Research article

Microbial contamination of public drinking water sources and associated factors in Kopay Medical Officer of Health area Jaffna, Sri Lanka

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Abstract

Introduction
Incidence of water borne diseases is high in the Jaffna district with ground water being the main source for the Jaffna population. Ensuring the quality of groundwater is therefore mandatory to prevent water borne diseases. This study was designed to describe the level of microbial contamination of public drinking water sources with selected associated factors and to assess the knowledge of the general public on transmission and prevention of waterborne diseases in the Kopay Medical Officer of Health (MOH) area.

Methods
A cross sectional, descriptive study was carried out on the quality of drinking water in the Kopay MOH area. A pretested interviewer administered questionnaire and an observation checklist were used to collect data. Bacterial studies of well water samples were carried out in the Division of Microbiology at the Faculty of Medicine, Jaffna.

Results
Coliforms and *E. coli* were found to be above the Sri Lankan Standard (SLS)[1] in 90% of the water samples collected from public water sources. Ninety four percent of the wells were unprotected. Of 200 participants, 57.5% (95% CI: 51.6%-65.2%) had poor knowledge on the transmission and prevention of water borne diseases. Of the 200, 174 (87 %,) (95%CI: 81.8%-91.1%)) used unsafe water for drinking and domestic purposes. The surrounding environment was found to be a significant risk factor for contamination also found (P< 0.001, OR-29.3, 95% CI: 2.0- 423.7).

Conclusions
The majority (90%) of public water sources were microbiologically unsuitable for drinking in the Kopay MOH area. Most people consume raw water from these unacceptable water sources. It was also found that the surrounding environment is highly conducive for contamination of well water in the study area. The study participants had poor knowledge on transmission of pathogens through water and the prevention of water borne diseases.

Keywords : Coliform contamination, E. coli, water quality, common water sources, Jaffna, Sri Lanka

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Introduction

Access to safe drinking water is a fundamental human right and the quality of drinking water is an important public health issue.[2] Global estimates show that about 2.2 million people die every year from diarrhoeal diseases of whom 90% are children under 5 years of age. Most (88%) of the diarrhoeal disease deaths are due to drinking unsafe water, inadequate sanitation and poor hygiene.[3]

In Sri Lanka, about one-quarter of households have no access to safe drinking water.[4] Access to water supply and sanitation facility or service is not available for 18% of the child population. A large percentage of Sri Lankan children suffer from diarrheal diseases.[5] In Jaffna most people depend on ground water. Therefore, ensuring the quality of groundwater is mandatory to prevent water borne diseases.

The Jaffna District is situated in the Northern part of Sri Lanka. In 2012, the Jaffna population was 583,378 - approximately 2.27% of the Sri Lankan population. The Jaffna District is divided into 11 Medical Officer of Health divisions (MOH area). The incidence of water borne diseases is high in the Jaffna district. 23% of the Jaffna population live in Kopay MOH area.[6,7] In 2009, 12.4% of typhoid cases reported in Sri Lanka were from the Jaffna district[8] of which 5.01% were from the Kopay MOH area. The geography of Jaffna is favourable for under water pollution, with limestone as the main aquifer. The shallow aquifer of Jaffna occurs in the cavities and channels of this limestone which has no purification capacity. Pollutants reaching the groundwater can therefore spread far and wide.[6]

Underground water pollution is detected using the coliform count. Coliforms are present in the faeces of all warm-blooded animals and humans. The coliform count is used as an indicator of treatment effectiveness, cleanliness and the integrity of the distribution systems. *Escherichia coli*, one species of the coliform group, is always found in faeces and therefore, is a more direct indicator of faecal contamination.[9]

Objectives

This study was designed to describe the level of microbial contamination and selected associated factors of public drinking water sources and to assess the knowledge of people regarding transmission and prevention of waterborne diseases in the Kopay MOH area.

Methodology

This is a community based cross sectional study carried out in Kopay MOH area during August to October 2010.

Samples size and sampling techniques

The Public Health Inspecter (PHI) register lists 72 public drinking water sources in the Kopay MOH area of which 50 were selected by simple random sampling for the study. The sample size was limited to 50 due to time and resource constraints. Approximately 4200 people belonging to 800 families consume water from these public wells in the Kopay MOH area. From each family, the head of the family was selected to participate in the questionnaire study. From the 800 heads of families 200 were selected by systematic random sampling for interview.

Water sample collection

Sterile 250ml amber glass bottles fitted with ground glass stoppers were used for sample collection. The sampling device was locally designed based on WHO guidelines.[9] Briefly, a bottle holder was made with a 2 inch diameter PVC pipe and the bottom sealed with a PVC end cap. A heavy metal disk was attached to the bottom. Two stainless steel hooks were attached symmetrically on either side of the holder and tied to a nylon rope to lower it into the water source. Samples were transported to the Microbiology laboratory within an hour of collection..

Study instrument

An interviewer administrated questionnaire was used for the collection of socio demographic data, knowledge and environmental factors. The questionnaire was structured in five parts: identification details, personal data, information on water sources, knowledge of transmission and preventive measures of waterborne diseases. A check list, prepared according to the PHI manual published by the Ministry of Health was used to assess the environmental factors which classify the well as protected, semi protected and unprotected (Table 1)

Table 1: Check list for classification of well [19]

Protected well	Semi protected well
Should be located away from the potential sources of contamination and, as far as is possible, at higher level from such sources.	A parapet wall – 2 ½ feet (0.75meters) in height with a steep, outward sloping top to prevent pollutants being washed into the well and people standing on it.
The upper portion of the well should be protected by an impervious casing for at least 3 meters (10ft.) below the ground level and 30 cm above the ground level (to prevent surface water flowing in.)	An apron around the parapet wall – 5ft. (1.5meter) wide sloping outwards.
The casing should be surrounded at ground level by a concrete platform at least 1 meter (3ft) wide sloping out to allow for drainage away from the well.	A lead away drain – 10ft (3meter) long
A lead away drain 3 meters (10ft) long should be constructed.	An impervious lining – at least 10ft (3meter) below ground level.
The well should be provided with a concrete cover to which a pipe is fitted eccentrically to withdraw water. The opening in the cover for the pipe should be well sealed to prevent entry of water from outside.	A pulley arrangement for raising water with a bucket attached to a rope or chain
	A common bucket – users should not be allowed to use their own buckets

Note : All wells are considered as unprotected

Data collection

Permission for data collection was obtained from Kopay MOH and Kopay Piradeshiya Sabha (Local Government Body responsible for water sanitation). Ethical clearance was obtained from the Ethical Review Committee, University of Jaffna. Informed consent was obtained from the subjects after explaining the purpose and methodology of the study prior to the principal investigators conducting interviews using the questionnaires.

Microbial analysis

Multiple tube method (MPN) was used to enumerate the total coliform and *E. coli* counts as described in Sri Lankan Standards.[9] Measured amounts of single and double strength modified MacConkey's medium were sterilized in bottles containing a Durham tube for demonstrating gas production. Using graduated pipettes, 10 ml of each sample was transferred to each of five tubes containing 10 ml double strength MacConkey broth. Five each of neat 1ml a 1/10 dilution of the sample was inoculated into 5 ml single strength medium. The tubes were incubated at 37 °C and examined after 24 and 48 hours for gas production and turbidity. Those that showed acid and sufficient gas to fill the concavity at the top of the Durham tubes at the end of 24 hours or 48 hours were considered to be presumptive positive for coliform bacilli. The results of the presumptive test were interpreted according to the MPN table and indicated as the total coliform count per 100 ml of water. Each presumptive positive tube was subcultured onto Brilliant Green Bile Broth and Tryptone water and incubated at 44 °C for 48 hours and examined for gas production. Half of the contents of the peptone culture were aseptically transferred to the test tube to which Kovac's reagent was added and mixed gently. Instant formation of a red colour ring at the upper layer indicates a positive indole reaction. If negative, the remaining original peptone culture in the water bath was examined for indole production after a further 18 hours of period. Production of gas in the broth tubes at 44 °C and a positive indole test was considered as positive reaction for *E. coli* and the count recorded according to the MPN table. Table 2 shows the total coliform and *E. coli* count permissible according to the SLS guidelines.

Table 2: Sri Lankan Standards for drinking water

Parameters	Maximum Desirable	Maximum Permissible
Total coliforms	Nil	10/100ml
E. coli	Nil	Nil

(Source: Sri Lankan standard 614 part 2, 1983)[1]

Data analysis

Data were analyzed by SPSS 17 package. Chi squire and Fishers' exact tests were used to explain the association. Odd ratios were used wherever applicable. P< 0.05 was taken as significant level.

Knowledge about water borne disease transmission and prevention:

The data were collected with four open ended questions and three close ended questions. Open ended questions were asked regarding common water borne diseases and symptoms of the above mentioned diseases. Close ended questions were mainly regarding typhoid fever transmission, mode of spread, causative organism, specific symptoms and some preventive measures. The 100 marks were given according to the weight of the questions. It was categorized under categorical variables into poor, average and good. Poor indicated marks below 40, average was 40-60 marks and good was above 60 marks. For bivariate analysis, average and good were combined and taken as satisfactory and poor was taken as unsatisfactory.

Results

Level of contamination

Of the sampled water sources, 47 were dug wells and 3, tube wells. Table 3 shows the coliform and *E. coli* counts in each well type. As shown, water from 45 sources (90%) was found to be unusable with a coliform count above the safe level. All tube well and 57.4% of the dug wells were positive for *E. coli*.

Table 3: Percentage of total coli forms and E. coli from sampled water samples

Water sources		Total coliforms		*E. coli*	
Type	No tested	Below permissible (%)	Above permissible (%)	Negative (%)	Positive (%)
Dug well	47	3(6.4)	44(93.6)	42.6	57.4
Tube wells	3	2(66.7)	1(33.3)	00	3(100)

In our study population, 174 of 200 households (87%) used water for drinking purpose without prior boiling. In addition, 70% of households (n=140) used these sources of water for cooking and food preparation and 39.5% (n=79) for washing laundry and other purposes such as washing kitchen utensils, bathing and cleaning their homes.

Environment of wells

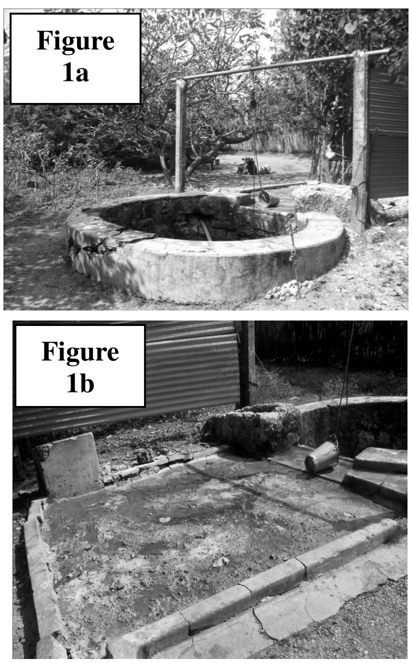

Figure 1
Examples of unprotected wells

Using the PHI checklist, only 3 of the 50 wells inspected were considered to be protected (Table 4). Figures 1a and 1b show the condition of unprotected wells in this study area. None of the wells have a parapet wall on the front where people stand and draw water and there is no apron around the parapet wall with a wide surface sloping outwards around the well. Some individuals bathed while standing next to the well, resulting in contaminated water going back into the well.

Among the 3 protected wells, 2 (66.7%) water samples proved usable. However, in the 47 unprotected wells, 44 (93.6%) were unsatisfactory for drinking purposes. These results indicate that the surrounding environment is an important risk factor (P< 0.001, OR-29.33, 95% CI: 2.0- 423.7). Factors promoting contamination were lack of protection and proper treatment of water, poor drainage system and poor surroundings. In the study area, latrine pits were unlikely to be the cause of contamination because they were built more than 35m away from water sources and there was no waste sewage pits close to the water sources.

Description of study participants

The study population had 176 (88%) participants aged 16-60 years, 9% above 60 and 3% below 16 (Table 5). There were 105 (52.5%) males and 155 (77.5%) nuclear families. Most households (56%) had four to six members. The majority (82%) had completed secondary education. Monthly income of 70.5% participants was less than Rs. 9000.00. Past history of typhoid was given by 11.5%.

Table 5
Socio demographic variables in participants(n=200)

Socio demographic variation		Numbers	%
Age	<16	6	3.0
	16-60	176	88.0
	>60	18	9.0
Gender	Male	105	52.5
	Female	95	47.5
Family type	Nuclear	155	77.5
	Extended	45	22.5
Number of family members	<4	68	34.0
	4-6	112	56.0
	>6	20	10.0
Education level	No formal education	7	3.5
	Primary	29	14.5
	Secondary	152	76.0
	Tertiary	12	6.0
Total family monthly income	<9000	141	70.5
	9000-13999	28	14.0
	14000-19999	19	9.5
	20000-31999	9	4.5
	>32000	3	1.5
Past History of typhoid	Yes	23	11.5
	No	177	88.5

Knowledge of participants on transmission and prevention of water borne diseases

Table 6 shows the educational level of study participants and their knowledge about transmission and prevention of water borne diseases. Most subjects (57.5%) had unsatisfactory knowledge. Among participants who had not passed G.C.E O/L, 80% had unsatisfactory knowledge and among the subjects who passed G.C.E O/L, 27.1% had unsatisfactory knowledge (P< 0.0001).

Water safety

Among the participants, 87% used raw water for drinking, Among raw water users 60.3% had unsatisfactory knowledge about transmission and prevention of waterborne diseases (P=0.035). Hand washing after defecation was noted in only 8.5% of the study population. Among the people who wash the hands after defecation, 29% draw water from the well to wash the hands which risks contamination of the rope and bucket. Few participants (3.5%) used their own buckets to raise water.

Table 6
Relationship of educational qualification to participant knowledge

Education level of the participants	Knowledge		Total
	Unsatisfactory	Satisfactory*	
G.C.E O/L not qualified	92 (80.0%)	23 (20.0%)	115 (100.0%)
G.C.E O/L qualified	23 (27.1%)	62 (72.9%)	85 (100%)
Total	115 (57.5%)	85 (42.5%)	200 (100.0%)

Discussion

Our study shows that the majority (90%) of public water sources were microbiologically unusable during the study period. Raw (unboiled) water from these sources were used by 87 % of the study participants. The results of the study also showed that the surrounding environment of the wells were conducive for contamination and this association between surrounding environment and contamination of wells is statistically significant.

Most pathogens that contaminate water supplies are from humans or animal faeces. It is Assessment of all water borne pathogens in each water sample is expensive and was beyond the scope of the current study. Coliforms indicate pollution of water and possibility of having disease-causing organisms (pathogens). *E. coli* contamination is considered as the most suitable index of recent faecal contamination.[9]

There are few studies in Sri Lanka on the microbial quality of well water. Previous studies in Kurunegala[10], Kalutara, Galle and Matara districts[11,12] have shown microbial contamination of well water. Our survey focused on the Kopay MOH area where the source of water is mainly dug wells with a few tube wells. Analysis of samples proved that the water used for domestic purposes, particularly for drinking, was substandard with only 10% of the water sources being safe according to the Sri Lankan Standards (SLSI 614 part 2:1993)[1]. More than half the wells were contaminated with *E. coli,* showing the risk of transmission of faeco-orally transmitted pathogens.

Seasonal variation, lack of well protection and proper treatment of water, poor drainage systems and geographical pattern and poor surroundings are responsible for contamination of ground water. Rainfall correlates well with bacterial counts as reported in Central Chile.[13] It may be due to leached contaminants from latrine pits, solid waste dumps and contaminated surface water. Howard *et al* (2003) reported correlation between the number of thermotolerant coliforms and rainfall in the previous 24 hours.[14] In the Jaffna district, rainfall occurs during October to November (inter monsoonal rains) and from October to February (North East monsoonal seasons) (Meteorology department, Jaffna). The climatic changes did not influence the results of this study as there was no rain during or immediately prior to this study period.

Earlier studies have shown that the leading source of contamination is locating latrine pits within 25m lateral distance from the water source.[15] Still and Nash proved in 2002 that the pit latrines above 20m from the water source with fine sandy soil create a negligible health risk.[16] In our study area, water sources were unlikely to be contaminated by latrine pits as all the common wells in the study area were built more than 35m away from the latrine pits and there was no waste sewage pits.

Unprotected wells (94%) were predominant in the study area, resulting in a high possibility of contamination. This is supported by the study conducted during January 1987 to February 1988 in Kurunagala, Sri Lanka[10] in which highest faecal coliform count was found in unprotected wells. In another retrospective study conducted in 2009 by Jayatilleke and Gunawardana in the Kalutara District, on 184 water samples from tube wells, protected and unprotected wells, water in two thirds of the wells were unsuitable for consumption.[11] Unfortunately they couldn't relate the water samples to the specific wells.

According to Still and Nash (2002), better well construction is more significant than latrine location in preventing water contamination.[16] In the current study, it was observed that 12% of wells had improper or damaged construction of parapet wall and the platform facilitating the waste water/pollutants getting into the wells. More than half the wells did not have proper drainage and waste water accumulated in the surrounding area. Domestic animals could freely move around the wells as none were fenced.

Knowledge regarding transmission and prevention of waterborne diseases

The transmission of water borne diseases is directly related to perception and behaviour of individuals in any population, including their personal hygiene. In this study area most of the consumers were of poor socio economic status. They didn't have adequate knowledge on the diseases transmitted through contaminated water..

Unprotected wells, ignorance of water borne diseases and poor socio-economic status in this area could facilitate outbreaks of typhoid like water borne illnesses. A number of studies have shown that microbial contamination occurs during collection, transport and storage of water. Wright *et al* in 2004 showed that significant deterioration in water quality occurs between the source and point of use.[17] The lack of hand washing after defaecation and using common property (rope and bucket) to draw water for hand washing after defaecation noted in the current study suggest that faecal contamination of water sources is a possible reason for deterioration in water quality, as described by Wright et al (2004) .[17]

Prevention should be based on ensuring access to safe water and by promoting safe food and water handling practices. Public awareness should therefore be raised to induce behavioural change.[18] Still and Nash indicated that combined improvements in water and sanitation have a synergistic effect on health,[16] indicating that appropriate measures to improve water and sanitation should be undertaken in this study area.

Conclusion

The majority (90%) of public water sources were microbiologically unsuitable in the Kopay MOH area. Most people consume raw water from these unacceptable water sources. It was found that the surrounding environment is highly conducive to contamination of well water. Although most of the community use unsafe water, the knowledge of the participants on transmission of pathogens through water and prevention of water borne diseases was poor. Therefore measures should be taken to improve the water quality, including proper maintenance and monitoring of these common wells.

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