C	A	C	A	C	A	C	A
November	85	-	-	-	-	-										
December	70	-	-	-	-	-										
January																

TABLE 6

SOURCE NUMBER 8

Month	Total Plate Count	Presumptive Test					Confirmation Test									
		I	II	III	IV	V	I		II		III		IV		V	
							C	A	C	A	C	A	C	A	C	A
November	50	-	-	-	-	-										
December	66	-	-	-	-	-										
January	70	-	-	-	-	-										
February	87	+	+	+	-	-	-	-	-	-	-	-				
March	91	-	-	-	-	-										
April	206	-	-	-	-	-										

TABLE 7

SOURCE NUMBER 9

Month	Total Plate Count	Presumptive Test					Confirmation Test									
		I	II	III	IV	V	I		II		III		IV		V	
							C	A	C	A	C	A	C	A	C	A
November	24	-	-	-	-	-										
December	11	-	-	-	-	-										
January	17	-	-	-	-	-										
February	28	-	-	-	-	-										
March	32	-	-	-	-	-										
April	35	-	-	-	-	-										

TABLE 8

SOURCE NUMBER 10

Month	Total Plate Count	Presumptive Test					Confirmation Test									
							I		II		III		IV		V	
		I	II	III	IV	V	C	A	C	A	C	A	C	A	C	A
November	34	-	-	-	-	-										
December	20	-	-	-	-	-										
January	22	-	-	-	-	-										
February	28	-	-	-	-	-										
March	34	-	-	-	-	-										
April	41	-	-	-	-	-										

TABLE 9

SOURCE NUMBER 11

Month	Total Plate Count	Presumptive Test					Confirmation Test									
							I		II		III		IV		V	
		I	II	III	IV	V	C	A	C	A	C	A	C	A	C	A
November	19	-	-	-	-	-										
December	20	-	-	-	-	-										
January	17	-	-	-	-	-										
February	30	+	+	+	+	-	-	-	-	-	-	-	-	-		
March	38	-	-	-	-	-										
April	32	-	-	-	-	-										

TABLE 10

SOURCE NUMBER 12

Month	Total Plate Count	Presumptive Test					Confirmation Test									
		I	II	III	IV	V	I		II		III		IV		V	
							C	A	C	A	C	A	C	A	C	A
November	11	-	-	-	-	-										
December	10	-	-	-	-	-										
January	6	-	-	-	-	-										
February	21	+	+	-	-	-	-	-	-	-						
March	46	-	-	-	-	-										
April	31	-	-	-	-	-										

TABLE 11

SOURCE NUMBER 13

Month	Total Plate Count	Presumptive Test					Confirmation Test									
		I	II	III	IV	V	I		II		III		IV		V	
							C	A	C	A	C	A	C	A	C	A
November	49	-	-	-	-	-										
December	28	-	-	-	-	-										
January	29	-	-	-	-	-										
February	83	-	-	-	+	+							-	-	-	-
March	28	-	-	-	-	-										
April	53	-	-	-	-	-										

TABLE 12

SOURCE NUMBER 15

Month	Total Plate Count	Presumptive Test					Confirmation Test									
							I		II		III		IV		V	
		I	II	III	IV	V	C	A	C	A	C	A	C	A	C	A
November	89	-	-	-	-	-										
December	74	-	-	-	-	-										
January	38	-	-	-	-	-										
February	77	-	-	-	-	-										
March	77	+	-	-	-	-	-	-								
April	63	-	-	-	-	-										

TABLE 13

SOURCE NUMBER 16

Month	Total Plate Count	Presumptive Test					Confirmation Test									
							I		II		III		IV		V	
		I	II	III	IV	V	C	A	C	A	C	A	C	A	C	A
November	32	-	-	-	-	-										
December	14	-	-	-	-	-										
January	16	-	-	-	-	-										
February	22	-	-	-	-	-										
March	36	-	-	-	-	-										
April	28	-	-	-	-	-										

TABLE 14

SOURCE NUMBER 17

Month	Total Plate Count	Presumptive Test					Confirmation Test									
		I	II	III	IV	V	I C	I A	II C	II A	III C	III A	IV C	IV A	V C	V A
November	28	-	-	-	-	-										
December	21	-	-	-	-	-										
January	23	-	-	-	-	-										
February	48	+	+	-	-	-	-	-	-	-						
March	40	-	-	-	-	-										
April	24	-	-	-	-	-										

TABLE 15

SOURCE NUMBER 20

Month	Total Plate Count	Presumptive Test					Confirmation Test									
		I	II	III	IV	V	I C	I A	II C	II A	III C	III A	IV C	IV A	V C	V A
November	12	-	-	-	-	-										
December	6	-	-	-	-	-										
January	5	-	-	-	-	-										
February	38	-	-	-	-	-										
March	38	-	-	-	-	-										
April	33	-	-	-	-	-										

TABLE 16

SOURCE NUMBER 21

Month	Total Plate Count	Presumptive Test					Confirmation Test									
							I		II		III		IV		V	
		I	II	III	IV	V	C	A	C	A	C	A	C	A	C	A
November	49	-	-	-	-	-										
December	36	-	-	-	-	-										
January	30	-	-	-	-	-										
February	31	-	-	-	-	-										
March	39	-	-	-	-	-										
April	35	-	-	-	-	-										

TABLE 17

SOURCE NUMBER 23

Month	Total Plate Count	Presumptive Test					Confirmation Test									
							I		II		III		IV		V	
		I	II	III	IV	V	C	A	C	A	C	A	C	A	C	A
November	80	-	+	-	-	-			-	-						
December	69	-	-	-	-	-										
January	67	-	-	-	-	-										
February	75	-	-	-	+	-							-	-		
March	67	-	-	-	-	-										
April	70	-	-	-	-	-										

TABLE 18

SOURCE NUMBER 24

Month	Total Plate Count	Presumptive Test					Confirmation Test									
							I		II		III		IV		V	
		I	II	III	IV	V	C	A	C	A	C	A	C	A	C	A
November	23	-	-	-	-	-										
December	12	-	-	-	-	-										
January	28	-	-	-	-	-										
February	44	+	+	-	-	+	-	-	-	-					-	-
March	72	-	-	-	-	-										
April	136	-	-	-	-	-										

TABLE 19

SOURCE NUMBER 25

Month	Total Plate Count	Presumptive Test					Confirmation Test									
							I		II		III		IV		V	
		I	II	III	IV	V	C	A	C	A	C	A	C	A	C	A
November	27	-	-	-	-	-										
December	20	-	-	-	-	-										
January	9	-	-	-	-	-										
February	26	-	-	-	-	-										
March	29	-	-	-	-	-										
April	21	-	-	-	-	-										

TABLE 20

SOURCE NUMBER 26

Month	Total Plate Count	Presumptive Test					Confirmation Test									
		I	II	III	IV	V	I		II		III		IV		V	
							C	A	C	A	C	A	C	A	C	A
November	29	-	-	-	-	-										
December	22	-	-	-	-	-										
January	18	-	-	-	-	-										
February	183	-	-	-	+	+							-	-	-	-
March	205	-	-	-	-	-										
April	195	-	-	-	-	-										

TABLE 21

SOURCE NUMBER 28

Month	Total Plate Count	Presumptive Test					Confirmation Test									
		I	II	III	IV	V	I		II		III		IV		V	
							C	A	C	A	C	A	C	A	C	A
November	10	-	-	-	-	-										
December	9	-	-	-	-	-										
January	8	-	-	-	-	-										
February	31	-	+	-	+	+			-	-			-	-	-	-
March	58	-	-	-	-	-										
April	48	-	-	-	-	-										

TABLE 22

SOURCE NUMBER 31

Month	Total Plate Count	Presumptive Test					Confirmation Test									
							I		II		III		IV		V	
		I	II	III	IV	V	C	A	C	A	C	A	C	A	C	A
November	31	-	-	-	-	-										
December	17	-	-	-	-	-										
January	17	-	-	-	-	-										
February	113	-	+	+	-	-			-	-	-	-				
March	149	-	-	-	-	-										
April	195	-	-	-	-	-										

TABLE 23

SOURCE NUMBER 34

Month	Total Plate Count	Presumptive Test					Confirmation Test									
							I		II		III		IV		V	
		I	II	III	IV	V	C	A	C	A	C	A	C	A	C	A
November	16	-	-	-	-	-										
December	9	-	-	-	-	-										
January	10	-	-	-	-	-										
February	30	-	-	-	-	-										
March	41	-	-	-	-	-										
April	53	-	-	-	-	-										

TABLE 24

SOURCE NUMBER 36

Month	Total Plate Count	Presumptive Test					Confirmation Test									
							I		II		III		IV		V	
		I	II	III	IV	V	C	A	C	A	C	A	C	A	C	A
November	77	-	-	-	-	-										
December	65	-	-	-	-	-										
January	78	-	-	-	-	-										
February	81	-	-	-	+	+							-	-	-	-
March	151	-	-	-	-	-										
April	215	-	-	-	-	-										

TABLE 25

SOURCE NUMBER 29

Month	Total Plate Count	Presumptive Test					Confirmation Test									
							I		II		III		IV		V	
		I	II	III	IV	V	C	A	C	A	C	A	C	A	C	A
November	127	+	+	-	-	-	-	+	-	+						
December	158	+	+	+	-	-	-	+	-	+	-	+				
January	207	+	+	-	+	-	-	-	-	-			-	+		
February	272	+	+	+	+	-	-	+	-	+	-	-	-	-		
March	277	-	+	+	+	+			-	+	-	+	-	-	-	+
April	230	-	-	+	+	-					-	+	-	+		

TABLE 26

SOURCE NUMBER 30

Month	Total Plate Count	Presumptive Test					Confirmation Test									
							I		II		III		IV		V	
		I	II	III	IV	V	C	A	C	A	C	A	C	A	C	A
November	8	-	-	-	-	-										
December	12	-	-	-	-	-										
January	13	-	-	-	-	-										
February	12	-	-	-	-	-										
March	39	-	-	-	-	-										
April	182	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+

TABLE 27

SOURCE NUMBER 32

Month	Total Plate Count	Presumptive Test					Confirmation Test									
							I		II		III		IV		V	
		I	II	III	IV	V	C	A	C	A	C	A	C	A	C	A
November	21	-	-	-	-	-										
December	13	-	-	-	-	-										
January	14	-	-	-	-	-										
February	194	+	+	+	+	-	-	+	-	+	-	-	-	-		
March	240	-	-	-	-	-										
April	242	-	-	-	-	-										

TABLE 28

SOURCE NUMBER 33

Month	Total Plate Count	Presumptive Test					Confirmation Test									
		I	II	III	IV	V	I		II		III		IV		V	
							C	A	C	A	C	A	C	A	C	A
November	6	-	-	-	-	-										
December	4	-	-	-	-	-										
January	6	-	-	-	-	-										
February	13	-	-	-	-	-										
March	20	-	-	-	-	-										
April	16	-	-	-	-	-										

TABLE 29

SOURCE NUMBER 14

Month	Total Plate Count	Presumptive Test					Confirmation Test									
		I	II	III	IV	V	I		II		III		IV		V	
							C	A	C	A	C	A	C	A	C	A
November	11	-	-	-	-	-										
December	8	-	-	-	-	-										
January	8	-	-	-	-	-										
February	18	-	-	-	-	-										
March	19	-	-	-	-	-										
April	18	-	-	-	-	-										

TABLE 30

SOURCE NUMBER 19

Month	Total Plate Count	Presumptive Test					Confirmation Test									
							I		II		III		IV		V	
		I	II	III	IV	V	C	A	C	A	C	A	C	A	C	A
November	26	+	-	-	-	-	-	+								
December	38	-	-	-	-	-										
January	14	-	-	-	-	-										
February	43	+	+	+	-	+	-	-	-	-	-	-			-	-
March	60	-	-	-	-	-										
April	70	-	-	-	-	-										

TABLE 31

SOURCE NUMBER 18

Month	Total Plate Count	Presumptive Test					Confirmation Test									
							I		II		III		IV		V	
		I	II	III	IV	V	C	A	C	A	C	A	C	A	C	A
November	290	+	+	+	+	+	-	+	-	+	-	+	-	+	+	+
December	207	+	+	+	+	+	+	+	-	+	+	+	+	+	-	-
January	190	+	+	+	+	+	+	+	+	+	-	+	-	+	+	+
February	293	+	+	+	+	-	+	+	-	+	-	+	-	+		
March	248	+	+	+	+	-	-	+	+	+	+	+	-	+		
April	286	+	-	+	+	-	-	+			+	+	+	+		

TABLE 32

SOURCE NUMBER 1

Month	Total Plate Count	Presumptive Test					Confirmation Test									
							I		II		III		IV		V	
		I	II	III	IV	V	C	A	C	A	C	A	C	A	C	A
November	141	+	+	+	-	+	-	+	-	+	-	+			-	+
December	94	+	-	+	+	-	-	+			-	+	-	+		
January	104	+	+	+	+	-	-	+	-	+	-	+	-	+		
February	225	+	+	-	+	-	-	+	-	+			-	+		
March	300	+	-	+	-	+	-	+			-	+			-	+
April	210	+	+	+	-	-	-	+	-	+	-	+				

TABLE 33

SOURCE NUMBER 3

Month	Total Plate Count	Presumptive Test					Confirmation Test									
							I		II		III		IV		V	
		I	II	III	IV	V	C	A	C	A	C	A	C	A	C	A
November	218	+	+	+	-	-	-	+	-	+	-	+				
December	211	+	-	+	+	+	-	-			-	+	-	+	-	+
January	169	+	-	+	+	-	-	+			-	+	-	+		
February	168	+	+	+	+	+	-	+	-	+	-	-	-	+	-	-
March	162	+	-	-	-	-	-	+								
April	165	+	-	+	-	-	-	+			-	+				

TABLE 34

SOURCE NUMBER 7

Month	Total Plate Count	Presumptive Test					Confirmation Test									
		I	II	III	IV	V	I		II		III		IV		V	
							C	A	C	A	C	A	C	A	C	A
November	70	-	+	-	-	-			-	+						
December	58	+	-	-	-	-	-	+								
January	48	-	+	+	-	-			-	+	-	+				
February	89	+	+	+	+	-	-	-	-	+	-	+	-	-		
March	66	-	+	+	-	-			-	+	-	+				
April	109	+	+	+	-	-	-	+	-	+	-	-				

TABLE 35

SOURCE NUMBER 22

Month	Total Plate Count	Presumptive Test					Confirmation Test									
		I	II	III	IV	V	I		II		III		IV		V	
							C	A	C	A	C	A	C	A	C	A
November	132	-	+	-	-	+			-	+					-	+
December	102	-	+	-	+	+			-	+			-	+	-	+
January	85	+	+	-	-	-	-	+	-	+						
February	149	+	+	+	+	+	-	+	-	-	-	+	-	+	-	-
March	164	-	+	+	+	-			-	+	-	+	-	+		
April	186	+	-	+	+	-	-	+			-	+	-	-		

TABLE 36

SOURCE NUMBER 27

Month	Total Plate Count	Presumptive Test					Confirmation Test									
							I		II		III		IV		V	
		I	II	III	IV	V	C	A	C	A	C	A	C	A	C	A
November	170	-	-	-	+	+							-	+	-	+
December	190	+	+	-	-	-	-	+	-	+						
January	130	+	-	+	+	-	-	+			-	+	-	+		
February	283	+	+	+	+	+	-	+	-	-	-	+	-	+	-	-
March	210	+	+	-	+	+	-	+	-	+			-	+	-	+
April	208	-	-	+	+	+					-	+	-	+	-	+

TABLE 37

SOURCE NUMBER 35

Month	Total Plate Count	Presumptive Test					Confirmation Test									
							I		II		III		IV		V	
		I	II	III	IV	V	C	A	C	A	C	A	C	A	C	A
November	39	+	-	-	-	-	-	+								
December	33	-	-	+	+	-					-	+	-	+		
January	35	-	-	+	-	-					-	+				
February	80	-	-	+	+	+					-	+	-	+	-	+
March	162	-	-	+	-	+					-	+			-	+
April	213	+	-	+	-	-	-	+			-	+				

CHAPTER IV

DISCUSSION, SUMMARY, AND CONCLUSIONS

The sources of drinking water included in this survey are all used more or less constantly by the people of Trinidad. Those in the older parts of town use rope and bucket wells, which are kept repaired, or the city well, which is operated by an electric pump and is also kept under close observation. The newer parts of town are furnished water from the city line or from private wells, depending upon the preference of the owner. The wells and pumps of this type are kept in good condition.

The total count, the test for Colon-Aerogenes bacteria, and a study of the sources of water themselves were made in order that they might be used as checks on each other in determining the classification of each source with regard to sanitation. The tests were made over a period of time which should provide for any seasonal variations that might occur.

The total count on the samples vary slightly from month to month in all cases. There is no particular increase in the number of organisms present in the spring months over that of the autumn and winter in most cases. The slight increase in some few cases may be explained by the snow and heavy rains of that period. The contamination in the wells classified as doubtful was found equally at all times, and the total count in these was very little higher than in some cases classified as satisfactory.

The results of the tests on sources numbers 2, 4, 5, 6, 8, 9, 10, 11, 12, 13, 15, 16, 17, 20, 21, 23, 24, 25, 26, 28, 29, 30, 31, 32, 34, and 36 are shown in tables 2 through 27. All of these sources are wells operated by electric pumps. They are between twenty feet and forty feet in depth with the exception of one which is two hundred feet deep. The use of number 6 was discontinued after the December test due to trouble with the engine operating the pump, but the well could have been classified as satisfactory up to that time. With the exception of numbers 29, 30, and 32 all the wells of this group are classified as satisfactory since no Colon-Aerogenes bacteria were found at any time. Some false positive presumptive tests in February were probably due to contamination of the lactose broth as no growth was obtained in the confirmation tests.

Source number 29, as shown in Table 25, gave positive tests for Aerogenes bacteria in each sampling. The well at the surface of the ground was constructed and the pump attached for the prevention of seepage or drainage into the well, but the presence of soil bacteria in the water indicated a flaw somewhere in the well, pump, or pipes. Since the well is more than fifty feet from a source of fecal contamination and no Colon bacteria were found at any time, this well has been classified as doubtful.

Source number 30, as shown in Table 26, was found to be free of Colon-Aerogenes bacteria during the first five months of the survey, but during the last test both Colon and Aerogenes bacteria were found. Upon investigation it was found that the pump had been removed from the well during a time of excessive rainfall. Soon after the pump was returned, the last test of this survey was made and later the routine tests by the Texas Power and Light Company laboratory showed positive, and their results were confirmed by the state laboratory. The use of the well was immediately discontinued, and chlorinated lime was used as a purifying agent for both the well and the pipes. Later tests made by the plant laboratory showed the water to be free of both types of bacteria. It is believed that contamination occurred as the pump was changed and that the water from the well is now potable. The well is classified as satisfactory.

Source number 32, shown in Table 27, gave positive tests for Aerogenes bacteria in February, but since there had been no positive tests before and there were none afterward, contamination during handling seems to have occurred. The well has been classified as satisfactory.

Source number 33, shown in Table 28, is composed of four wells between thirty and forty feet in depth. From these the water is pumped into a common storage tank where it is chlorinated. This source is classified as satisfactory.

Source number 14, shown in Table 29, is an underground cistern in which rainwater is collected, stored, and purified by means of an activated charcoal filter. An electric pump is used to pump the water. Since no Colon-Aerogenes bacteria were found at any time, this source is classified as satisfactory.

Source number 19, as shown in Table 30, is a well-cased and covered well which uses a hand pump that is in good repair and does not have to be primed. One positive test at the beginning of the survey was probably due to contamination after the water was taken from the well since such a test was not obtained again. This well has been classified as satisfactory.

Sources numbers 1, 3, 7, 18, 22, 27, and 35 are all wells using a rope and bucket. All of these wells are walled with bricks and mortar, and the wall is extended well above the ground. With the exception of number 18, which is seldom used for drinking water, the wells are all checked regularly and kept in good condition. Sources of fecal contamination in all cases are more than fifty feet from the well. As shown in tables 31 through 37, Aerogenes bacteria were found in all tests, and Colon bacteria were found also in Number 18, Table 31. The possibilities of contamination by fecal bacteria as well as the soil bacteria from the rope and bucket being present at all times makes the classification of these wells doubtful even though no fecal bacteria were found in the majority of the cases. Number 18 is classified as unsatisfactory since Colon bacteria were found each month and the well is no longer repaired.

The survey was made in an attempt to find sources of fecal contamination. The well giving positive tests for Colon-Aerogenes bacteria and not having proper care was classified as unsatisfactory. The wells giving no positive tests for Colon bacteria but giving positive tests for Aerogenes bacteria were classified as doubtful. In all cases but one, these were rope and bucket wells. Where no evidence of Colon-Aerogenes bacteria was found at any time or means of correction of the fault were employed, the wells were classified as satisfactory.

Summary

1. A bacterial analysis was made of the thirty-six sources of drinking water of Trinidad, Texas, in an effort to determine the potability of each.

2. Each source was tested monthly from November 1, 1943 to April 13, 1944.

3. The field work included making a sanitary survey of each well and collecting the samples.

4. The experimental work included making total plate counts, presumptive tests, and confirmation tests with due regard to the methods for the examination of water made standard by the American Public Health Association and the American Water Works Association.

5. The results of the various tests were recorded in tabular form.

6. Survey findings and classifications of the sources as satisfactory, doubtful, or unsatisfactory with comments as to why certain classifications were given were discussed.

7. The number of bacteria showed no particular change with the change of seasons and the amount of rainfall. The Colon-Aerogenes bacteria, when present at all, were uniformly present throughout the testing period.

8. Aerogenes bacteria were found in all the rope and bucket wells but not in those wells closed at the top and using good pumps.

Conclusions

Of the thirty-six sources of drinking water in Trinidad, Texas, tested, seventy-seven and eight-tenths percent were classified as satisfactory, nineteen and four-tenths percent as doubtful, and two and eight-tenths percent as unsatisfactory.

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