COLLEGE OF THE VIRGIN ISLANDS
Caribbean Research Institute

WATER RESOURCES RESEARCH CENTER

CAPSULE REPORT NO. 4
AUGUST 1985

WATER QUALITY OF CISTERN WATER IN ST. THOMAS, U.S. VIRGIN ISLANDS

By
F. Rinehart, R. Pebbles, P. Hoffman, M. Canoy and A. Knudsen

INTRODUCTION

St. Thomas, U.S. Virgin Islands relies on a variety of sources for its domestic water supply. The fresh water supply is obtained from salt water distillation plants, rain water stored in cisterns, and from wells. Rain water collected from rooftop catchments and stored in cisterns is the major source of water for rural St. Thomas. All dwelling units are required by law to have cisterns. Since cistern water is not part of the public water distribution system, it is not covered by the Safe Drinking Water Act (Public Law 93-523).

Collected rain water may be contaminated from a variety of sources. It contains atmospheric dust, aerosols, accumulated dust and debris from roofs, broken down products from roofing materials, organic debris from overhanging trees, microorganisms, fecal material from rodents, birds, and lizards and salt deposited from sea spray. During storage, the water interacts with cistern walls. Frogs may visit and reside in the cistern. Under special circumstances, the cistern itself can be subjected to groundwater seepage.

PURPOSE OF STUDY

A two phase study was carried out in 1983 by the Caribbean Research Institute of the College of the Virgin Islands. The first phase was a survey of a sample set of cisterns to determine the scope and limits of the problem of cistern contamination. The second phase was an in-depth study of bacteriological and chemical contamination of water stored in cisterns.

PHASE I

The first phase of the study involved collecting and analysing rain water samples from 30 cisterns of private homes. The cisterns were from sites all over the island. These cisterns were known to have received only rain water for at least the two previous years. The intent of this phase of the study was to characterize the quality of water collected under the best circumstances.

The samples were tested for chemical composition and bacteriological contamination by a variety of standard methods. The chemical tests indicated the presence and levels of chloride, nitrate, calcium, magnesium, iron, copper and, in some cases, lead. The total solids and conductivity of the water were also tested. The bacteriological tests determined the total concentration of bacteria of all types and also the presence of coliform baceria. Coliform bacteria presumes the presence of human fecal material. Bacteriological tests were also conducted to determine the possible presence of other disease causing bacteria.

METHODS OF ANALYSIS

At the sampling sites, each donor was given a set of written instructions to use when collecting the water samples. Each donor was also asked to fill out a questionnaire describing the cistern from which the water was drawn and the roof which collected the water.

Bacteriological tests were of two kinds. The first test estimated the total number of bacteria present. There is no accepted limit for total bacterial count in drinking water. The second set of tests revealed the presence of coliform bacteria. There was no clear correlation between total bacterial count and the presence of coliforms in these samples. However, if the first test indicated the presence of coliforms, an additional test was performed to confirm the presence of coliforms. Of the 30 cisterns tested, only four were found to be contaminated by coliform bacteria. Several cisterns with relatively large numbers of bacteria had no detectable coliform bacteria.

The chemical analysis of 23 cistern water samples is presented in Table 1. Inorganic substances in cistern water were present in small quantities. The primary constituent of the solids in cistern water was calcium ion, about 20% by mass. Measurements of the heavy metals content of cistern water were done for only a few metals: lead, cadmium, silver, iron, and copper. Only copper and iron were found in any of the samples and only in very low concentrations. Iron could leach from cistern walls or from plumbing. Copper is also likely to leach from plumbing. The nitrate concentrations were also small. It may be significant that the cistern with the largest nitrate concentration was also found to harbor a large concentration of bacteria. Cistern water, although it often appeared turbid, was relatively devoid of inanimate material. The principal components were calcium, sodium chloride, carbonates, sulfate and silicate.

PHASE II

The second, in-depth, phase of the study uncovered much significant information. Visual inspection of the cisterns in some households revealed that there were a few centimeters to as many as 44 centimeters of sludge in the bottom of cisterns. This sludge consisted largely of plant debris, dust, animal feces, and decomposing animal remains which had been washed in from the roof collection system. It was evident that cistern water supplies on St. Thomas are subject to potentially significant contamination from a variety of materials. It was also found that contamination of the household water supply could readily occur through purchased water.

RESULTS

A high density of many different types of bacteria was found in some of the cistern water. This is important in light of the fact that chlorine was not often used. Most of the cistern water samples could be classified as unacceptable based upon their total coliform count. The tests suggested that most cisterns had been contaminated for a considerable length of time and had not been chlorinated. It also points to a probable heavy loading with rotting vegetation.

In addition to coliform bacteria, salmonella and shigella bacteria were also found to be present in many cisterns. Salmonella can cause a variety of diseases such as thyphoid. Proteus, Aerobacter, Sirratia and Pseudomonas were also found to be present in the cisterns. These are secondary disease causers (pathogens) and may initiate an infection if a person has been weakened or exposed to a primary pathogen.

To assess the relative potable and palatable quality of cistern water, a compilation of existing U.S. Environmental Protection Agency water quality criteria and regulations was developed. The water was measured against these criteria and the results are as follows: All of the water samples collected had acceptable pH values. Calcium, magnesium, sodium and potassium were within the acceptable range for domestic water supplies. The other ions were also found to be within the acceptable range.

CONCLUSIONS

The current situation in St. Thomas is critical with a high potential for disease. The majority of the cisterns tested showed that potential disease causing bacteria were present. Most of the cistern water in public housing or in Bovoni and Tutu failed to meet the Environmental Protection Agency and U.S. Public Health Authority's bacterial standards. However, the level of major chemicals in the cistern water was within the safe drinking water standards.

RECOMMENDATIONS

1. Paint used on rooftops collection systems should have as low a level of heavy metals, such as mercury and lead, as possible.
2. Alternative sources of water, such as wells, should be carefully evaluated by the authorities to ensure they meet safe drinking water guidelines and regulations.
3. Local authorities should provide low-cost means for testing the quality of cistern stored water.
4. Cistern stored water should be chlorinated.
5. At about yearly intervals, the leaf debris and sludge in the bottom of the cistern should be carefully siphoned off or pumped out. If necessary all trees and shrubbery that overhang the rooftop collection area should be removed from the area.

Condensed by Yahaya Bello from: "Water Quality of Cistern Water in St. Thomas U.S. Virgin Islands, June 1983-June 1984" by F. Rinehart, et al, Technical Report No. 15, Water Resources Research Center, Caribbean Research Institute, CVI, St. Thomas, V.I., September 1983.

For further information on this report contact:

Water Resources Research Center
College of the Virgin Islands
St. Thomas, Virgin Islands 00802
(809) 774-9200

The research on which this report is based was financed in part by the United States Department of the Interior, Geological Survey, through the Water Resources Research Institute. Contents of this publication do not necessarily reflect the views and policies of the United States Department of the Interior, nor does mention of trade names or commercial products constitute their endorsement by the United States Government.

Table 1
Chemical Analysis of Cistern Water Samples

	Concentrations in mg/1 (ppm)							
Sample	Solids	$C1^-$	NO_3^-	Ca^{2+}	Mg^{2+}	Fe ions	Cu^{2+}	Conductivity[a]
1.1	47	5.6	1.37	5.3	0.14	0.15	0.03	70
1.2	37	4.6	1.06	6.6	0.17	0.04		56
2.4	60	7.7	1.76	5.9	0.13	0.16		94
2.5	75	ND[b]	0.24	10.4	0.56	ND	ND	75
3.1	75	5.0	1.51	9.5	0.40	ND	0.01	139
3.2	38	4.6	1.00	7.2	0.15	0.07		68
3.3	33	4.6	1.06	6.5	0.24	ND	0.01	75
3.4	24	4.5	0.85	4.6	0.39	ND	0.04	49
3.5	53	4.9	0.91	7.0	0.25	ND		69
3.7	53	8.4	0.94	10.8	0.17	0.06	0.06	99
3.8	31	5.5	0.91	6.5	0.57	ND		62
3.9	39	ND	0.27	11.1	0.40	ND	ND	79
3.10	59	ND	0.32	20.2	1.68	ND	ND	136
4.1	56	5.1		10.7	0.19		0.08	
4.2	62	3.9	1.14	11.6	0.25	0.12	0.03	81
5.1	49	4.8	1.33	7.3	0.10	0.09	0.04	88
5.2	27	4.2	0.55	5.8	0.29	ND	0.03	56
6.1	65	5.6		8.2	0.20	0.03	0.03	
6.2	54	6.4	1.19	7.5	0.15			73
6.3	39	ND	0.26	9.6	0.73	ND	ND	81
7.1		ND	0.22	9.9	ND	ND	ND	
7.2	28	ND	0.22	9.9	ND	ND	ND	62
8.1	63	4.7	3.68	10.1	0.29	0.10	0.06	89

a. Conductivity in units of micromhos
b. Not Detected