The sanitary condition of rural drinking water in a Nile Delta village

II. Bacterial contamination of drinking water in a Nile Delta village

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INTRODUCTION

Whilst the major danger associated with drinking water is that it may be contaminated with sewage or human excreta, the danger of pollution from animals must not be overlooked. Outbreaks of infection from drinking water are frequently reported (Melnick & Gerba, 1979) and high prevalence rates of diarrhoeal diseases have been found in the Nile Delta (Sallam *et al.* unpublished data). The supply of potable water is a critically urgent national problem and is of especial importance to communities which must rely on poorly designed supply systems and which lack even the minimum quality control services.

The bacteriological control of potable water depends on counting certain micro-organisms as indicators of faecal pollution. Although pathogenic coliforms other than *Escherichia coli* are found in faecal material, their low frequency makes it difficult to use them as indicators of pollution (Papavasilliou, 1958; Dufour, Strickland & Cabelli, 1975); however counts of *E. coli* may be relied upon as indicators of pollution (Hufham, 1974). A study of the ratio of *E. coli* to faecal streptococci provides an indication of the source of pollution, a ratio less than 0.7 indicates an animal source, whilst a ratio over 4 indicates a human source (Geldreich & Kenner, 1969).

Although the village studied is supplied with municipal treated water, over 90 % of the villagers still use water after storage in a 'Zir' since this provides cooled water (El Shafhy, unpublished data). The zir is an earthenware, conical-bottomed vessel through which water seeps and evaporates, cooling the remainder.

This paper reports a bacteriological study of tap water and zir water in one village.

MATERIALS AND METHODS

A random sample of 107 (18·5 %) of the 578 households in Abbis II village in the Nile Delta was studied and zir water collected. Ten water samples were collected from household taps and one from a public tap.

Zir and tap water samples were collected in sterile 250 ml bottles by a standard procedure (A.P.H.A., 1975). These samples were sent to the laboratory and examined within 1 h.

Media

Three separate media were used: m-TEC (for the isolation of thermotolerant *E. coli*), m-E (for the isolation of enterococci) and EIA (Esculin Iron Agar), purchased from Key Scientific Products Co., Los Angeles, California. The media were prepared, sterilized at 121 °C for 20 min, cooled to 45 °C and poured in 48 mm Petri dishes.

Isolation of bacteria

Dilutions were made, if necessary, with sterile phosphate buffer (pH 7·2). Duplicate aliquots of the original sample or dilution were passed through 0·45 mm filters which were then placed on m-TEC and m-E plates.

The m-TEC plates were placed in water-tight plastic bags, incubated at 37 °C for 2 h, followed by 18–20 h in a 44·5 °C water bath. The membrane filters were then transferred to filter pads saturated with urease solution reagent (urea 2·0 g, phenol red 0·01 g, distilled water 1000 ml pH 5·2), after 15–20 min, all yellow colonies were counted as thermotolerant *E. coli* (Dufour *et al.* 1975).

The m-E plates were incubated for 48 h at 41 °C. The membrane filters were then transferred to EIA plates and allowed to stand for 20–30 min at room temperature. Red or pink colonies which formed a black or reddish brown precipitate in the EIA medium were counted as faecal streptococci (Levine, Fischer & Cabelli, 1975).

RESULTS

Bacterial counts of zir and tap water samples are given in Table 1 together with means and standard deviations. Counts of *E. coli* and faecal streptococci were higher in zir water than in tap water. The results show that a wide range of counts was obtained. Table 2 shows the degree of bacterial pollution in zirs by period since last filling; there is no change in the count of *E. coli* or faecal streptococci after storage. In Table 3 the degree of bacterial pollution of zir water is expressed by season; it is clear that there were no differences in counts between summer and winter season. There was no significant difference in degree of bacterial pollution in zir water whether or not the family utensil had a handle or whatever was the type of cover.

The ratio of *E. coli* to faecal streptococci is shown in Table 4, this ratio was < 0·7 in all zirs in proximity to mammals, 57 % in proximity to birds and 50 % in proximity to both animals. Seventy percent of zirs in proximity of neither animal had a ratio over 4.

Table 1. *Bacterial counts per 100 ml sample of 107 zir and 11 tap water samples*

Organism	Source	Percent samples with count/100 ml					Mean	S.D.
		0–2	3–9	10–99	100–999	1000		
E. coli	Zir	45·8	14·9	27·1	7·5	4·7	0·84	79·7
	Tap	100	0	0	0	0	0 ·	0
Faecal streptococci	Zir	7·5	14	39·2	37·4	1·9	132·3	137·4
	Tap	36	18	46	0	0	8·9	12·2

Table 2. *Pollution of zir water in relation to time since last filled*

Organism	Period since last filled (h)	Number of samples	Percent of samples with count/100 ml			
			0–9	10–99	100–999	1000
E. coli	6	27	63	22	7	7
	6–24	56	59	29	9	4
	24	24	63	29	4	4
Faecal streptococci	6	27	37	44	19	0
	6–24	56	14	41	43	2
	24	24	21	25	50	4

Table 3. *Degree of pollution of zir water in relation to season*

Organisms	Season	Number of samples	Percent of samples with count/100 ml			
			0–9	10–99	100–999	1000
E. coli	Summer	59	64	20	8	7
	Winter	48	56	35	6	2
Faecal streptococci	Summer	59	22	48	27	3
	Winter	48	21	27	52	0

Table 4. *Ratio of coliforms to streptococci in relation to aminals*

Proximity to animals	Total samples	Number with faecal streptococci only	Ratio of E. coli/faecal streptococci*				Number with E. coli only
			< 0·7	0·7–1·5	1·6–4	> 4	
Birds	14	7	4	2	0	1	0
Mammals	7	2	4	0	0	0	1
Both	6	4	1	1	0	0	0
Neither	77	33	27	3	4	8	2

* Where both found.
Three further samples yielded neither *E. coli* nor streptococci.

DISCUSSION

The provision of safe and adequate water supply for all communities is important in maintaining public health and in reducing disease. The microbiological contamination of drinking water by human and animal wastes remains the pre-eminent problem for the greatest portion of the world's population. Water circulating in the distribution system, whether treated or not, should not contain any organism that may be of faecal origin. The presence of *E. coli* in drinking water indicates that a health hazard exists because of the possible presence of pathogens (A.P.H.A., 1975).

It is obvious from Table 1 that none of the tap water had *E. coli* greater than 2 per 100 ml of water, but that 64 % had faecal streptococci. Zir water had high bacterial densities compared with that of tap water, indicating that bacteria are already present in water prior to its collection. Water that is of excellent quality when it enters the distribution system may undergo some deterioration before it

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reaches the consumer's tap through sewage leakage into the soil, packing used in the joining of mains, booster pumps or through washers on service taps. Seventy percent of tap water samples in this study has less than 0·3 mg/l residual chlorine (unpublished observations), this is not sufficient to yield a water that is free of faecal streptococci which resist chlorine more than do *E. coli* (Wilson & Miles, 1975).

Zir water was polluted with *E. coli* and faecal streptococci, the presence of *E. coli* shows recent and perhaps dangerous pollution because it cannot survive long out of its natural habitat (Sandhu, Warren & Nelson, 1979). The unhygenic methods of filling and taking water from zirs might lead to water pollution.

Storage of water affects its bacterial content, it causes a reduction in numbers due to sedimentation; due to the activities of other organisms (protozoa) and by a diminishing food supply (Wilson & Miles, 1975). However results in Table 2 show that storage does not reduce the bacterial density of zir water. This indicates the probablility of contamination during the filling and taking water processes. Table 3 shows that there was no significant difference in counts between summer and winter, this may be due to the fact that the zir is an earthenware pot particularly used for cooling and keeping drinking water cold; the temperature of zir water is more or less the same in winter and summer.

Faecal streptococci are consistently present in the faeces of all warm-blooded animals and in the environment associated with animal discharges (A.P.H.A., 1975). Normally there is no need for species identification of faecal streptococci in water pollution studies. Density ratios in relation to faecal coliforms are adequate to assign the probable source of water discharge. The results in Table 4 show that zirs in proximity to animals had *E. coli*/faecal streptococci ratio of < 0·7, yet 60 % of zirs in proximity to neither mammals nor birds have the same ratio. This suggests that contamination either exists in the water leaving the taps or is added to zirs during storage from hands and utensils contaminated with animal wastes.

Since the water entering the distribution system may undergo some deterioration before it reaches the consumer's tap, two points should be stressed to assure safe water for drinking:

(1) The necessity of maintaining a sufficiently high pressure throughout the whole system to prevent contamination from entering the system.

(2) The necessity for every distribution system to have available means of chlorination to deal with accidental pollution which is always a possibility.

Zirs should be redesigned in a way to prevent contamination from the unhygenic methods used in filling and taking water.

REFERENCES

A.P.H.A., American Public Health Association (1975). *Standard Methods for the Examination of Water and Waste-water*, 14th ed. New York.

Dufour, A. P., Strickland, E. R. & Cabelli, V. J. (1975). Enumeration method for thermotolerant. *E. coli*. Marine Field Station, Health Effect Research Laboratory, U.S. Environmental Protection Agency, West Kingstone, Rhode Island 02892.

El Shafhy, F. A. Housing sanitation and health practices among rural families in Abbis II village. Thesis, University of Alexandria.

Geldreich, E. E. & Kenner, B. A. (1969). Concepts of faecal streptococci in stream pollution. *Journal of the Water Pollution Control Federation* 41, 336–351.

HUFHAM, J. B. (1974). Evaluating the membrane faecal coliform test by using *E. coli* as the indicator organisms. *Applied Microbiology* **27**, 771–776.

LEVINE, M. A., FISCHER, J. R. & CABELLI, V. J. (1975). Membrane filter technique for enumeration of *Enterococci* in marine waters. *Applied Microbiology* **30**, 66–71.

MELNICK, J. L. & GERBA, C. P. (1979). Is the water safe to drink ? *Journal of Infectious Diseases* **139**, 736–737.

PAPAVASSILIOU, J. (1958). The rapid identification of *Escherichia coli* I by the production at 44° of both indole and gas from lactose. *Journal of Applied Bacteriology* **21**, 104–106.

SALLAM, S., HASSAN, M. N. R., HASAB, A., REDA, A., ABDEL GAWAD, A., EL-ATTAR, L. & EL SHAZLY, S. Epidemiology of diarrhoeal diseases in Egypt. (Unpublished data).

SANDHU, S. S., WARREN, J. W. & NELSON, P. (1979). Magnitude of pollution Indicator organisms in rural potable water. *Applied and Environmental Microbiology* **37**, 744–749.

WILSON, G. S. & MILES, A. (1975). *Principles of Bacteriology, Virology and Immunity*, 6th ed. London: Edward Arnold.

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