

East African Medical Journal Vol. 79 No. 5 May 2002

BACTERIOLOGICAL QUALITIES OF IN-DOOR AND OUT-DOOR DRINKING WATER IN KIBERA SUB-LOCATION OF NAIROBI, KENYA

J.K. Chemuliti, BVM, MSc, Kenya Trypanosomiasis Research Institute, P.O. Box 362, Kikuyu, P.B. Gathura, BVM, MSc, PhD, M.M. Kyule, BVM, MSc, MVP, PhD, and F.M. Njeruh, BVM, MSc, PhD, Department of Public Health Pharmacology and Toxicology, University of Nairobi, P.O.Box 29053, Nairobi, Kenya.

Request for reprints to: Dr. J. K. Chemuliti, KETRI, P.O. Box 362, Kikuyu, Kenya

BACTERIOLOGICAL QUALITIES OF INDOOR AND OUT-DOOR DRINKING WATER IN KIBERA SUB-LOCATION OF NAIROBI, KENYA

J.K. CHEMULITI, P.B. GATHURA, M.M. KYULE and F.M. NJERUH

ABSTRACT

Objectives: To compare the bacteriological quality of out-house (tank or standpipe) water and in-house drinking water (storage containers) and determine the risk factors influencing it.

Design: A cross-sectional study.

Setting: The study was carried out in Kibera slums located 7 km southwest from the Nairobi City centre.

Subjects: Water samples from twenty outside tanks/standpipes and sixty from in-house water storage containers.

Main outcome measures: Pour plate method was used to enumerate total bacterial counts in water, while the multiple tube technique was used to determine faecal coliform (FC) and faecal streptococci (FS) numbers. A questionnaire and environmental observation were used to determine the risk factors influencing bacteriological quality of water.

Results: The mean total bacterial counts (TBC) for out-house water was 46.6 per 100 ml while that for in-house water was 818.2 per 100 ml. Faecal coliforms were isolated from 7 (35%) standpipes and 57 (95%) in-house storage containers. The mean faecal coliform count was 93 and 103.4 per 100 ml for out-house and in-house water, respectively. The counts were significantly higher in the latter. Faecal streptococci were isolated from 2 (10%) standpipes and 37 (61.7%) in-house storage containers. The mean faecal streptococci counts were 35 and 65 per 100 ml for out-house and in-house water sources, respectively. *Escherichia coli* was isolated in 2 (10%) of out-house water and 30 (50%) of in-house. Of these, four were enteropathogenic, serotype 011 from one out-house water source and serotypes 011, 011, 0112ac from in-house water sources.

Conclusions: Bacteriological contamination of water at the source with a further deterioration between the collection points and homes was observed. A defective water delivery system and inadequate environmental sanitation were a potential source of contamination for out-house water. Scoops were a major source of contamination for stored water.

INTRODUCTION

Water has a great potential of transmitting a variety of enteric diseases. These diseases are for example cholera, typhoid fever, infectious hepatitis, amoebic and bacillary dysentery. Contaminated water has been associated with the occurrence of disease outbreaks particularly in communities living in areas with poor hygiene and sanitation. It is estimated that about 10 million people in developing countries die annually from water borne infections, half of whom are children under the age of five years(1). Recognition of the role of water in possible transmission of diseases has led to development of bacteriological standards for drinking water quality. The World Health Organization(2) guidelines for drinking water stipulate that any water intended for drinking must contain no faecal coliform (*Escherichia coli*) or thermotolerant coliform in any one sampling. The presence of this microorganism in water is indicative of its

unsuitability for consumption since all kinds of potential waterborne disease pathogens may be present. Furthermore, some strains of *Escherichia coli* are pathogenic and known to cause disease.

It is estimated that 60% of Nairobi residents live in unplanned squatter settlements, which lack adequate and quality water supplies and sanitation facilities(3). Although some of these areas may be served by a water distribution network, crowding, leaks, lack of sewerage systems and garbage disposal facilities exert great pressure on water quality(4). Water quality is further threatened by possibility of post collection contamination between communal water points and houses. This type of contamination has been attributed to various water handling habits such as storage in open vessels or vessels that are not cleaned regularly, use of communal cups to draw water and hands touching water during collection and storage(5). In view of the foregoing, the study was initiated with the objectives of assessing the bacteriological quality of water at the source

(out-house tanks/standpipes) and households (storage containers). Risk factors influencing water quality were also determined.

MATERIALS AND METHODS

Study location: The study was carried out in Kibera sub-location located approximately 7 km southwest of Nairobi city centre. This is a low-income slum area with an estimated population of 500,000 people. Three out of the nine villages, namely, Mashimoni, Makina and Silanga were randomly selected for the study.

Collection of samples: Eighty water samples were collected from 20 standpipes and 60 storage containers in households that drew water from the standpipes. Before the samples were taken the general environment both inside and outside the houses was noted and recorded. Water samples for bacteriological analysis were collected in 500 ml sterilized glass bottles containing 0.1% sodium thiosulphate. All samples were transported to the laboratory in ice-coolers and processed within 3-6 hours of collection. A questionnaire was administered at the time of collection to determine the risk factors that could affect the quality of water. All samples were analysed for total bacterial count, faecal coliform counts, faecal streptococci counts and the presence of *Escherichia coli*.

Bacteriological analysis: All tests were carried out in duplicates using the standard methods(6). The total bacterial count (TBC) was assessed using the pour plate method after a serial dilution in physiological saline ten fold up to 10^6 . The most probable number of coliforms (MPN) was determined using the multiple tube technique and computed from a five tube statistical table. These were confirmed on solid media (eosin methylene blue agar). Faecal coliforms were enumerated on the basis of positive or negative production of acid and gas in brilliant green lactose bile broth at 44.5°C for 24 hours. The presence of *Escherichia coli* was confirmed using IMVic formula and later serologically typed using Denka Seiken test sera. The most probable number of faecal streptococci was also determined using the multiple tube technique and confirmed on solid medium (MacConkey agar). The data was compiled and analysed statistically using statistix (SX) and SAS programs

RESULTS

Bacteriological analysis: A summary of results is shown in Table 1. The mean total bacterial counts (TBC) for out-house water was 46.6 per 100 ml while that for in-house water was 818.2 per 100ml. The total bacterial counts were significantly higher for in-house water than for out-house water ($p = 0.0001$). Faecal coliforms (FC) were isolated from 57 (95%) in-house sources and 7 (35%) out-house sources. The mean count was 93 and 103.4 per 100 ml for out-house and in-house water, respectively. The FC counts were significantly higher ($p = 0.0486$) for in-house water than for out-house water. Two (10%) of out-house and 37 (61.7%) of in-house water sources were contaminated with faecal streptococci. Mean faecal streptococci counts were 35 and 65 per 100 ml respectively for out-house and in-house water sources. *Escherichia coli* was isolated in 2 (10%) of out-house water and 30 (50%) of in-house. Of these, four were enteropathogenic, serotype 011 from one out-house water source and serotypes 011, 011, 0112ac from in-house water sources.

Table 1

Results obtained from bacteriological analysis of 80 water samples in Kibera sub-location of Nairobi

	Out-house sources	In-house sources	Both sources
1. Number of samples	20	60	80
2. Total bacterial count per 100ml sample			
Range	1-305	8-4200	1-4200
Mean	48.55	818.17	625.76
3. Faecal coliform count per 100ml sample			
Number of negative samples	13 (65%)	3(5%)	16 (20%)
Number of positive samples	7 (35%)	57(95%)	64 (80%)
Range	2-161	5-92	2-161
Mean	9.3	103.38	79.86
Number of pathogenic <i>E. coli</i>	1 (serotype 011)	3 (serotypes 011, 011, 0112ac)	4
4. Faecal streptococci per 100ml sample			
Number of negative samples	18 (90%)	23 (38.3%)	41 (51.25%)
Number of positive samples	2(10%)	37 (61.7%)	39 (48.75%)
Range	2-70	2-542	2-542
Mean	36	65.3	49.9

Environmental observation: Water points/standpipes were located less than 10 meters for most residents. These were supplied by the Nairobi City Council reservoirs through a network of entwining ground pipes made of either plastic or metal. Some of the pipes were old and rusty with evidence of leakage. There was no proper drainage system to carry wastewater, which was allowed to flow along the spaces between houses and along footpaths. Garbage disposal facilities were non-existent. Refuse was dumped in open spaces between blocks of houses. Several households shared a pit latrine, which was not kept clean.

Questionnaire response: Members of sixty households were interviewed. The number of persons living in each household ranged from one to eleven. All households stored their water in containers of which 54 (90%) had containers made of plastic, 4 (6.67%) had earthenware containers and 2 (3.33%) had metal containers. Forty-eight (80%) households did not cover their containers with lids while, the remaining 12 (20%) did. Stored water took an average of 2.28 days to replenish with the containers taking an average of 4.43 days before they were cleaned. Water was processed by boiling in 42 (70%) of the households while in 18 (30%) it was not.

A cup or mug was used to scoop drinking water from the containers in 26 (43.3%) of the households while in 34 (56.7%), water was poured out of the containers. Total bacterial counts were significantly higher in households that scooped water than in those that poured out their drinking water ($p=0.0202$). In 42 (70%) of the households, residents reported that they were aware water could act as a vehicle for disease transmission, while 5 (8.3%)

households believed they had suffered a waterborne infection at one time. Thirty-five (58%) of households, indicated that they knew measures they could take to ensure that water was safe for drinking.

DISCUSSION

The presence of thermotolerant coliforms and faecal streptococci in water indicates actual contamination with faeces (human and non-human) and potential contamination by disease causing pathogens of all kinds. Human bacterial pathogens potentially transmitted in drinking water include some strains of *Escherichia coli*, *Shigella* spp., *Vibrio cholerae*, *Yersinia enterocolitica* and *Campylobacter jejuni* (7).

The World Health Organisation (WHO) guidelines for bacteriological quality of drinking water require that all waters intended for drinking must contain no *Escherichia coli* or thermotolerant coliforms in any 100 ml sample. Faecal coliforms and faecal streptococci were detected in 7 (35 %) and 2 (10%) of the sampled communal water points indicating lack of safety for consumption. The poor levels of environmental hygiene coupled with a dilapidated water delivery system noted at the time of sampling could have been the probable sources of contamination to water at the communal points. Water quality in damaged supplies has been shown to deteriorate due to entry of polluting material into the system(8). The most common entry points for pollution were breakages and loose joints in the pipes. Contamination of water at a communal point presents a serious health risk to Kibera residents from an epidemiological point of view as this could lead to a widespread infection. A large outbreak of *Campylobacter jejuni* gastroenteritis was reported in Canada following contamination of municipal water supply(9).

The possibility of pollution of water between collection and use especially where communal taps are used, has long been recognised (10). There was a significant increase in bacterial concentration between the collection points and eventual use in Kibera. Faecal coliforms and faecal streptococci were isolated from containers in 57 (95%) and 37 (61.7%) of households, respectively. Use of scoops or bowls to draw water from the storage containers was a risk factor to the bacteriological quality of stored water. In one household for example, the bowl used to draw water was placed on the floor. Yeager(11), for example, reported a lower incidence of diarrhoea in children in households using water reservoirs with a tap than those in which scoops or mugs were used to retrieve drinking water. Although the health effects of post collection contamination may be limited since pathogens transmitted in this way may be within the family, it is important to know if such contamination is occurring so that its health effects may be estimated and appropriate intervention measures taken.

Occurrence of pathogenic *E.coli* in water is considered to be of high public health significance and presents a serious risk of disease(12). However, being a faeco-oral pathogen, means that other vehicles of transmission namely,

contaminated food, hands or utensils can also play a role. Although some strains of *E.coli* have been associated with waterborne epidemics(13), these do not occur by this means exclusively. Furthermore, other factors such as the organism ability to persist in water, withstand conventional water treatment and the minimum infective dose are significant before the establishment of an infection via the oral route. Pathogenic *E.coli* were isolated from one standpipe (serotype O11) and three households (serotypes O11 and O112ac). The presence of pathogenic *E.coli* is evidence of the risk associated with consumption of water and calls for urgent intervention measures.

Safe water is essential for good health. All efforts must therefore be taken to safe guard its quality at all stages of distribution. An efficient and well-maintained distribution system coupled with good hygienic practices would ensure that water is safe at the point of collection and before consumption.

ACKNOWLEDGEMENTS

This work was done by, J.K. Chemuliti as a part fulfillment for a Master of Veterinary Public Health degree of the University of Nairobi. The author is grateful to the University of Nairobi for the award of a Scholarship, which enabled her to carry out this research.

REFERENCES

1. World Health Organization. Epidemiology and control of Schistosomiasis, Technical report 643. WHO, Geneva, Switzerland, 1980.
2. World Health Organization. Guidelines for drinking water quality. 2nd edition. Volume 2. Health criteria and other supporting information. WHO, Geneva, Switzerland, 1996.
3. Obudho, R.A. Urbanization and spatial planning in Kenya. A case of bottoms-up approach to planning. Paper presented at a seminar on interaction of Man, Space and environment overtime, Silver springs Nairobi, April 24-27, 1986.
4. Feachem, R.G. Water supplies for low-income communities: Resource allocation, planning and design for a crisis situation. In Feachem, McGarry and Mara (ed.), Water, Waste and Health in hot climates, 1977.
5. Burgers, L., Boot, M. and Wijk-Sijbesma, C. Hygiene education in water supply and sanitation programmes. Literature review with selected and annotated bibliography. (Technical paper series: No. 27). The Hague, Netherlands, IRC International Water and Sanitation center; 1988.
6. American Public health Association (APHA). Standard methods for examination of water and wastewater. 17th edition, 1992.
7. World Health Organization. Guidelines for drinking water quality. 2nd edition, 1996.
8. Feachem, R.G. Water supplies for low-income communities in developing countries. *J. environ. eng Div. ASCE* 101 EE5, 1975; 687-702
9. Millson, et al. An outbreak of *Campylobacter jejuni* gastroenteritis linked to melt water contamination of a municipal well. *Canadian J. Public Health*, 1991;82:27-31
10. Wagner, E.G. and Lanoix, J.N. Water supply for rural areas and small communities. WHO Monograph Series, No. 42. Geneva, 1959.
11. Yeager, Beth A.C. Transmission factors and socio-economic status as determinants of diarrhoeal incidence in Lima, Peru. *J. Diarrhoeal Dis. Res.* 1991; 9:186-193.
12. Moore, A.C., Herwaldt, B.L., Craun, G.F., Calderon, R.L., Highsmith, A.K. and Juranek, D.D. Surveillance for waterborne disease outbreaks-united states, 199 1-1 992. *MMWR-CD-surveillance Summary.* 1993; 42:1 -22.
13. Feachem, R.G. A., Hogan, R.C and Merson, M. H. Diarrhoeal disease control: Reviews of potential interventions. *Bull. WHO.* 1983; 61: 637-640.