MICROBIAL QUALITY OF WATER IN OLD WELLS AND THE PUBLIC DISTRIBUTION SYSTEM IN THE U.S. VIRGIN ISLANDS

by

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Completion Report
Project No. A-015-VI
Agreement No. 14-34-0001-1150

October 1981

The work upon which this report is based was supported in part by funds provided by the United States Department of the Interior, as authorized by the Water Research and Development Act of 1978

Technical Report No. 8
Water Resources Research Center
Caribbean Research Institute
College of the Virgin Islands
St. Thomas, USVI 00802

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ACKNOWLEDGMENT

The authors wish to thank Dr. Richard Champney, his colleagues, the administration, and staff of the Caribbean Research Institute for their support in undertaking this project.

ABSTRACT

The Virgin Islands public water supply must meet the published standards in the provisions of the Safe Drinking Water Act (Public Law 93-523). The objective of this study was to determine whether there exists a potential health hazard to users of the Virgin Islands public water supply and old water wells. These old wells which were built in the early 1900's could serve as an alternate water source in water-short areas.

Coliform bacteria were used as the reference indicator for bacteriological quality. The presence of fecal streptococcus and Salmonella spp. was ascertained as potential indicators of water quality.

The public water distribution system and old wells did not generally meet the microbiological standards set forth in the Safe Drinking Water Act. Fecal streptococcus and Salmonella spp. were excellent indicator organisms of fecal pollution. A potential health hazard is believed to be associated with the public water distribution system in St. Croix and St. Thomas.

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drinking water in the U.S. Virgin Islands, there have been suggestions that old wells, built in the early 1900's and closed when public distribution system was built, be used as an alternative water source and be re-opened. These old wells would certainly enhance the supply of drinking water in the U.S. Virgin Islands. Therefore, our study also included a microbial analysis of the water in the old wells to determine whether the water was potable based on these microbiological standards.

PROCEDURE

Commercially available bags (Whirl-pak) were used to contain the samples. The bags were sterile, sealed in manufacture, and opened only at the time of sampling. When sampling deep wells, the bags were weighted and then lowered into the water. The bags were pulled out of the water and back into the water several times, thus simulating a scooping motion.

Within a few hours after the water samples had been taken, they were microbiologically analyzed.

The membrane filter method provided a direct count of bacterial colonies on the surface of the filter. The sample was filtered soon after collection. After the sample was filtered, the membrane filter was placed on media formulated to encourage growth of the bacteria for which the test was designed. At least four different tests were performed on each sample. Bacterial analyses were conducted in accordance with the ana-

lytical recommendations set forth in "Standard Methods for the Examination of Water and Wastewater," (American Public Health Association, 1975). The standard sample used was 100 milliliters.

The coliform group includes all of the aerobic and facultative anaerobic, gram-negative, nonspore-forming, rod-shaped bacteria that ferment lactose in 24-48 hours at 35°C. This definition includes the genera: Escherichia, Citrobacter, Enterobacter, and Klebsiella. M-Endo broth was used to detect the presence of coliform bacteria. Verification of total coliform colonies was accomplished by transferring selected sheen colonies into phenol red lactose broth. After incubation at 35°C for 24-48 hours, confirmed acid and gas tubes were reported.

The term, "Fecal Streptococcus" and "Lancefield's Group D Streptococcus" have been used synonymously. "Fecal streptococci" is used to indicate sanitary quality of water. A suitable volume of sample (100m) was passed through the 0.45um membrane filter, which was then placed on Sodium Azide broth and incubated at 35°C for 48 hours.

The genus Salmonella is comprised of a large number of serologically related gram negative, nonspore-forming bacilli. Ordinarily salmonellae do not ferment lactose or sucrose but ferments glucose. A suitable volume of sample (100ml) was passed through the 0.45um membrane filter, which was then placed on Bismuth Sulfite agar and incubated at 35°C.

RESULTS AND DISCUSSION

The total bacterial count (Tables 1 and 2) provided a means of determining the density of aerobic and facultative anaerobic bacteria. This was an empirical measurement since no single growth medium will satisfy the physiological requirements of all the bacteria in a water sample. A colony count of less than 100 bacteria/ml is the standard used to judge whether a sample is suitable for drinking purposes. Variations of normally good results may suggest disturbances in the distribution system. Sudden increases in colony counts have been reported to precede waterborne disease outbreaks. The total bacterial count usually will provide statistical data suggesting when contamination of water supply is occurring.

All of the old wells on St. Croix and St. Thomas exceeded the total bacterial quality standards. The public systems in St. Croix and St. Thomas showed great variation in results. In St. Croix the water from the well fields possess a high level of bacteria whereas water from WAPA and Martin Marietta was within the bacterial standards. In St. Thomas, except for 8/81, the water in the public distribution system exceeded the bacterial standards.

If a standard of 2 coliforms/100ml is applied to these samples, to indicate fecal pollution, then 84.4% of the water samples can be considered nonpotable. The total coliform counts are shown in Tables 3 and 4. Failure to meet the coliform standard was frequent in both the old wells and public distribution

TABLE 1

TOTAL BACTERIAL COUNT - ST. CROIX

CELLS/100ml

	Oct. 1980	Nov. 1980	March 1981	June 1981	Aug. 1981
St. Croix Wells					
Prince St., F'sted.	TNTC	TNTC	TNTC	1.4×10^5	TNTC
New St., F'sted.	TNTC	TNTC	TNTC	1.4×10^5	TNTC
Queen St., F'sted.	TNTC	TNTC	TNTC	9.2×10^4	TNTC
Market St., F'sted.	TNTC	N.D.	TNTC	TNTC	1.8×10^5
Water Gut, C'sted	TNTC	N.D.	5.6×10^4	2.7×10^5	6.2×10^4
Wharf, C'sted.	TNTC	TNTC	7.4×10^4	TNTC	TNTC
Market Place, C'sted.	TNTC	TNTC	3.7×10^4	8.5×10^4	1.4×10^5
East St., C'sted.	TNTC	N.D.	1.1×10^5	9.5×10^4	TNTC
St. Croix, Public					
Public Works Tank, C'sted.	TNTC		7.5×10^2	0	N.D.
LaGrande Princess	TNTC	9.4×10^2	3.8×10^4	3.0×10^3	2.0×10^3
WAPA	N.D.	N.D.	1.2×10^3	2.0×10^3	0
Fair Plains Wells Field-No Cl_2	N.D.	N.D.	TNTC	TNTC	2.0×10^3
Fair Plains Wells Field-Cl_2	4.5×10^1	N.D.	TNTC	1.0×10^3	N.D.
Martin Marietta	1.5×10^1	N.D.	0	1.0×10^3	N.D.
Sewage Treatment Plant Effluent	1.8×10^2	N.D.	N.D.	N.D.	0
Concordia Wells Field	N.D.	N.D.	7.6×10^4	N.D.	5.0×10^3
Public Works Tanks, F'sted.	N.D	N.D.	TNTC	4.6×10^4	0

F'sted. - Frederiksted
C'sted. - Christiansted
N.D. - Not Done
TNTC - Too Numerous to Count

TABLE 2

TOTAL BACTERIAL COUNT - ST. THOMAS

CELLS/100ml

	Oct. 1980	Nov. 1980	March 1981	June 1981	Aug. 1981
St. Thomas Wells					
Market Square	TNTC	7.0×10^{3}	TNTC	TNTC	TNTC
Western Cemetery	TNTC	TNTC	TNTC	TNTC	TNTC
Savan	TNTC	TNTC	TNTC	N.D.	TNTC
Old Hospital	1.4×10^{3}	TNTC	TNTC	3.6×10^{4}	3.2×10^{4}
St. Thomas Public					
Western Cemetery Standpipe	TNTC	N.D.	4.5×10^{3}	4.4×10^{4}	0
De Jongh Gut Standpipe	TNTC	TNTC	N.D.	N.D.	N.D.
Evans Grocery Standpipe	N.D.	8.8×10^{3}	N.D.	2.0×10^{3}	1.5×10^{3}
PWD Sub Base	7.0×10^{2}	1.1×10^{3}	TNTC	N.D.	0
Port Authority Airport	9.0×10^{3}	3.2×10^{3}	TNTC	3.7×10^{4}	TNTC
Sebastian	TNTC	7.0×10^{4}	1.2×10^{4}	TNTC	0
Polyberg Standpipe	TNTC	TNTC	N.D.	3.0×10^{3}	2.8×10^{4}
Antilles Airboats	7.5×10^{2}	2.0×10^{1}	5.8×10^{4}	3.0×10^{3}	2.0×10^{3}

N.D. - Not Done

TNTC - Too Numerous to Count

TABLE 3

TOTAL COLIFORM

CELLS/100ml

	Oct. 1980	Nov. 1980	March 1981	June 1981	Aug 1981
St. Croix Wells					
Prince St., F'sted.	TNTC	TNTC	TNTC	9.3×10^4	6.0×10^3
New St., F'sted.	7.0×10^2	2.0×10^4	1.4×10^3	1.8×10^5	0
Queen St., F'sted.	3.0×10^3	TNTC	6.6×10^4	6.2×10^4	0
Market St., F'sted.	TNTC	1.3×10^4	1.8×10^5	3.9×10^5	1.5×10^4
Water Gut, C'sted.	9.0×10^2	TNTC	2.0×10^3	3.0×10^4	1.5×10^3
Wharf, C'sted.	TNTC	2.1×10^4	3.1×10^4	9.0×10^3	4.5×10^3
Market Place, C'sted.	TNTC	TNTC	1.0×10^4	4.7×10^4	5.0×10^2
East St., C'sted.	TNTC	TNTC	7.5×10^3	4.6×10^4	5.0×10^3
St. Croix Public					
Public Works Tank, C'sted.	4.2×10^3	0	5.0×10^3	0	N.D
LaGrande Princess	3.5×10^2	8.3×10^2	4.5×10^2	0	0
WAPA	N.D.	TNTC	1.3×10^2	0	0
Fair Plains Wells Field No Cl_2	N.D.	N.D	5.5×10^3	3.4×10^5	0
Fair Plains Wells Field Cl_2	0	N.D.	1.9×10^3	0	N.D
Martin Marietta	0	N.D.	1.5×10^2	0	N.D.
Sewage Treatment Plant Effluent	0	N.D.	N.D.	N.D.	0
Concordia Wells Field	N.D.	N.D.	7.5×10^2	0	0
Public Works Tank, F'sted.	N.D.	N.D.	6.1×10^4	0	0

F'sted - Frederiksted
C'sted - Christiansted
N.D. - Not Done
TNTC - Too Numerous to Count

TABLE 4

TOTAL COLIFORM

CELLS/100ml

	Oct. 1980	Nov. 1980	March 1981	June 1981	Aug. 1981
St. Thomas Wells					
Market Square	TNTC	1.2×10^{3}	7.0×10^{4}	TNTC	0
Western Cemetery	7.5×10^{3}	1.1×10^{3}	1.3×10^{4}	TNTC	0
Savan	TNTC	3.0×10^{3}	TNTC	-	-
Old Hospital	TNTC	7.5×10^{2}	5.0×10^{3}	2.0×10^{3}	5.0×10^{2}
St. Thomas Public					
Western Cemetary Standpipe	2.0×10^{3}	1.0×10^{2}	4.5×10^{2}	2.2×10^{4}	0
De Jongh Gut Standpipe	1.0×10^{3}	2.5×10^{3}	-	-	-
Evans Grocery Standpipe	1.1×10^{2}	2.0×10^{1}	-	0	0
PWD Sub Base	4.1×10^{2}	5.6×10^{2}	1.0×10^{5}	3.6×10^{4}	0
Port Authority Airport	1.1×10^{4}	1.1×10^{2}	6.8×10^{4}	4.2×10^{4}	3.0×10^{3}
Sebastian	9.6×10^{3}	-	8.5×10^{3}	TNTC	0
Polyberg Standpipe	3.3×10^{2}	5.0×10^{1}	-	0	0
Antilles Airboats	1.0×10^{3}	0	1.4×10^{3}	1.0×10^{3}	0

N.D. - Not Done

TNTC - Too Numerous to Count

system. The water samples from the St. Thomas distribution system consistently exceeded the coliform standard, whereas samples from the St. Croix distribution system on 6/81 and 8/81 for most part conformed to the coliform standard.

The total coliform group has been used as an indicator of reduction of pathogenic bacteria in wastewaters. It has also been used as an indicator of fecal pollution of water. The presence of coliform bacteria in drinking water should initiate an immediate search for the contamination source.

The fecal streptococci (Tables 5,6) and Salmonella (Tables 7,8) data, again indicated contamination of wells and public water systems from fecal origin. Fecal streptococci are excreted regularly by humans in lower abundance than E. coli. Therefore, they can be considered a good indicator of fecal pollution. Salmonella spp. are carried and can be potentially spread to man by all types of animals.

In general, the microbiological data for the wells on both St. Croix and St. Thomas indicate that they do not offer the potential of an increased supply of potable water for the inhabitants of these two islands. Assuming that the water chemistry is acceptable, water purification would be needed.

The public distribution study revealed several major facts: (1) The water throughout the system is frequently highly contaminated. Although the degree of contamination is not the same throughout the system, there is no discernible pattern, e.g., at times the water at WAPA had lower bacterial counts than other sampling sites; at other times they were higher.

FECAL STREPTOCOCCUS

CELLS/100ml

	Oct. 1980	Nov. 1980	March 1981	June 1981	Aug 1981
St. Croix Wells					
Prince St., F'sted.	TNTC	1.1×10^3	0	5.6×10^4	0
New St., F'sted.	1.4×10^2	8.7×10^3	0	0	2.0×10^3
Queen St., F'sted.	1.3×10^2	TNTC	4.8×10^3	3.6×10^4	0
Market St., F'sted.	TNTC	2.7×10^2	6.0×10^3	3.7×10^5	0
Water Gut, C'sted.	1.8×10^3	1.0×10^3	0	2.8×10^4	0
Wharf, C'sted.	TNTC	2.5×10^3	0	7.2×10^4	0
Market Place, C'sted.	2.4×10^3	3.0×10^4	0	6.6×10^4	0
East St., C'sted.	TNTC	1.3×10^2	3.5×10^2	2.0×10^3	0
St. Croix Public					
Public Works Tank, C'sted.	2.0×10^1	0	0	0	N.D.
LaGrande Princess	1.1×10^2	0	0	0	0
WAPA	N.D.	1.1×10^3	0	0	0
Fair Plains Wells Field No Cl_2	N.D.	N.D.	0	0	0
Fair Plains Wells Field Cl_2	0	0	N.D.	3.0×10^2	N.D.
Martin Marietta	7.0×10^0	N.D.	0	0	N.D.
Sewage Treatment Plant Effluent	0	N.D.	N.D.	N.D.	0
Concordia Wells Field	N.D.	N.D.	0	0	0
Public Works Tank, F'sted.	N.D.	N.D.	0	5.0×10^2	0

F'sted - Frederiksted
C'sted - Christiansted
N.D. - Not Done
TNTC - Too Numerous to Count

TABLE 6

FECAL STREPTOCOCCUS

CELLS/100ml

	Oct. 1980	Nov. 1980	March 1981	June 1981	Aug. 1981
St. Thomas Wells					
Market Square	TNTC	1.0×10^{1}	0	1.4×10^{5}	0
Western Cemetery	N.D.	4.0×10^{1}	0	TNTC	0
Savan	1.0×10^{4}	1.0×10^{2}	3.2×10^{3}	N.D.	N.D.
Old Hospital	4.7×10^{1}	3.0×10^{2}	1.4×10^{3}	1.0×10^{3}	0
St. Thomas Public					
Western Cemetary Standpipe	3.4×10^{2}	0	3.5×10^{2}	3.2×10^{4}	0
De Jongh Gut Standpipe	1.8×10^{2}	1.4×10^{3}	N.D.	N.D.	N.D.
Evans Grocery Standpipe	N.D.	0	N.D.	N.D.	0
PWD Sub Base	0	0	TNTC	4.5×10^{4}	0
Port Authority Airport	8.7×10^{1}	0	2.5×10^{2}	3.5×10^{4}	0
Sebastian	3.4×10^{2}	0	N.D.	0	0
Polyberg Standpipe	9.2×10^{1}	0	0	1.0×10^{3}	0
Antilles Airboats	N.D.	N.D.	N.D.	N.D	N.D.

N.D. - Not Done

TNTC - Too Numerous to Count

TABLE 7

SALMONELLA SP.

CELLS/100ml

	Oct. 1980	Nov. 1980	March 1981	June 1981	Aug 1981
St. Croix Wells					
Prince St., F'sted.	TNTC	7.0×10^{3}	TNTC	4.8×10^{4}	7.5×10^{4}
New St., F'sted.	TNTC	1.2×10^{4}	TNTC	2.0×10^{3}	1.2×10^{5}
Queen St., F'sted.	3.5×10^{1}	2.0×10^{4}	TNTC	1.0×10^{3}	0
Market St., F'sted.	TNTC	1.7×10^{4}	TNTC	1.4×10^{5}	1.3×10^{4}
Water Gut, C'sted.	TNTC	7.0×10^{4}	TNTC	2.2×10^{4}	1.9×10^{4}
Wharf, C'sted.	TNTC	2.0×10^{4}	TNTC	1.8×10^{5}	4.5×10^{4}
Market Place, C'sted.	TNTC	1.5×10^{4}	TNTC	3.0×10^{3}	6.1×10^{4}
East St., C'sted.	TNTC	TNTC	TNTC	0	2.0×10^{3}
St. Croix Public					
Public Works Tank, C'sted.	TNTC	2.3×10^{3}	0	0	N.D
LaGrande Princess	TNTC	1.0×10^{1}	0	0	0
WAPA	N.D.	1.0×10^{3}	5.0×10^{2}	0	0
Fair Plains Wells Field No Cl_2	N.D.	N.D.	5.5×10^{4}	0	1.0×10^{3}
Fair Plains Wells Field Cl_2	1.0×10^{1}	N.D.	5.0×10^{2}	0	N.D.
Martin Marietta	0	N.D	0	0	N.D.
Sewage Treatment Plant Effluent	0	N.D.	N.D.	N.D.	0
Concordia Wells Field	N.D.	N.D.	1.0×10^{2}	0	2.0×10^{3}
Public Works Tank, F'sted.	N.D.	N.D.	TNTC	0	0

F'sted - Frederiksted
C'sted - Christiansted
N.D. - Not Done
TNTC - Too Numerous to Count

TABLE 8

SALMONELLA SP.

CELLS/100ml

	Oct. 1980	Nov. 1980	March 1981	June 1981	Aug. 1981
St. Thomas Wells					
Market Square	TNTC	1.5×10^{3}	1.1×10^{5}	3.6×10^{5}	9.7×10^{4}
Western Cemetery	9.1×10^{3}	4.6×10^{2}	2.0×10^{4}	2.5×10^{5}	4.5×10^{4}
Savan	5.0×10^{4}	8.7×10^{3}	TNTC	N.D.	1.7×10^{5}
Old Hospital	7.5×10^{1}	1.2×10^{4}	4.0×10^{2}	0	0
St. Thomas Public					
Western Cemetary Standpipe	0	1.6×10^{3}	0	0	0
De Jongh Gut Standpipe	2.6×10^{2}	TNTC	N.D.	N.D.	N.D.
Evans Grocery Standpipe	N.D.	1.0×10^{1}	N.D.	0	0
PWD Sub Base	0	0	0	0	0
Port Authority Airport	N.D.	0	3.0×10^{4}	0	6.2×10^{5}
Sebastian	9.7×10^{1}	0	N.D.	0	0
Polyberg Standpipe	1.2×10^{2}	0	7.3×10^{4}	0	0
Antilles Airboats	0	0	7.2×10^{3}	0	0

N.D. - Not Done

TNTC - Too Numerous to Count

It would appear that there are numerous points of contamination into the systems but they may not all be continuous. (2) At certain times the St. Croix system seems relatively good. This would indicate that proper water treatment may be capable of overcoming some of the contamination of the system. (3) The St. Thomas results seem less variable.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. The public water distribution system in St. Croix and St. Thomas generally does not meet the microbiological standard set forth in the Safe Drinking Water Act.
2. Fecal streptococci and *Salmonella* are effective indicators of fecal contamination of water supplies.
3. The old wells on St. Croix and St. Thomas do not conform to microbiological standards of the Safe Drinking Water Act.
4. Inconsistent results indicate that chlorination of public water distribution systems was performed on a sporadic schedule.
5. A potential health hazard is associated with the public water distribution system in St. Croix and St. Thomas as well as with use of the old wells.

Recommendations

1. Water from the public water distribution system and old wells should either be chlorinated on a regular basis or exposed to some other disinfecting process such as ultraviolet radiation.
2. A search should be initiated for the sources of contamination in the public potable water system.
3. Use of fecal *Streptococci* and *Salmonella* spp. as indicator organisms of fecal pollution should be studied further.

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