Environ Health Prev Med (2008) 13:198–206
DOI 10.1007/s12199-008-0029-x

REGULAR ARTICLE

Bacterial quality of drinking water stored in containers by boat households in Hue City, Vietnam

Kaoruko Seino · Takehito Takano · Nguyen K. L. Quang · Masafumi Watanabe · Tomoko Inose · Keiko Nakamura

Received: 10 October 2007 / Accepted: 8 February 2008 / Published online: 22 April 2008

Abstract
Objectives To examine the bacterial quality of drinking water stored in containers by boat households in the river basin of Hue City, and associated factors.
Methods Ready-to-drink water stored in containers on boats was collected from 766 households. *Escherichia coli* (*E. coli*), total coliforms, and *Enterobacteriaceae* in the water were examined by the rehydratable dry-film plating method. Socioeconomic characteristics, water source, handling practices, and proficiency of disease prevention of individual households were assessed.
Results *E. coli*, over ten counts of total coliforms, and over ten counts of *Enterobacteriaceae* were detected in 25.7, 44.5, and 51.5% of 1-ml samples of ready-to-drink water stored in containers on the boats. Bacterial contamination of the water stored in containers by boat households was significantly associated with use of river water as a source of drinking water, non-boiling before storing containers for drinking, and limited proficiency in disease prevention regardless of the influence of socioeconomic characteristics of the households ($P < 0.01$, $P < 0.05$, $P < 0.01$, respectively).
Conclusions Bacterial contamination of ready-to-drink water stored by boat households was indicated. The households' proficiency in disease prevention buffered contamination. A comprehensive health promotion program with a wide range of contents is required for the communities of boat households.

Keywords Ready-to-drink water · Household water storage · Disease prevention · Water-handling practice · River

K. Seino · K. Nakamura
International Health, Division of Public Health, Graduate School of Tokyo Medical and Dental University, Tokyo, Japan

T. Takano (✉) · N. K. L. Quang · M. Watanabe · T. Inose
Health Promotion, Division of Public Health, Graduate School of Tokyo Medical and Dental University, 1-5-45 Yushima, Bunkyo, Tokyo 113-8519, Japan
e-mail: whocc.hlth@tmd.ac.jp

Introduction

Living on boats along rivers has been a familiar lifestyle for the people in Vietnam. According to the government records, there are 6,278 people living on boats along Huong River in Hue City, Vietnam [1]. They earn their living by sand extraction or fishing while navigating or floating their boats or by cyclo-driving and day-labor while their boats are moored to the riverbank [2]. People in boat households take water for drinking from various sources, including tap water from standpipes on the riverbank, river water, and others [1, 3].

Access to safe drinking water is essential to achieve good health in the population [4]. Diarrheal diseases cause an estimated 1.8 million deaths each year worldwide [5], and these diseases have been discussed in relation to limited access to safe water, inadequate treatment of water for drinking by households, and lack of proper storage practices for drinking before consumption [5–7]. There is a great deal of concern regarding in-house microbial contamination during handling and storage of water in developing countries [8, 9].

The prevalence of water-related infectious diseases has been reported to be high among people living on boats compared with national estimates for the total population in Vietnam [2]. The lifestyles of these people who generally

make their living using their boats or live under cramped conditions on boats moored to riverbank restricts their collection of fresh water and its handling and storage before drinking. Generally, water for drinking is stored in containers by boat households with or without treatment after collection from a variety of sources.

The quality of water collected and stored for drinking by households is related to various factors associated with living conditions and hygiene practices [10]. Disinfection and safe storage of water by households improve the quality of drinking water and prevent diseases [11]. For prevention of diseases and promotion of health, it is important to improve knowledge regarding disease prevention and health-promotion measures in addition to personal skill development to cope with various situations faced by people in their daily lives [12].

The quality of drinking water in developing countries is a prime concern for prevention of water-related diseases [13, 14]. However, effective countermeasures to secure the health of people are not well developed without identifying factors of people's daily life in relation to the quality of water for drinking [15]. There is a significant need to identify such factors among people living on boats, who are practicing particular lifestyles, by empirical examination of their daily life and water quality. Thus, we performed a survey focusing on a wide range of variables based on people's daily life. The objective of this study was to examine bacterial quality of ready-to-drink water stored in containers by boat households in the river basin of Hue City, and its association with socioeconomic characteristics of the households, water source, water-handling practices, and the households' comprehensive disease-prevention capacity.

Materials and methods

Study area and subject households

In the basin of Huong River in Hue City, a survey was conducted between 4 August and 19 September 2003. In the area, there are 941 households living on boats according to the city's registration records. The registration records of boat households were well maintained, according to the report from neighborhood commune leaders, and all boats on the river were clearly labeled with registration number systematically issued by the city authority. Study teams consisting of professionals trained for this survey visited individual boats to collect samples of ready-to-drink water and to conduct a survey by interviewing the heads of households.

The ethical appropriateness of the survey was approved by Hue Peoples' Committee. Informed consent to participation in the study was obtained from the head of each household.

Water sampling

From individual households, a 50 ml sample of water was collected from a container of ready-to-drink water that was identified as the one most frequently used, according to the report of the head of household. The water was collected using sterile bottles and transported for testing immediately to laboratories located within 20 min of each of the riverbanks.

Enumeration of bacteria in ready-to-drink water

The quality of water samples was assessed by the rehydratable film method (Petrifilm) for three bacterial indicators: *Escherichia coli*, total coliforms, and *Enterobacteriaceae*. Aliquots of 1 ml of the water samples were inoculated and spread on *E. coli*/Coliform Count Plates (3M Petrifilm EC plates) and *Enterobacteriaceae* Count Plates (3M Petrifilm EB plates). After incubation at 37 ± 1°C for 24 ± 2 h, counts of *E. coli*, total coliforms, and *Enterobacteriaceae* on each plate were determined.

Questionnaire survey

Socioeconomic characteristics, source of ready-to-drink water, water-handling practices by households, and each household's disease-prevention capacity were assessed by using a structured questionnaire.

The socioeconomic characteristics of boat households were assessed by income, literacy level of the head of the household, occupation of the household, and family size. Income was divided into non-poor and poor according to the national poverty line, 150,000 Vietnam dong (VND) per capita per month (equivalent to ten US dollars) [16].

The source of household drinking water was identified: tap water from land, river, and others, including public wells along riverbanks and purchased bottled water.

Water-handling practices consisted of boiling (boiled/not boiled), time after boiling (<1, 1–12, >12 h), size of container (≤10 l/>10 l), and container material (metal/plastic). The length of time between boiling and sampling was defined as "time after boiling".

To assess the comprehensive capacity of disease prevention by family members, we used the "disease-prevention proficiency score," which had previously been applied to boat households among which water-related diseases are prevalent [2]. This score reflects each household's knowledge regarding infectious diseases, preventive measures, and their disease prevention practices. Households were divided into three categories based on the score:

non-functional (score 0–2), minimally functional (score 3–6), and functional (score 7–9).

Analyses

The correlation coefficients were calculated among counts of *E. coli*, total coliforms, and *Enterobacteriaceae*. The distributions of colony counts per 1 ml ready-to-drink water stored in containers on boats tested using three indicators were examined.

The occurrence of *E. coli* >0 count/ml, total coliforms >10 counts/ml, and *Enterobacteriaceae* >10 counts/ml of ready-to-drink water sampled from containers were defined as indicators of bacterial contamination of the drinking water. The percentages of bacterial contamination based on these three indicators were examined individually according to socioeconomic characteristics, water source, handling practices, and disease-prevention proficiency score using the chi-square test. The percentages of bacterial contamination were further examined by disease-prevention proficiency score for each of the water source and water-handling practice categories using the chi-square test. Differences in water source and water-handling practices by socioeconomic characteristics and disease-prevention proficiency were analyzed by use of the chi-square test.

Multivariate logistic regression analysis was performed to evaluate the association between bacterial contamination of ready-to-drink water and source, water-handling practices, or disease-prevention proficiency after adjustment for the influence of income, literacy, occupation, and number of people on boats.

Results

Participating households, collected water samples, and bacterial colony counts

Household interviews were conducted in 782 boat households (83.1% of the households listed) after obtaining informed consents. Boats that floated for their work to upper or lower streams of the river were not able to fully participate in the study. Ready-to-drink water samples were collected from 766 boat households, and bacterial-count examinations were completed for 739 water samples.

Percentages of detection of *E. coli*/ml, over ten counts of total coliforms/ml, and over ten counts of *Enterobacteriaceae*/ml from the water in the containers of boat households stored for drinking were 25.7, 44.5, and 51.5%, respectively (Table 1).

The correlation coefficients for counts of *E. coli* and total coliforms, *E. coli* and *Enterobacteriaceae*, and total coliforms and *Enterobacteriaceae* were 0.56, 0.56, and 0.82, respectively.

Table 1 Distribution of bacterial counts in ready-to-drink water stored in containers by boat households

Colony count per 1 ml	*E. coli*		Total coliforms		*Enterobacteriaceae*	
	n	%	*n*	%	*n*	%
0	549	74.3	266	36.0	237	32.1
1–10	145	19.6	144	19.5	121	16.4
11–100	38	5.1	205	27.7	176	23.8
>100	7	1.0	124	16.8	205	27.7

Bacterial contamination and household characteristics

Table 2 shows the distribution of bacterial contamination in ready-to-drink water on boat households according to socioeconomic characteristics, source and handling of water, and disease-prevention proficiency. Percentages of bacterial contamination in ready-to-drink water were significantly higher, for all the three indicators of contamination, in households that used boats for earning their livelihood than in those that did not use boats, in households with more than four members than in those with four or less members, and in households that boiled water than in those that did not. The percentage of bacterial contamination was highest in households whose source of water in containers was the river, and lowest in those whose source of water in containers was tap on land, and the association between percentage of bacterial contamination and source of water in containers was statistically significant. The percentage of bacterial contamination was highest in households with non-functional disease-prevention proficiency, and lowest in those with functional disease-prevention proficiency, and the association between percentage of bacterial contamination and disease-prevention proficiency was statistically significant.

Associations of water source, handling practices, and disease-prevention proficiency

Table 3 shows bacterial contamination of water by source and handling practices, and by disease-prevention proficiency. The prevalence of bacterial contamination of ready-to-drink water of households whose disease-prevention proficiency was classified as functional was significantly lower than of those classified as non-functional when water was obtained from taps on land, boiled before pouring, stored for over 1 h, and stored in >10 l plastic containers.

Water source and water-handling practices were different according to socioeconomic characteristics and disease-

Table 2 Bacterial contamination of ready-to-drink water stored in containers by boat households; associations of socioeconomic characteristics, source, water-handling practices, and disease-prevention proficiency

	n	*E. coli* >0 count/ml (%)	Total coliforms >10 counts/ml (%)	*Enterobacteriaceae* >10 counts/ml (%)
Socioeconomic characteristics				
Monthly income per capita				
Non-poor	507	26.8	46.0	53.3
Poor	232	23.3	41.4	47.8
Literacy level of head of household				
Literate	339	21.7*	40.7*	48.1*
Illiterate	376	28.7	47.9	54.5
Occupation of household				
Not require boat	172	19.2*	48.4*	44.8*
Require boat	442	27.1	36.0	54.3
Number of family members on boat				
1–4	294	21.1*	39.1*	46.9*
>4	445	28.8	48.1	54.6
Source of water in containers				
Tap on land	676	23.7**	42.0**	49.4**
River	47	55.3	76.6	78.7
Others	16	25.0	56.3	62.5
Water-handling practices				
Boiling				
Boiled before pouring	316	19.3**	37.0**	43.3**
Not boiled before pouring	421	30.2	49.9	57.5
Hours after boiling				
<1	32	15.6	25.0	34.4
1–12	275	23.6	39.3	45.8
>12	106	23.6	42.5	47.2
Size of containers (l)				
≤10	173	22.0	36.4*	45.1
>10	553	26.8	47.2	53.3
Material of containers				
Metal	63	22.2	38.1	50.8
Plastic	648	26.1	44.8	51.1
Disease-prevention proficiency				
Functional	149	12.8**	27.5**	36.9**
Minimally functional	343	24.2	42.3	49.9
Non-functional	246	35.8	58.1	62.5

*$P < 0.05$; **$P < 0.01$. Chi-squire test for comparison of percentages

prevention proficiency of the households (Table 4). The percentage of households that took drinking water from the river was significantly higher among households that used boats for earning their livelihoods and that had more than four people living on boats. The percentage of households that took drinking water from river was significantly lower among households whose disease-prevention proficiency was functional than among those for which it was non-functional.

Water for drinking was boiled more often by households that were non-poor, whose heads of households were literate, that had four or fewer people living on boats, and that were classified as functional in disease-prevention proficiency. Water-handling practices; hours after boiling, size of containers, material of containers were not significantly associated with socioeconomic characteristics or disease-prevention proficiency.

Associations of water source, water-handling practices, and disease-prevention proficiency with bacterial contamination of ready-to-drink water

Table 5 shows the prevalence of bacterial contamination of ready-to-drink water according to water source, water-handling practices, and disease-prevention proficiency adjusted by households' socioeconomic characteristics.

Table 3 Bacterial contamination in ready-to-drink water stored in containers by boat households; associations of source and handling practices, and disease-prevention proficiency

	Disease-prevention proficiency	*n*	*E. coli* >0 count/ml (%)	Total coliforms >10 counts/ml (%)	*Enterobacteriaceae* >10 counts/ml (%)
Source of water in containers					
Tap on land	Functional	144	12.5**	27.1**	36.1**
	Minimally functional	311	22.2	39.2	47.6
	Non-functional	220	33.2	55.9	60.5
River	Functional	3	33.3	66.7	66.7
	Minimally functional	20	50.0	75.0	75.0
	Non-functional	4	62.5	79.2	83.3
Others	Functional	2	0.0	0.0	50.0
	Minimally functional	12	33.0	6.7	66.7
	Non-functional	2	0.0	50.0	50.0
Water-handling practices					
Boiling					
Boiled before pouring	Functional	101	7.6**	23.7**	29.7**
	Minimally functional	156	23.9	38.3	46.4
	Non-functional	59	31.0	50.9	53.4
Not boiled before pouring	Functional	48	33.3	43.3	66.7
	Minimally functional	187	25.9	50.0	56.3
	Non-functional	185	40.3	65.3	71.0
Hours after boiling					
<1	Functional	10	10.0	20.0	40.0
	Minimally functional	17	17.6	17.7	29.4
	Non-functional	5	20.0	60.0	40.0
1–12	Functional	57	5.3**	21.1**	26.3**
	Minimally functional	147	26.5	40.8	49.7
	Non-functional	71	32.4	51.7	53.5
>12	Functional	42	11.9	31.0	35.7
	Minimally functional	48	22.9	43.8	47.9
	Non-functional	16	56.3	68.8	75.0
Size of containers (l)					
≤10	Functional	36	13.9	22.2	38.9
	Minimally functional	72	19.4	36.1	47.2
	Non-functional	65	29.2	46.6	46.2
>10	Functional	111	12.6**	29.7**	36.9**
	Minimally functional	267	25.1	43.8	50.2
	Non-functional	174	38.5	63.8	68.4
Material of containers					
Metal	Functional	13	13.3	26.7	40.0
	Minimally functional	24	26.4	32.1	50.0
	Non-functional	19	30.0	50.0	60.0
Plastic	Functional	130	13.1**	26.9**	36.2**
	Minimally functional	303	23.3	42.2	43.8
	Non-functional	214	37.4	59.3	63.1

**$P < 0.01$. Chi-squire test for comparison of percentages

Statistically significant associations were demonstrated between bacterial contamination of ready-to-drink water stored in containers on boats and use of the river as a water source, omission of boiling water before pouring into the container, and lack of disease-prevention proficiency ($P < 0.01$, $P < 0.05$, $P < 0.01$), after excluding the

Table 4 Source and handling practices used to prepare ready-to-drink water in containers by boat households; associations of socioeconomic characteristics and disease-prevention proficiency

	n	Source of water in containers (%)			Water-handling practices (%)								
		Tap	River	Others	Boiling		Hours after boiling (h)			Size of containers (l)		Materials of containers	
					Boiled	Not boiled	<1	1–12	>12	≤10	>10	Metal	Plastic
Socioeconomic characteristics													
Monthly income per capita													
Non-poor	507	91.1	6.7	2.2	69.2	30.8*	8.3	72.1	19.6*	22.5	77.5	10.3	89.7
Poor	232	92.2	5.6	2.2	60.3	39.7	6.6	55.5	38.0	26.6	73.4	5.8	94.2
Literacy level of head of household													
Literate	339	92.0	5.0	9.9	67.8	32.9*	8.3	63.9	22.8*	23.9	76.1	9.3	90.7
Illiterate	376	91.5	6.9	1.6	59.2	40.8	7.7	62.9	29.4	24.2	75.8	8.5	91.5
Occupation of household													
Not require boat	172	96.5	1.2	2.3**	66.3	33.7	6.7	69.2	24.0	21.4	78.6	7.2	92.8
Require boat	442	90.0	7.7	2.3	59.0	41.7	10.0	65.2	24.8	23.0	77.0	9.6	90.4
Number of family members on boat													
1–4	292	94.6	3.7	1.7*	70.9	29.1*	7.5	67.4	25.1*	26.6	73.4	9.5	90.5
>4	445	89.4	8.1	2.5	57.8	42.2	8.2	65.9	26.1	22.0	78.0	8.4	90.6
Disease-prevention proficiency													
Functional	149	96.6	2.0	1.3**	79.7	20.3**	9.2	73.4	17.4**	24.5	75.5	10.3	89.7
Minimally functional	343	90.7	5.8	3.5	66.5	33.5	8.0	69.3	22.6	21.2	78.8	8.5	91.5
Non-functional	246	89.4	9.8	0.8	48.4	51.6	5.4	56.1	38.5	27.2	72.8	8.5	91.5

*$P < 0.05$; **$P < 0.01$. Chi-squire test for comparison of percentages

influence of income, literacy, occupation, and number of family members on boats.

Discussion

This study demonstrated the variation of bacterial contamination of water stored in containers for drinking by people living on boats in Hue City, Vietnam. The prevalence of bacterial contamination in ready-to-drink water on boats was significantly associated with use of the river as a water source, omission of boiling, and lack of functional disease-prevention proficiency, regardless of family income, literacy, occupational requirement for boats, and number of people on the boat.

The households included in this study represented the entire population of boat households in Hue, City Vietnam, where people have long lived using boats as their residence and for their livelihood. Despite their frequent daily mobility on the river, 81.3% of the subject households participated in the study. The participation of the heads of communities, professionals working in floating clinics, local security personnel, and professionally trained survey teams was regarded as having encouraged boat households to participate in the study.

The quality of ready-to-drink water was assessed by three bacteriological indicators: *E. coli*, total coliforms, and *Enterobacteriaceae*. Counts of total coliforms and *Enterobacteriaceae* showed high correlations. The prevalence of *E. coli*, total coliforms >10 counts/ml, and *Enterobacteriaceae* >10 counts/ml had similar trends with the variation of characteristics of households. This was considered to indicate that the bacterial contamination observed in ready-to-drink water stored in containers by boat households was not characterized by the prevalence of any specific potential pathogens.

The results of this study indicated a greater likelihood of contamination of ready-to-drink water of boat households where families' occupations required boats. Generally, socioeconomic disadvantage has a negative impact on access to water sources [17]. Occupations requiring boats were closely related to use of the river as a source of water for drinking, and this was related to bacterial contamination of ready-to-drink water of such households. Although there were only marginal differences in bacterial contamination of water by income or educational status of the boat households, it should be noted that the practice of boiling water was more frequent among households with relatively high income and educational status.

Table 5 Bacterial contamination in ready-to-drink water stored in containers by boat households; associations of source, handling practices, and disease-prevention proficiency adjusted by socioeconomic characteristics

	E. coli >0 counts/ml		Total coliforms >10 counts/ml		*Enterobacteriaceae* >10 counts/ml	
	aOR	95%CI	aOR	95%CI	aOR	95%CI
Source of water in containers						
Tap	1.00		1.00		1.00	
River	3.26	1.58–6.69**	3.70	1.62–8.44**	3.44	1.45–8.15**
Others	0.94	0.25–3.47	1.36	0.46–3.98	1.38	0.46–4.09
Water-handling practices						
Boiling						
Boiled before poring	1.00		1.00		1.00	
Not boiled before poring	1.56	1.06–2.32*	1.49	1.05–2.11*	1.73	1.22–2.45*
Hours after boiling (h)						
<1	1.00		1.00		1.00	
1–12	1.43	0.51–3.95	2.04	0.86–4.83	1.86	0.82–4.18
>12	1.99	0.67–5.94	2.62	1.03–6.67*	2.13	0.88–5.17
Size of containers (l)						
≤10	1.00		1.00		1.00	
>10	1.20	0.75–1.92	1.59	1.06–2.38*	1.40	0.95–2.08
Material of containers						
Metal	1.00		1.00		1.00	
Plastic	1.10	0.55–2.19	1.35	0.74–2.45	1.24	0.69–2.23
Disease-prevention proficiency						
Functional	1.00		1.00		1.00	
Minimally functional	1.93	1.04–3.56*	1.82	1.13–2.91*	1.59	1.02–2.45*
Non-functional	3.30	1.77–6.24**	3.51	2.12–5.82**	2.68	1.65–4.35**

Multiple regression analysis models were used to calculate adjusted odds ratio (aOR) and 95% confidence intervals (95% CI). aORs were calculated for individual set of variables in the table, individually adjusted by income, literacy, occupation, and number of family members

* $P < 0.05$; ** $P < 0.01$

Use of the river as a source of drinking water was a significant factor in bacterial contamination of ready-to-drink water stored by boat households. Water pollution has been reported in Huong River, the river in the study area [18]. Considering the relationship between river water pollution and rapid urbanization, there remains a significant negative association between use of the river and contamination of ready-to-drink water, which will adversely influence the health of people.

Bacterial contamination of ready-to-drink water was more prevalent among boat households with large families than among those with smaller families. The relationship between bacterial contamination of ready-to-drink water and large family size could be explained by the high prevalence of omission of boiling water for drinking among these households. Contact of stored drinking water with the hands is a potential source of contamination [10], and frequent hand contact in large families increases the risk of contamination of water for drinking stored in containers on boats.

Boiling is a practice commonly used to treat water for drinking by households [19]. The percentage of households that boiled water for drinking in the study population, 42%, was lower than average reported for the country in general, 70% [20]. Our results indicated that omission of boiling of water for drinking was a critical contributing factor to bacterial contamination of drinking water on boats. However, bacterial contamination was observed at a substantial percentage even in boiled water among households lacking functional disease-prevention proficiency. Difficulties in performing satisfactory boiling for sterilization, even when they reported that they did boil water, and recontamination in storage containers after boiling, as indicated in previous studies [4], would explain the bacterial contamination of ready-to-drink water among boat households that reported boiling water for drinking. Promotion of appropriate water-handling practices among households is crucial to ensure safe water for drinking.

A comprehensive capacity for disease prevention, disease-prevention proficiency, was a consistent independent factor related to storing ready-to-drink water in containers by boat households, without bacterial contamination. Previous studies have indicated that disease prevention is successful when both knowledge and practices are acquired by individuals [21, 22]. Capacity building to gain comprehensive understanding of disease prevention and health and direct instruction on performance will facilitate sustainable access to safe water favorable for people living on boats.

This study was conducted at the end of the dry season in the study area. Higher bacterial densities are observed during the rainy season than during the dry season both in source water and in stored water in containers for drinking [23, 24]. Further studies are required to monitor seasonal variation of the bacterial quality of ready-to-drink water of boat households in Hue City.

According to the criteria of Vietnam, coliforms should not be detected in water for drinking [25]. The percentage of water samples that satisfied the criteria among subject boat households in Hue City, 34%, was higher than that reported for a rural area in Vietnam (0–4%) and lower than that report for a province (52%) [26]. It should be noted that 90% of the boat households in Hue City, even those with occupations requiring boats, used tap water on land as a source of drinking water. This was achieved due to a government program, since 1997, of installation of standpipes on riverbanks to make tap water available for people living on boats [1]. Without this access to tap water, it would be impracticable for people living on boats to obtain drinking water without bacterial contamination, even with appropriate knowledge and practice of disease prevention and better water handling.

In conclusion, the results of this study indicated that the microbial quality of drinking water stored in containers was associated with water source, boiling practices, and disease-prevention proficiency. A comprehensive health promotion capacity building program with a wide range of contents and measures to provide access to safe water sources are required to improve the quality of drinking water for everyday use by people living under fragile conditions on boats.

Acknowledgments We acknowledge members of the Hue People's Committee, Bureau of Foreign Affairs of Hue City, and Hue Healthcare Center for supporting conduct of the survey. We appreciate Dr Masashi Kizuki's advice on statistical analysis. The study was partly supported by a Grants-in-Aid for Scientific Studies by the Ministry of Education, Science, and Culture of Japan.

References

1. Hue Government. The project of residing people living on boat in Hue city. Hue City; 2002.
2. Quang NK, Takano T, Nakamura K, Watanabe M, Inose T, Fukuda Y, Seino K. Variation of health status among people living on boats in Hue, Vietnam. J Epidemiol Community Health. 2005;59:941–7.
3. Minh LD. The resettlement of fishing-boat dweller community in Hue City, Vietnam: solution for environmental problems. In: 8th International conference of the Asian planning schools association; 2005.
4. World Health Organization. Guidelines for drinking-water quality, first addendum to 3rd ed., vol. 1. Recommendations. Geneva: WHO; 2006.
5. World Health Organization. Water, sanitation and hygiene links to health facts and figures-updated November 2004. Geneva: WHO; 2004.
6. van der Hoek W, Konradsen F, Ensink JH, Mudasser M, Jensen PK. Irrigation water as a source of drinking water: is safe use possible? Trop Med Int Health. 2001;6:46–54.
7. Fewtrell L, Kaufmann RB, Kay D, Enanoria W, Haller L, Colford JM Jr. Water, sanitation, and hygiene interventions to reduce diarrhoea in less developed countries: a systematic review and meta-analysis. Lancet Infect Dis. 2005;5:42–52.
8. Jensen PK, Ensink JH, Jayasinghe G, van der Hoek W, Cairncross S, Dalsgaard A. Domestic transmission routes of pathogens: the problem of in-house contamination of drinking water during storage in developing countries. Trop Med Int Health. 2002;7:604–9.
9. Wright J, Gundry S, Conroy R. Household drinking water in developing countries: a systematic review of microbiological contamination between source and point-of-use. Trop Med Int Health. 2004;9:106–17.
10. Trevett AF, Carter RC, Tyrrel SF. Mechanisms leading to post-supply water quality deterioration in rural Honduran communities. Int J Hyg Environ Health. 2005;208:153–61.
11. Quick RE, Kimura A, Thevos A, Tembo M, Shamputa I, Hutwagner L, Mintz E. Diarrhea prevention through household-level water disinfection and safe storage in Zambia. Am J Trop Med Hyg. 2002;66:584–9.
12. World Health Organization. Health promotion glossary. WHO/HPR/HEP/98. Geneva: WHO; 1998.
13. Kosek M, Bern C, Guerrant RL. The global burden of diarrhoeal disease, as estimated from studies published between 1992 and 2000. Bull World Health Organ. 2003;81:197–204.
14. Gundry S, Wright J, Conroy R. A systematic review of the health outcomes related to household water quality in developing countries. J Water Health. 2004;2:1–13.
15. Jagals P, Nala NP, Tsubane TJ, Moabi M, Motaung KC. Measuring changes in water-related health and hygiene practices by developing-community households. Water Sci Technol. 2004;50:91–7.
16. Vietnam government. The comprehensive poverty reduction and growth strategy, No. 2685/VPCP-QHQT. Hanoi; 2002.
17. Shier RP, Dollimore N, Ross DA, Binka FN, Quigley M, Smith PG. Drinking water sources, mortality and diarrhoea morbidity among young children in northern Ghana. Trop Med Int Health. 1996;1:334–41.
18. Nhien N. Community participation and urban policies on health and environment of the city of Hue: Vietnam. In: Takano T, editor. Healthy Cities and urban policy research. London: Spon Press; 2003. p. 261–4.
19. Mintz E, Bartram J, Lochery P, Wegelin M. Not just a drop in the bucket: expanding access to point-of-use water treatment systems. Am J Public Health. 2001;91:1565–70.
20. Ministry of Health of Vietnam and UNICEF. Environmental sanitation in rural Vietnam; 2007.
21. Hairi F, Ong CH, Suhaimi A, Tsung TW, bin Anis Ahmad MA, Sundaraj C, Soe MM. A knowledge, attitude and practices (KAP) study on dengue among selected rural communities in the Kuala Kangsar district. Asia Pac J Public Health. 2003;15:37–43.
22. Koenraadt CJ, Tuiten W, Sithiprasasna R, Kijchalao U, Jones JW, Scott TW. Dengue knowledge and practices and their impact on Aedes aegypti populations in Kamphaeng Phet, Thailand. Am J Trop Med Hyg. 2006;74:692–700.
23. Musa HA, Shears P, Kafi S, Elsabag SK. Water quality and public health in northern Sudan: a study of rural and peri-urban communities. J Appl Microbiol. 1999;87:676–82.
24. Isobe KO, Tarao M, Chiem NH, Minh le Y, Takada H. Effect of environmental factors on the relationship between concentrations

of coprostanol and fecal indicator bacteria in tropical (Mekong Delta) and temperate (Tokyo) freshwaters. Appl Environ Microbiol. 2004;70:814–21.
25. Ministry of Health of Vietnam. Hygiene criteria of fresh water. No.1329/2002/BYT/QD. Hanoi; 2002.
26. National institute of Occupational and Environmental Health. Setting up of a model for community drinking water quality management system in selected villages. Ha Noi; 2007.