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Incidence of Coliphage in Potable Water Supplies

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Samples of drinking water from different sources in greater Cairo, Egypt, and bottled drinking water were tested for total coliform, fecal coliform, and coliphage populations. Of the 147 samples tested, 4 samples were positive for both total coliforms and coliphage, 65 samples were negative for total coliforms, fecal coliforms, and coliphage, and 78 samples were positive for coliphage and negative for total coliforms and fecal coliforms. The incidence of coliphage in these potable water supplies reflects the probability of human pathogenic virus survival in these waters also.

The safety of drinking water is an ongoing concern in all countries. Traditionally the safety of potable water supplies has been controlled by disinfection, usually by chlorination, and by coliform population estimates. However, in a recent study (9) it was shown that coliform-free potable water may not necessarily be free of microbial pathogens. The data from this study (9) indicated that, while many of the treated potable waters sampled may have been free of coliforms, they did contain various concentrations of coliphage, an indication of inadequate water treatment and a warning that human enteric viruses may also survive treatment.

Studies by the Atlantic Research Corporation scientists (8) on the use of coliphage as an indicator of fecal pollution has greatly advanced the knowledge of the usefulness of this water quality indicator. There is also sufficient evidence to suggest that the coliphage test has many advantages over traditional bacteriological and virological tests, in that the procedure is economical, is simple to perform, and provides results within 6 h.

In this note, we present the results of an investigation into the safety of a variety of Cairo, Egypt, drinking water samples collected from distribution lines, storage tanks, wells, and bottled waters. The indicator systems used to test for the safety of these waters were total coliform, fecal coliform, and coliphage population estimates.

Triplicate drinking water samples were collected from various sources within greater Cairo, Egypt, usually monthly over a 10-month period (October 1986 to July 1987). The samples were collected from three water treatment plants (Tebbin, Giza, and Rod El-Farag), four deep wells located at Mastorod, and six storage tanks from various locations which provide drinking water to high-rise buildings. Three brands of bottled water were also tested: Baraka, Helwan, and Mineral. Water samples collected from the water treatment plants and storage tanks were dechlorinated with sodium thiosulfate (0.1 g/liter of sample) before examination.

In the bacteriological examination of these waters, two coliform most-probable-number (MPN) procedures and two fecal coliform MPN procedures were used on all water samples. In one of the coliform procedures, a 10-tube MPN procedure with lauryl sulfate tryptose broth (35°C for 48 h) (1) and confirmation in brilliant green lactose bile broth (35°C for 48 h) was used, and in the other 10-tube MPN procedure, MacConkey broth (35°C for 48 h) results were confirmed by subculturing positive tubes to Levine EMB agar (Difco Laboratories). Fecal coliform populations were estimated by a 10-tube MPN procedure with A1 broth (44.5°C for 24 h) (1) and a 10-tube MPN series with lauryl sulfate tryptose broth (35°C for 48 h) followed by brilliant green lactose bile broth (35°C for 48 h), with positive tubes confirmed in EC broth (Difco) (44.5°C for 24 h) (1).

Two procedures were used to estimate coliphage concentrations. One procedure is that described in section 919C of *Standard Methods for the Examination of Water and Wastewater* (1), which requires the addition of 2,3,5-triphenyltetrazolium chloride and *Escherichia coli* C (ATCC 13706) as host. The other procedure used was the MPN technique recommended by Kott (4), with *E. coli* C as host.

Condensed results are shown in Table 1. The mean values of triplicate tests are presented. Of the total 147 samples tested, 78 samples were positive for coliphage and negative for total coliforms and fecal coliforms; 65 samples were negative for total coliforms, fecal coliforms, and coliphage; and 4 samples were positive for both total coliforms and coliphage. Two of the four samples positive for both coliforms and coliphage were found in the Mineral bottled water, and both fecal and total coliforms were recovered. In the other two samples, obtained from wells 20 and 31, no fecal coliforms were recovered.

Several researchers (6, 8) have demonstrated that coliphages are more resistant to inactivation by chlorination than are coliforms. In one study (8), it was shown that *E. coli* cells are nonviable after a 5-min contact with 6 mg of chlorine per liter while coliphages survive an exposure to 25 mg of chlorine per liter for 80 min. Thus, while chlorine effectively kills coliform bacteria, coliphages survive in large numbers (8).

In an extensive review of the early literature, Grabow (2) found that the results of many studies indicated that most common pathogenic viruses are more resistant to chlorination than are *E. coli*. In a later study, Kott et al. (5) reported that coliphages are similarly resistant to chlorination as polioviruses. Thus, the presence of coliphage in these drinking water samples, with and without coliform presence, strongly suggests that viruses can also survive the normal treatment and disinfection processes accorded these potable

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TABLE 1. Incidence of coliphage in drinking water containing no coliforms[a]

Water sample source[b]	Results of coliphage determination by[c]				Results of total coliform determination by[d]			
	APHA method (1)		Kott method (4)		Lauryl sulfate tryptose broth		EMB agar	
	Mean no. of positive results/ total no. of samples	Range of coliphage concn[e]	Mean no. of positive results/ total no. of samples	Range of coliphage concn[e]	Mean no. of positive results/ total no. of samples	Range of coliform concn[f]	Mean no. of positive results/ total no. of samples	Range of coliform concn[f]
Treatment plants								
Tebbin	4/10	10–330	1/10	2	0		0	
Giza	7/10	3–600	0/10	0	0		0	
Rod-El Faraq	5/10	4–800	0/10	0	0		0	
Storage tanks								
1	4/10	13–94	1/10	2	0		0	
2	4/10	7–150	0/10	0	0		0	
3	5/10	3–700	0/10	0	0		0	
4	3/10	10–870	1/10	1	0		0	
5	1/10	90	0/10	0	0		0	
6	1/8	7	0/8	0	0		0	
Wells								
20	7/8	3–33	6/8	2–7	0		1/8	5
21	7/9	10–770	4/9	3–12	0		0	
31	10/10	13–2,200	5/10	3–20	1/10	2	3/10	2–4
32	7/10	7–1,140	3/10	3–7	0		0	
Bottled waters								
Baraka	5/7	3–47	1/7	3	0		0	
Helwen	3/7	3–10	0/7	0	0		0	
Mineral	5/8	27–100	3/8	5–8	2/8	3–4	2/8	2

[a] Data are based on triplicate determinations per sample.
[b] Chlorinated water samples from the treatment plants and storage tanks were dechlorinated before examination. Samples from the wells and bottled waters were not chlorinated.
[c] The total numbers of samples positive for coliphage are 78 and 25 (n = 147) as determined by the American Public Health Association (APHA) and Kott methods, respectively.
[d] The total numbers of samples positive for total coliforms are 3 and 6 (n = 147) as determined by lauryl sulfate tryptose broth and EMB agar, respectively. Of 147 samples tested, only 2 samples of bottled water (Mineral) were positive for fecal coliforms as estimated by EC and A1 broth techniques.
[e] Expressed as the number of coliphages per 100 ml.
[f] Expressed as the MPN index per 100 ml.

water samples (3). Another implication of the data from these studies is that coliform-free potable waters are not necessarily pathogen-free potable waters.

The findings reported here of coliform-free but coliphage-containing potable waters are not single rare events. Similar results have also been reported in studies of Singapore (9) and Peru (7) potable water supplies.

Another interesting finding in this study is the great superiority of the American Public Health Association coliphage procedure (1) over the Kott MPN procedure (4), even though both techniques were performed with the same *E. coli* C host. Moreover, it was found that there was closer agreement among the triplicate American Public Health Association (1) coliphage results than among the Kott procedure (4) coliphage results. From these data and other data obtained by using the American Public Health Association coliphage technique (1), it appears that this method is at present the best available technique for coliphage estimation. The technique has the added benefit of being a relatively simple, inexpensive procedure which can produce results within 6 h.

In summary, we believe, on the basis of these and earlier reported data (7, 9), that the coliphage test should be included as part of any potable water testing scheme to protect the unwary consumer.

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