Western Kentucky University
TopSCHOLAR®

Masters Theses & Specialist Projects | Graduate School

8-1935

A Comparative Pollution Study of the Domestic Water Supply of Warren County, Kentucky

Glenn Scott
Western Kentucky University

Follow this and additional works at: https://digitalcommons.wku.edu/theses

Part of the Biology Commons, and the Hydrology Commons

Recommended Citation
Scott, Glenn, "A Comparative Pollution Study of the Domestic Water Supply of Warren County, Kentucky" (1935). *Masters Theses & Specialist Projects.* Paper 3034.
https://digitalcommons.wku.edu/theses/3034

This Thesis is brought to you for free and open access by TopSCHOLAR®. It has been accepted for inclusion in Masters Theses & Specialist Projects by an authorized administrator of TopSCHOLAR®. For more information, please contact topscholar@wku.edu.

Scott,

Glenn Thomas

1935

A COMPARATIVE POLLUTION STUDY OF THE DOMESTIC WATER SUPPLY OF WARREN COUNTY, KENTUCKY

BY

GLENN THOMAS SCOTT

A THESIS

SUBMITTED IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF ARTS

WESTERN KENTUCKY STATE TEACHERS COLLEGE

AUGUST, 1935

Approved:-

Major Professor [illegible signature]

Department of -------Biology - M. C. Ford

Minor Professor [illegible signature] Wilson

Graduate Committee [illegible signature], Ch.

42651

CONTENTS

FIGURES AND TABLES

INTRODUCTION

The domestic water supply of Warren County, outside of the city of Bowling Green, is obtained from deep wells and springs. The county is about evenly divided into a southern section of cavernous limestone and a northern section of mixed sandstone and limestone formations.

The wells of the southern cavernous limestone region receive water from unfiltered underground streams and lakes. Most of the wells of the northern region are drilled in sandstone and the water, in a majority of cases, is filtered through porous sandstone and shale.

The purpose of this study was to make a comparative pollution study of the domestic water supply of Warren County.

REVIEW OF THE LITERATURE

The Kentucky State Board of Health for many years has analyzed domestic water supplies on request, and in cases of epidemics. These reports are sent to the persons requesting the analysis. Although the water of hundreds of wells and springs in Warren County has been analyzed, no real attempt has been made to establish the relationship between the kind of geological formation and the relative percent of polluted wells and springs.

Caird, after a study of fifteen years, proved the direct relationship between the percent of samples of a water supply showing Escherichia coli and the number of deaths from typhoid fever. The presence of Escherichia coli and Aerobacter aerogenes or any lactose fermenter in water indicates pollution. The presence of Aerobacter aerogenes alone, in a supply, merely indicates remote pollution or soil contamination which is not so objectionable and certainly not so dangerous as sewage pollution. Differentiation of colon organisms and other lactose gas formers in routine water analysis is of very great importance.

Turneare and Russell state that a rather high percentage of the wells and springs in limestone regions are polluted. Sandstone has twice as great a purifying effect on water as has limestone. The filtration is very effective in regions of thick alluvial soil.[1]

Kibbey states that there are a great many factors that may lead to contamination of wells and springs. Any well or spring which receives water that has flowed over the surface of the ground is open to suspicion. Very shallow wells in any region are easily polluted by deep cesspools. The drainage following impervious clay or rock enters the well unfiltered and probably polluted. If an open toilet is situated so that surface water from its immediate vicinity may enter a well or spring, water of this type is to be condemned. If the nature of a soil is such that rain water may percolate unfiltered through it from the vicinity of an open toilet and reach the well or spring it is to be considered almost as dangerous.[2]

Ehlers and Steele state that springs and wells located in limestone strata may be connected and receive pollution from great distance. The water which seeps into the ground will be filtered naturally as it moves by gravity to subsurface water, but may or may not receive sufficient filtration to remove pollution.[3]

Turneare and Russell say the surface openings or mouths of all wells should be well protected so as to prevent the possibility of surface wash gaining entrance. Open top and bucket type wells may be extremely dangerous disseminators of disease, especially during a typhoid epidemic in a community.

The geological formation has a much greater influence upon the quality of ground water than have surface conditions. The statement is often made, "I have a wonderful spring of pure water that comes from solid rock." This statement is very misleading and incorrect since water that comes from rock must pass through a crevice or hole in the rock and in many instances travel for a considerable distance through a cave or other channels without any purification. Instances are on record where this type of contamination has been definitely traced for over a mile. Limestone is therefore the most treacherous formation from which to secure a ground water supply.[4]

Deep well contamination from cesspools and other sources is very common in limestone formation, where the sewage enters a water channel coming near the surface and follows this same channel to great depths.[5]

While deep ground water is presumably free from bacteria, or at least nearly so, water as it is taken from wells almost always contains an appreciable bacteria content. In the case of shallow dug wells, where opportunity for pollution from above or seepage from sides is present, and where the temperature of a considerable mass of water is such as to permit more rapid bacterial growth, it is not at all uncommon to find many hundreds of organisms per cubic centimeter.[6]

1 F. E. Turneaure and H. L. Russell, Public Water Supplies (New York, John Wiley and Sons, Third Edition, 1929), pp. 87-110.
2 C. H. Kibbey, Principles of Rural Sanitation (Philadelphia, F. A. Davis and Co., 1927), pp. 185-201.
3 Victor M. Ehlers and Ernest W. Steele, Municipal and Rural Sanitation (New York, McGraw Hill Book Co., First Edition, 1929), pp. 82-[illegible].
4 Turneaure and Russell, loc. cit.
5 Ibid.
6 Ibid.

DESCRIPTION OF AREA

Warren County lies in the Mississippian formation, with the exception of a small portion in the northern part of the county which is in the Pennsylvanian sandstone area (Figure I).

From north to south the county is composed of three distinct regions, the Northern Pennsylvanian, the Chester, and the Pennyrile Plateau. The Northern Pennsylvanian area is characterized by the Pottsville sandstone. Asphaltic impregnated conglomeratic sandstone of the Pottsville age occurs in a restricted area bordering Green River in the extreme northern part of the county. Small veins of coal occasionally occur in this region.

Bordering this area and extending from the mouth of Clifty Creek south to the edge of Dripping Springs escarpment is the Chester area. This area is alternating sandstone shales and limestone. The divisions forming this area, from the face of the Dripping Springs escarpment north, are Renault Paint Creek limestone, Cypress sandstone, Golconda limestone, Hardinsburg sandstone, Glen Dean limestone, and Tar Springs sandstone. The sandstone forms the flats, while the limestone and shale form the much broken areas between the flats.

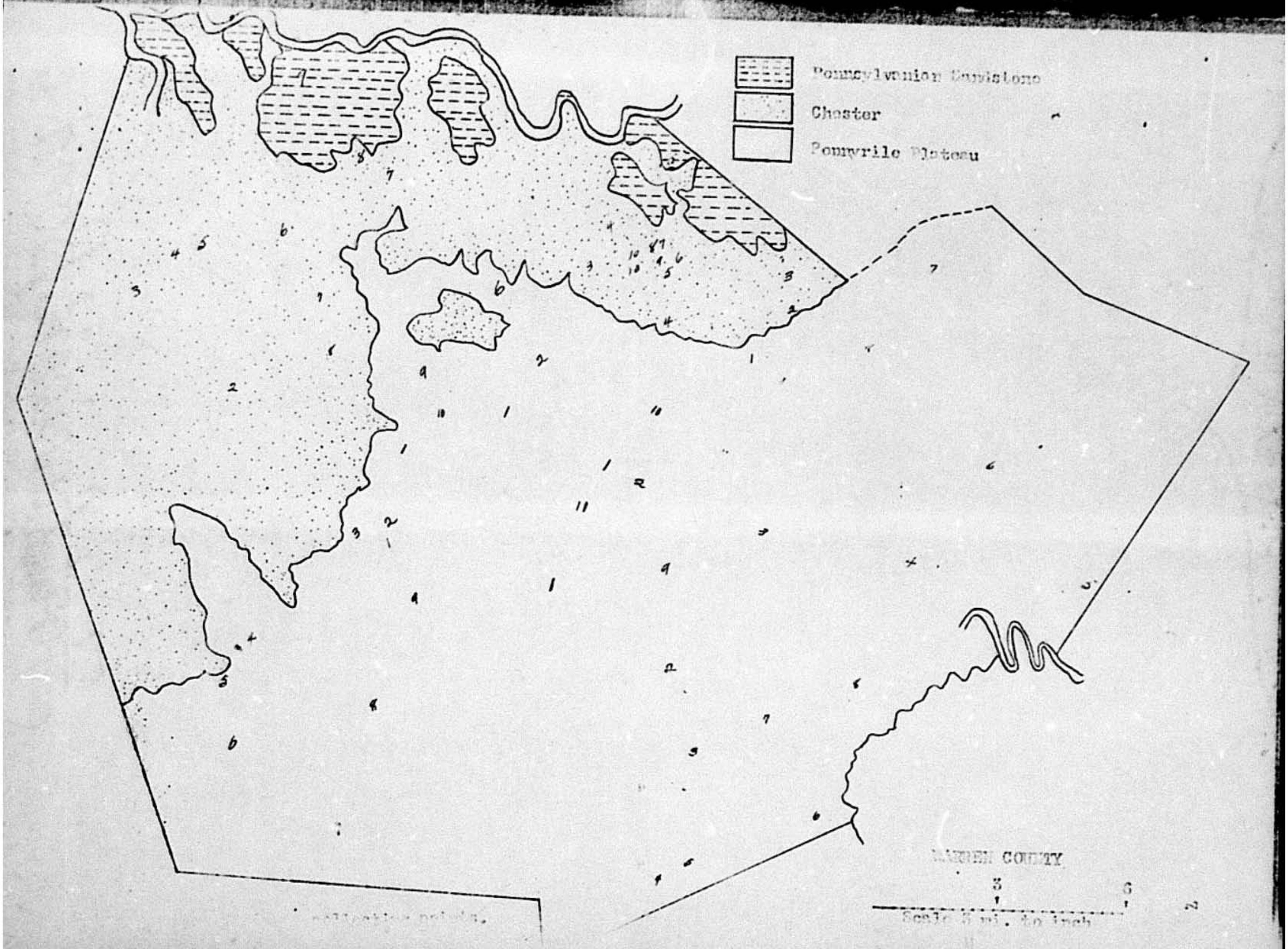
To the south of the Chester escarpment lies the relatively level Pennyrile Plateau, which composes sixty percent of the area of the county. This region is made up entirely of limestone, including St. Genevieve, St. Louis, Warsaw, and Fort Payne. The limestone of the Mississippian formation is from four hundred to six hundred feet in thickness. Bordering the southern edge of the county another formation, the Osage, outcrops in places.

The pitted or sinkhole areas, characteristic of the St. Louis and St.

Genevieve division of the Mississippian limestone system, are characterized by the widely ramifying subsurface drainage developed in these limestones. These subterranean channels have contributed natural sewage channels for the city of Bowling Green. Little or no surface drainage occurs in this area.

A recent topographic map of the Bowling Green quadrangle showed 2,563 sinks. A close check of some quadrangles of this region revealed about 4,500 separate and distinct sinkholes that were outlets for surface water.

The county is also well known for its large sinking streams. The streams of this group, fall into sinkholes, merge into other Karst drainage, and follow cavernous courses eventually flowing into Green River at some unknown point. The great subcarboniferous limestone underlying this type of region is no doubt literally honeycombed with subterranean channels.


Pennsylvanian Sandstone
Chester
Pennyrile Plateau
BARREN COUNTY
3
6
Scale 3 mi. to inch
collection points.

METHODS OF STUDY

In sampling the water supply a map of the county was used, and sixty samples in six groups of ten each were taken from the different areas of the county. The location of each supply was indicated on the map by a number.

The sampling containers were sterilized 250 c.c. Erlenmyer flasks carefully plugged with cotton. To further prevent contamination the necks and cotton plugs of the flasks were wrapped in paper. The water from each well sampled was pumped for several minutes in order to get the sample directly from the source. The samples, when taken, were promptly placed into an iced box where they remained until testing operations were begun. Important facts relative to the well sampled were recorded, such as kind of stone predominating, type and depth of well, distance to bedrock, water return into well, distance to toilets, cesspools, or barns, and general topography.

Tests were begun immediately on returning to the laboratory. In order to get some preliminary knowledge of the total number of bacteria per cubic centimeter, samples were plated on water agar. The lactose broth presumptive test was also used and this was supplemented by the differential Endes test. Three types of tests were made: first, to determine the evidence of surface water in the supply, second, to determine the total number of bacteria per cubic centimeter, and third, to confirm the presence or absence of the colon group of bacteria indicating pollution by fecal matter.

Lactose broth in fermentation tubes was used. Formation of acid and gas in these tubes indicated the presence of the coli-aerogenes group. For each sample four tubes of lactose broth were used. Two containing 40 c.c.

of the broth were inoculated with 10 c.c. of the sample, and the other two containing 10 c.c. of broth were inoculated with 1 c.c. of the sample. These tubes were incubated at 37° C. for forty-eight hours. The amount of gas formed in the small inverted tube was recorded at twenty-four and forty-eight hour periods. These readings were grouped, first, as positive presumptive test where the gas formed within twenty-four hours occupied ten per cent or more of the inverted vial; second, as doubtful tests where no gas was formed in twenty-four hours, or if the gas formed was less than ten per cent the incubation was continued to forty-eight hours and a second reading made; and third, as negative test where no gas formed during forty-eight hours. Water not showing the presence of gas-forming organisms, but having a total bacterial count of more than one hundred to two hundred per c.c., is usually considered undesirable for domestic uses.

Nutrient agar plates were used in determining the total bacterial count. Two dilutions were used to each sample, 1 to 100 and 1 to 10. Duplicates of all dilutions were made. The plates were incubated for thirty-six hours at 37° C; then the plate counts were recorded.

The fermentation tubes showing gas were tested with the differential medium Endo's. Dilutions were secured by inoculating sterile water in tubes to prevent the aerogenes group from covering the coli. At the end of twenty-four hours the plates were examined, the coli being distinguished from other organisms by small, well isolated colonies having very dark centers. The aerogenes group produces larger colonies than coli, with neighboring colonies showing a tendency to run together and not possessing a metallic sheen as do the coli.

The water was designated as good where it showed a negative test or no gas formation in forty-eight hours, or polluted where it fermented lactose broth with the formation of acid and gas. If polluted, samples were classified as showing or not showing traces of sewage or coli.

RESULTS

One objective in making this study was to determine the per cent of the domestic water supply of Warren County that was polluted.

The presence of gas formers is a positive presumptive test indicating surface water contamination, which in most cases is undesirable. This may mean remote pollution or simply soil contamination, but it most probably means sewage in the supply. Since sewage contamination is far more dangerous than other lactose fermenting organisms, it is of great importance to differentiate between coli and these types in water examination.

The second purpose was to compare the relative pollution in the two main geological areas, limestone and sandstone. As pollution in the sense of surface water contamination was so high it was necessary to analyze the results on the basis of the presence or absence of coli in the different geological areas.

Of the sixty samples taken (Table VII) fifty-seven fermented lactose broth with the production of acid and gas, and three gave a negative test. In other words, according to this study ninety-five per cent of the water supply of the county was contaminated with surface water. When these specimens were subjected to the differential medium, Endos, to confirm the presence of Escherichia coli thirty-three produced the coli type of colonies and from twenty-four samples there developed colonies that were not of the coli type. Therefore, fifty-eight per cent of the polluted samples showed sewage contamination. In this group forty-eight wells were tested, twenty-five of which showed bacteria coli, which was fifty-two per cent of the total number polluted. Of the nine springs tested five showed coli, or fifty-six per cent direct sewage pollution.

It is a recognized fact that the relative pollution of the water supply varies greatly with the geology of the region. In order to reach conclusions relative to this matter the results of the sampling were divided into two large groups, one from the limestone region and the other from the sandstone. There were thirty-one polluted wells in the limestone group, twenty of which showed typical coli colonies. Thus, sixty-five per cent of the wells in the limestone region were contaminated by fecal matter. Of the springs tested in this region all contained Escherichia coli.

In the sandstone area fourteen wells were given the Endo differential test. Five of these showed presence of coli or a thirty-six per cent sewage pollution for the sandstone group, as compared with the sixty-five per cent sewage pollution of the limestone group.

It is a known fact that various types of limestone and sandstone differ greatly in their structure. The sandstones vary in porosity. The limestones vary in their solubility in water, which governs the formation of caves and fissures through which water may flow. It was deemed advisable to determine the location of wells and springs in the different geological types of the two formations (Table I).

TABLE I
MISSISSIPPIAN LIMESTONE FORMATION

Type of Limestone	Number of Wells	Polluted	Coli	Per Cent Coli
St. Genevieve	9	9	8	89
St. Louis	15	14	6	40
Warsaw	7	5	3	43
Paint Creek	1	1	1	100
Leitchfield	2	2	2	100

TABLE II
MISSISSIPPIAN AND PENNSYLVANIAN SANDSTONE FORMATION

Kind	Number of Wells	Polluted	Coli	Per Cent Coli
Cypress	5	5	2	40
Hardinsburg	7	7	2	29
Pottsville	2	2	1	50

From Table II it appears that the water supply in the Hardinsburg sandstone is the most nearly free of Escherichia coli.

TABLE III
SPRINGS

Type of Stone	Number of Springs	Polluted	Coli	Per Cent Coli
St. Genevieve	2	2	2	100
Paint Creek	3	3	3	100
Cypress	2	2	1	50
Hardinsburg	2	2	0	0

There were so few samples taken in the sandstone area a definite conclusion could not be made for that area separately. It seems well to note the close relation in the per cent of sewage pollution between wells and springs in the same type of rock (Tables II and III).

Analysis of the nutrient agar plate counts yielded interesting results (Table IV). Experiments heretofore have proved that the aerogenes group lives much longer in underground water than do pathogens. Where the plate counts were low the coli group was usually not present, but with very high total bacterial counts they were usually found.

TABLE IV
RELATIONSHIP BETWEEN HIGH-PLATE COUNT AND THE PRESENCE OF COLI

Type of Organism	Number of Samples	Bacteria Count per C. C.	
		Less than 200	More than 200
Coli	33	27%	73%
Other Growth	24	54%	46%

Coli are not as hardy as the aerogenes organisms, for they do not survive unless there is a fresh supply of sewage and surface water. High total counts are always a sign of surface pollution, which may be caused by harmless organisms. Water supplies having a high bacterial count should receive further analysis.

There seems to be a definite relationship between the group of organisms and the amount of gas produced from the fermentation of lactose broth (Table V).

TABLE V
RELATION BETWEEN PER CENT OF GAS FORMED AND PER CENT OF COLI

Type of Organism	Number of Samples	Bacteria Count Per C. C.	
		Less than 40	More than 40
Coli	33	30%	70%
Aerogenes	24	52%	48%

Of the sixteen in the coli group that produced more than forty per cent gas, five of these showed very high bacterial count from four hundred to two thousand per c.c. An excess number of coli would, under normal conditions, very probably produce more than forty per cent gas in forty-eight hours.

TABLE VI
RELATIONSHIP BETWEEN CONSTRUCTION OF WELL AND BACTERIA CONTENT

Type	Number	No Gas	Coli	Per Cent Coli
Pump	21	3	9	43
Walled	11	0	4	37
Open Top Cased	16	0	9	56

There is not enough variation between the wells equipped with a pump or an open top to prove that they are contaminated at the surface (Table VI). For example, the wells with a pump showed forty-three per cent contamination by coli, whereas the open top walled wells showed coli contamination in only thirty-seven per cent of the cases. The open top cased well gave a fifty-six per cent fecal matter contamination, but an average of both types, the open top cased and the open top walled, gave forty-nine per cent fecal matter contamination. From these figures it is evident that the chief reason for the high per cent pollution of the domestic water supply of the county is geological rather than because of other conditions.

SUMMARY

The relative pollution study of the domestic water supply of Warren County revealed a very high percentage of pollution. Fifty-six per cent of the supply received direct sewage contamination. The springs showed a higher per cent sewage pollution than the wells. The comparison of the pollution in the sandstone and limestone, proved that geological formation had a great deal of influence on the ground water. The wells and springs of the limestone area showed sixty-five per cent sewage pollution as compared with the thirty-three per cent sewage pollution of the sandstone area.

The wells were grouped according to the different types of limestone and sandstone for the purpose of determining the effect of these different types of geological formation on the relative pollution of the water. There was a marked difference in the number of wells showing sewage contamination with the different types of limestone. The soft white St. Louis and the very much broken Leitchfield formations showed a very high per cent of sewage pollution.

Aerogenes in seventy per cent of the cases produced more than forty-per cent gas in forty-eight hours.

In the case of the nutrient agar plate count where there were two hundred or more bacteria per cubic centimeter, in seventy-three per cent of the cases coli were present.

A grouping of the wells as to type, pump, walled, and open top cased, indicated that the pollution is not in the main due to construction, but to the geological formation or surface topography.

TABLE VII

Sample	Type	Percentage Gas 24 hours	48 hours	Bacterial Count No. to C.C.	Endo's	Type of Substratum	Geological Type	Water Return into well	Topography and General Remarks
1	Well	30	45	200	Growth	Limestone	St. Louis	Yes	Flat, no sinks near
2	Cistern	0	20	200	Coli			Yes	Open top
3	Well	0	0	15		Limestone	Warsaw	No	Well drained
4	Well	0	9	5	Growth	Limestone	Warsaw	No	Hilly, no barns near
5	Well	0	10	265	Coli	Limestone	Warsaw	No	Low and swampy
6	Well	3	12	250	Growth	Limestone	Warsaw	Yes	On hill, open top
7	Well	17	28	2000	Coli	Limestone	St. Louis	Yes	Indoor toilet near
8	Well	25	38	85	Coli	Limestone	Warsaw	Yes	Very hilly
9	Cistern	9	18	100	Coli			Yes	Bad odor, effervesence
10	Cistern	0	5	5	Growth			No	Metal roof, pit toilets
1	Well	18	30	250	Coli	Limestone	St.Genevieve	No	Septic tank, rolling
2	Spring	21	38	350	Coli	Limestone	Paint Creek	Yes	Hilly, cattle near
3	Well	26	37	200	Growth	Sandstone	Hardinsburg	Yes	Rolling, walled well
4	Well	0	40	100	Growth	Sandstone	Hardinsburg	Yes	Well over-flows at top
5	Spring	25	38	130	Coli	Limestone	Paint Creek	Yes	Barns on hill above

Sample	Type	Percentage Gas 24 hours	48 hours	Bacterial Count	Endo's	Type of Substratum	Geological Type	Water return into well	Topography and General remarks
6	Well	10	50	600	Coli	Sandstone	Cypress	Yes	High ridge
7	Well	22	54	400	Coli	Sandstone	Cypress	Yes	High ridge, walled well
8	Well	30	40	400	Growth	Limestone	St. Louis	Yes	Casing, flat, almost swampy
9	Well	22	30	2000	Coli	Limestone	St.Genevieve	Yes	Casing above ground, several houses near.
10	Well	23	31	300	Coli	Limestone	St.Genevieve	Yes	Houses near
1	Well	28	60	225	Coli	Limestone	St.Genevieve	No	Barn near, hilly, sulphur water
2	Spring	12	40	850	Coli	Limestone	Paint Creek	Yes	Hilly, base of high hill
3	Well	25	55	5000	Coli	Limestone	Paint Creek	Yes	Hilly, planked top
4	Well	10	35	20	Coli	Limestone	St.Genevieve	No	Level, oil in water
5	Well	15	45	200	Coli	Limestone	St.Genevieve	No	Level
6	Well	15	37	200	Coli	Limestone	St. Louis	No	Very level
7	Well	24	54	175	Coli	Limestone	St. Louis	No	Very level, small town well
8	Well	28	50	10	Growth	Limestone	St. Louis	No	Very level
9	Well	20	50	10	Growth	Limestone	St. Louis	No	Level
10	Well	25	40	125	Coli	Limestone	St. Louis	No	Level, white sulphur well

Sample	Type	Percentage Gas 24 hours	48 hours	Bacterial Count	Endo's	Type of Substratum	Geological Type	Water return into well	Topography and Remarks
1	Well	40	67	250	Growth	Limestone	St. Louis	Yes	Rolling, casing
2	Well	0	9	25	Growth	Limestone	St. Louis	No	High ridge
3	Well	0	0	20	0	Limestone	St. Louis	No	Ridge, no houses near
4	Well	20	65	200	Coli	Limestone	St. Louis	No	Casing, high ridge
5	Well	30	60	2000	Coli	Limestone	Warsaw	No	Level, several houses near
6	Well	0	0	10	0	Limestone	Warsaw	No	Rolling, sulphur water
7	Spring	30	65	200	Coli	Limestone	St.Genevieve	No	Level, walled on sides and top
8	Well	10	55	265	Coli	Limestone	St. Louis	No	Rolling, small town well
9	Well	40	55	4000	Coli	Limestone	St.Genevieve	Yes	Level, casing
10	Spring	20	45	100	Coli	Limestone	St.Genevieve	Yes	Rolling
11	Well	20	45	100	Growth	Limestone	St. Louis	No	High hill
12	Well	30	60	20	Growth	Limestone	St. Louis	Yes	Hilly, walled
13	Well	20	41	5	Growth	Sandstone	Hardinsburg	No	Level, shallow well
14	Well	12	25	5	Growth	Sandstone	Hardinsburg	No	Level, 17 ft. deep
15	Well	35	60	2000	Coli	Sandstone	Pottsville	Yes	Walled wooden top, side of hill

Sample	Type	Percentage Gas 24 hours	48 hours	Bacterial Count	Endo's	Type of Substratum	Geological Type	Water return into well	Topography and Remarks
6	Well	28	40	700	Growth	Sandstone	Cypress	No	Well drained, no sinks near
7	Well	35	45	2000	Coli	Sandstone and Shale	Leitchfield	Yes	Level country, open top, walled
8	Well	25	55	100	Coli	Limestone	Leitchfield	Yes	Casing and sand bucket
9	Well	50	65	500	Growth	Sandstone	Pottsville	Yes	Water in bed of coal
10	Spring	10	14	150	Growth	Sandstone	Hardinsburg	Yes	Hilly region
1	Well	30	50	500	Growth	Limestone	St.Genevieve	Yes	Walled, level
2	Spring	15	35	1000	Growth	Sandstone	Cypress	Yes	Top of escarpment
3	Well	20	40	900	Growth	Sandstone	Cypress	Yes	High, escarpment
4	Well	18	40	350	Coli	Limestone	St.Genevieve	Yes	Level region
5	Spring	30	55	100	Coli	Sandstone	Cypress	No	High, escarpment
6	Well	25	40	300	Growth	Sandstone	Cypress	Yes	Very shallow, escarpment
7	Well	28	45	800	Growth	Sandstone	Cypress	Yes	Sand hill
8	Cistern	30	45	400	Coli	Sandstone	Hardinsburg	No	Has seep
9	Well	25	65	300	Growth	Sandstone	Hardinsburg	Yes	Level, open top
10	Spring	25	45	50	Growth	Sandstone	Hardinsburg	Yes	Base of hill

BIBLIOGRAPHY

American Public Health Association, Standard Methods of Water Analysis (Lancaster, Pa., Lancaster Press, Inc., Seventh Edition, 1933), pp. 111-156.

Ehlers, Victor M., and Steele, Ernest M., Municipal and Rural Sanitation (New York, McGraw Hill Book Co., First Edition, 1929), pp. 62-80.

Kibbey, C. H., Principles of Rural Sanitation (Philadelphia, F. A. Davis and Co., 1927), pp. 185-201.

Levine, Max, Bacteria Fermenting Lactose and Their Significance in Water Analysis (Ames Iowa, Iowa State College of Agriculture and Mechanic Arts), pp. 5-99.

Prescott, Samuel Cate, and Winslow, Charles-Edward A., Elements of Water Bacteriology (New York, John Wiley and Sons, Fifth Edition, 1931), pp. 58-150.

Turneaure, F. E., and Russell, H. L., Public Water Supplies (New York, John Wiley and Sons, Third Edition, 1929), pp. 87-110.