MICROBIOLOGICAL QUALITY OF DRINKING WATER AND USING WATER OF A CHAO PHYA RIVER COMMUNITY, BANGKOK

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Abstract. Safe water is essential for good health of humans. The contamination of water with infected fecal material is common in areas with poor standards of hygiene and sanitation. The determination of microbiological quality of water is essential. Simple routine testing of the bacteriological quality of drinking water is designed to detect the presence of coliform bacteria and virological assessment is to detect the presence of enteric viruses, especially hepatitis A virus (HAV). Therefore, this study attempted to determine the HAV and coliform bacteria contamination in drinking water and using water of a Chao Phya River community, Bangkok where crowded living conditions increase the risk of water-related diseases. 95 samples of dringking water and 75 samples of used water in containers were collected with sterile technique for determining HAV antigen by ELISA and coliform contamination by the Most Probable Number Technique (MPN). The results revealed that HAV and coliform contamination rates of drinking water were 25.26% and 64.21%, respectively. The rain water had the highest contamination (60.00% and 80.00%). Tap water was 23.73% for HAV (14/59 samples) and 64.41% for coliforms (38/59 samples) whereas running water had the least contamination (2.94% for HAV and 5.88% for coliforms). The contamination rates of used water were 10.69% for HAV and 38.67% for coliforms.

INTRODUCTION

Safe water is essential for good health of humans. Contaminated water leads to several water-related diseases including cholera, typhoid fever, diarrhea, dysentery and hepatitis A. The determination of microbiological quality of water is necessary. It is typically expressed in terms of the presence of indicator bacteria. The most commonly used indicator bacteria are the fecal coliforms (cairncross and Feachem, 1983; Ohashi *et al*, 1978). If a sample of water is positive for fecal coliforms, it suggests the potential presene of any pathogen which is being excreted by the animal and human populations (Cairncross and Feachem, 1983). Virological assessment is to detect the presence of enteric viruses, especially hepatitis A virus (HAV) which can servive at least one week in a dried state and for 12 days to 10 months in water (McCaustland *et al*, 1982). HAV is the etiologic agent of viral hepatitis A which causes a global economic loss of 1,500-3,000 million US dollars annually (Stephen, 1988). In Thailand, HAV antigen has been detected in several types of water such as underground water (9.1%), tap water (54.1%) and water from the Chao Phya River (57.1%) (Vithanomsat *et al*, 1990). The hepatitis A outbreaks reported in recent years were related to low sanitary quality of drinking water (Epidemiology Division, 1987, 1993). Therefore, the study of microbiological water quality is valuable not only for water quality improvement but also for health planning to control water-related diseases.

MATERIALS AND METHODS

Study design

This was a cross-sectional study of 95 households of a low socio-economic community located on the bank of the Chao Phya River, during September 1992 to March 1993. Housewives were interviewed and specimens of water in containers (95 samples of drinking water and 75 samples of using water) were collected with sterile technique and stored in an ice-box for determining the HAV antigen and coliform bacteria.

Assay of HAV antigen

Each water specimen was filtered through modified filter-paper by *in situ* flocculation of ferric and aluminium hydroxides. After that 10 ml of 3% beef extract (pH 9.5) was passed through the filter to elute adsorbed viruses. The filter eluate was assayed for HAV antigen by using ELISA (Organon Teknika kit)

with 99.8% sensitivity and 99.9% specificity. The optical density (OD) values > 0.1 above positive control were considered positive for HAV antigen.

Assay of coliform bacteria

The detection and enumeration of coliform bacteria was carried out by Most Probable Number Technique (MPN) (Ohashi *et al*, 1978). The cut-off number of positive coliform contamination was greater than 2.2 coliforms/100 ml for drinking water and greater than 10 coliforms/100 ml for using water (Environmental Quality Standards Division, 1989).

RESULTS

The results revealed that total HAV and coliform contamination rates of drinking water in containers were 25.26% and 64.21%, respectively. The highest contamination was found in rain water (60% and 80%) followed by tap water (23.73% and 64.41%) and filtered water (22.58% and 61.29%), respectively (Table 1).

It was found that the plastic gallon containers had the highest HAV contamination rate (38.89%) whereas the coolers had the highest coliform contamination (86.67%). Twelve samples of water in coolers with ice were 100% positive for coliform bacteria (Table 2).

Boiled water (in containers) was 40% HAV positive and 60% coliform positive whereas untreated water was 24.07% HAV positive and 66.67% coliform positive (Table 3).

Among seventy-five samples of using water, tap water (in containers) had the highest contamination rate of HAV (20%), whereas the highest rate of coli-

Table 1

Microbiological quality of drinking water of a Chao Phya River community, Bangkok (1993).

Types of drinking water in containers	No. tested	HAV contamination		Coliform contamination	
		No.	%	No.	%
Tap water	59	14	23.73	38	64.41
Filtered water	31	7	22.58	19	61.29
Rain water	5	3	60	4	80
Total	95	24	25.26	61	64.21

Table 2

Microbiological quality of drinking water by the characteristics of containers.

Characteristics of containers	No. tested	HAV contamination		Coliform contamination	
		No.	%	No.	%
Plastic gallon	18	7	38.89	10	55.56
Jar (earthenware)	32	9	28.13	22	68.75
Cooler	15*	3	20	13	86.67
Bottle (glass or plastic)	30	5	16.67	16	53.33
Total	95	24	25.26	61	64.21

* Twelve samples with ice were 16.67% positive for HAV and 100% positive for coliform bacteria.

Table 3

Microbiological quality of drinking water by the types of treatment.

Types of treatment	No. tested	HAV contamination		Coliform contamination	
		No.	%	No.	%
Boiled	10	4	40	6	60
Filtered	31	7	22.58	19	61.29
Untreated	54	13	24.07	36	66.67
Total	95	24	25.26	61	64.21

form contamination was found in the river water (100%). The running water had the least HAV and coliform contamination (2.94% and 5.88%, respectively; Table 4).

The comparison of HAV and coliform contamination rates were analysed by x^2 test. It was found that the positivity of HAV was not associated with the positivity of coliforms ($p > 0.05$), as shown in Table 5.

DISCUSSION

The microbiological quality of drinking water is typically expressed in terms of the concentration and frequency of occurrence of particular species of bacteria, viruses, protozoa or helminth eggs. The detection and enumeration of all these pathogens is far too complex and in any case many of the pathogens are present only in very small numbers. Therefore, it is normal practice to detect and enumerate only indicator bacteria. The most commonly used indicator bacteria are the coliforms (Cairncross and Feachem, 1983). In many developing countries including Thailand, there is no virological assessment of drinking water due to the difficulty of methods for detection. Viruses have been only rarely isolated from water (Hejkal *et al*, 1982). Recent studies could demonstrate the HAV antigen from contaminated water in several areas because an appropriate method has been developed and HAV can be concentrated 100- to 10,000-fold onto microporous filters and by organic floculation (Farah and Preston, 1985; Bloch *et al*, 1990; Vithanomsat, 1990). In Thailand, outbreaks of hepatitis A have been reported to be associated with waterborne transmission (Epidemiology Division, 1987, 1993).

This study showed 25.26% HAV contamination and 64.21% coliform contamination in drinking water (in containers). Vithanomsat *et al* (1990) demonstrated a high prevalence of HAV antigen in several types of

Table 4

Microbiological quality of using water of a Chao Phya River community, Bangkok (1993).

Types of using water	No. tested	HAV contamination		Coliform contamination	
		No.	%	No.	%
Running water	34	1	2.94	2	5.88
Tap water in containers	30	6	20	16	53.33
River water in containers	11	1	9.09	11	100
Total	75	8	10.69	29	38.67

Table 5

The comparison of HAV and coliform contamination rates*.

Results of determination	Drinking water		Using water		Total	
	No.	%	No.	%	No.	%
HAV +ve, Coliform +ve	13	13.68	5	6.67	18	10.59
HAV +ve, Coliform –ve	11	11.58	3	4	14	8.23
HAV –ve, Coliform +ve	48	50.53	24	32	72	42.35
HAV –ve, Coliform –ve	23	24.21	43	57.33	66	38.82
Total	95	100	75	100	170	100

* The positivity of HAV was not associated with the positivity of coliform bacteria ($p > 0.05$).

water such as underground water (9.1%), tap water (54.1%) and Chao Phya River water (57.1-70.6%). Moreover, they could detect the antigen in chlorinated water. In this study it was found that HAV antigen positivity in the tap water (in containers) was 23.73% but only about 3% in running water. Water from the Chao Phya River demonstrated about 9% for HAV and 100% for coliforms. About 30% of samples of coliform contaminated drinking water were commercial bottled drinking water.

In addition, this study showed no association between HAV positivity and coliform positivity. Some samples of water positive for HAV antigen were negative for coliform contamination. If the bacteriological water quality was done only, the risk of HAV infection would not be known. Thus, HAV detection in drinking water should be done as well as the coliform detection and enumeration. However, positivity for HAV antigen might not reflect infectivity of HAV. Individuals who drank the HAV antigen contaminated water might not become ill depending on their immunity to HAV and their ages. In childhood, hepatitis A infection is generally asymptomatic and disease severity increases with age in Thailand (Poovorawan *et al*, 1993). In recent years, the polymerase chain reaction (PCR) for detection of the genome of HAV has been developed (Desenclos *et al*, 1991). The cost of this method is rather expensive and the method should be evaluated for field work.

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REFERENCES

Bloch AB, Stramer SL, Smith D, *et al.* Recovery of hepatitis A virus from a water supply responsible for a common source outbreak of hepatitis A. *Am J Public Health* 1990; 80 : 428-30.

Cairncross S, Feachem RG. Engineering and infectious diseases. In: Cairncross S, Feachem RG, eds. Environmental Health Engineering in the Tropics. New York : John Wiley and Sons 1983: 3-20.

Desenclos JC, Klontz KC, Wilder MH, et al. A multistate outbreak of hepatitis A caused by the consumption of raw oysters. *Am J Public Health* 1991; 81 : 1268-72.

Environmental Quality Standards Division, Office of the National Environment Board, Thailand. Laws and Standards on Pollution Control in Thailand. 2nd ed. 1989.

Epidemiology Division, Ministry of Public Health, Thailand. Hepatitis A in Surin. *Weekly Epidemiol Surv Rep* 1987; 18 : 37-40.

Epidemiology Division, Ministry of Public Health, Thailand. An outbreak of hepatitis A in Nakhonsrithammaraj. *Weekly Epidemiol Surv Rep* 1993; 24 : 709-17.

Farah SR, Preston DR. Concentration of viruses from water by using filters modified by *in situ* precipitation of ferric and aluminum hydroxide. *Appl Environ Microbiol* 1985; 50 : 1502-4.

Hejkal TW, Keswick B, LaBelle RL, *et al.* Viruses in a community water supply associated with an outbreak of gastroenteritis and infectious hepatitis. *J Am Water Works Assoc* 1982; 74 : 318-21.

McCaustland KA, Bond WW, Bradley DW, *et al.* Survival of hepatitis A virus in feces after drying and storage for 1

month. *J Clin Microbiol* 1982; 16 : 957-8.

Ohashi M, Murakami H, Kudoh Y, Sakai S. Assessment of the sanitary quality of drinking-water, ice, and beverages. In: Chashi M *et al*, eds. Manual for the Laboratory Diagnosis of Bacterial Food Poisoning and the Assessment of the Sanitary Quality of Food. SEAMIC Publication, 1978; 12.

Poovorawan Y, Tieanboonlers A, Chumdermpadetsuk S. Changing seroepidemiology of hepatitis A virus infection in Thailand. *Southeast Asian J Trop Med Public Health* 1993; 24 : 250-4.

Stephen CH. Global impact of hepatitis A virus infection changing pattern. In: Zuckerman AJ, ed. Viral Hepatitis and Liver Diseases. New York: Alan R Liss 1988: 14-24.

Vithanomsat S, Nilakul C, Louisiriratchanakol S, *et al*. Investigation on human enteric pathogens from water resources in Central Region of Thailand. *J Med Tech Assoc Thai* 1990; 18 : 31-5.

Vithanomsat S. Hepatitis A virus detected in chlorinated and non-chlorinated waters by using micro ELISA. *Weekly Epidemiol Surv Rep* 1990; 21 : 390-9.