Al Ameen J Med Sci 2016; 9(2):130-133 ● US National Library of Medicine enlisted journal ● ISSN 0974-1143

SHORT COMMUNICATION CODEN: AAJMBG

Post-earthquake drinking water quality in the Kathmandu valley: A pilot study

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Abstract: *Background and Objective:* Present pilot study was undertaken to analyze water quality in the Kathmandu valley after massive earthquake of 25 April 2015. The water samples were collected from different sources viz. deep boring, dug well, stone spout, and spring water. *Method*: Sample analysis was carried out for microbiological parameters such as *E. coli* and Total Coliform (TC) bacteria. The bacterial population (*E. coli* TC) was enumerated using microfiltration method. *Result:* The results showed that more than 90 percent samples are contaminated with *E. coli* and TC bacteria. The microbial count ranges from 01 CFU to >300 CFU per 100 mL of water. These values exceed the Nepal national drinking water quality guidelines. Maximum *E. coli* (>300 CFU/mL) were estimated in dug well, while >300 coliform were enumerated in spring water. *Conclusions:* Water containing *E. coli* and coliform bacteria beyond the guidelines cannot be used for drinking purpose until treated using suitable methods. This study results may be considered as a first report on the problem, immediately after the disaster and have lacuna in sampling process due to post disaster situation in this area. The report will enable policy holders to initiate more sanitation programs and other activities in this region. Further elaborated studies covering all disaster location sites in detail manner should be undertaken to give more insights into the problem.

Keywords: Bacterial contamination, Drinking water, Treatment, Waterborne diseases

Introduction

Kathmandu valley experienced a massive earthquake on 25 April 2015. Post disaster drinking water quality has been always considered as crucial issues in disaster management especially related to health care perspectives like water borne diseases and other illness [1]. In order to safeguard public health in such situations, access to quality drinking water for public should be ensured [2]. The fundamental aspect in post disaster management is to assess the water quality in the area and action to be taken by policy holders based on the same.

Safe drinking water is essential for healthy human life. Water intended for human consumption should be free from harmful chemicals and microbiological agents. The water quality gets affected due to natural phenomena and mostly by human activities. Natural disasters such as flood, landslide and earthquake significantly influence on the quality of waters. Among these, the earthquake alone can bring big change in the characteristics of water. In general, after massive earthquakes water quality of ground and surface water get altered suddenly. This is due to disturbance in ground water table and also in the earth crust around earthquake affected areas. Similarly, the earthquake bring change in soil structure by making it porous which facilitate in percolation of sewer and street runoff in ground water table. In such circumstances, it is difficult to maintain the purity of water for drinking and other domestic usage. The Nepal Academy of Science and Technology undertake water quality test from different sources around the valley to ensure the quality of drinking water supplied to earthquake victims. The work was carried out during April 2015 to May 2015. The objective of this pilot study was to analyze drinking water quality in the Kathmandu valley after the earthquake of 25 April 2015. The work was mainly focused on analysis of microbiological parameters such as *E. coli* and TC bacteria and suggests possible protective measures of water borne epidemics.

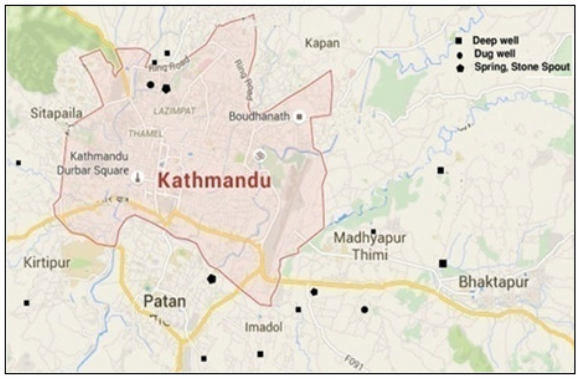
Sampling sites: Water samples were collected from different places in the Kathmandu valley particularly, from the earthquake affected areas and the sources from where water was supplied to earthquake victims in different temporary shelters. The water sources were; deep boring, dug well (shallow well), stone spouts, and spring water. The sampling sites and water sources selected for this study is presented in the following table (table 1).

Table-1: Drinking water sources and sampling sites

Source	Sampling sites
Deep boring	Balaju, Matatirtha, Naya Thimi, Jhaukhel, Sudal, Tahakhel and Bode (09)
Dug well (shallow well)	Mitranagar, Gongabu (01)
Stone spout	Balaju and Dhobighat (02)
Spring water	Taukhel and Godamchaur (02)

The sampling sites are also presented in the figure 1. As shown in the figure; the sites from where water samples were collected (deep boring, dug well, and stone spouts) are indicated by symbols.

Fig-1: Map showing sampling sites.



Material and Methods

Sterilized polyethylene bottles (250 mL) were used for sampling. Membrane filter (Whatman filter paper) and M-endo agar Hi-media were used in the estimation of *E. coli* and coliform bacteria.

Sampling: The water samples were collected from different sources of Kathmandu, Lalitpur and Bhaktapur districts in the Kathmandu valley. The sampling sites were selected based on the frequency of drinking water supplied to earthquake victims in the valley. Sample collection was made according to standard method [3]. The samples were collected in the polyethylene bottles (250 mL capacity) sterilized in an autoclave at 121° C and 15 LB pressure for 15 min. Before collecting the samples, the sample bottles were purged at least three times by the water to be collected for analysis. The samples were stored in a portable icebox and transported to the laboratory. The samples were stored at ~4° C in a refrigerator until analysis.

Sample analysis: The *E. coli* and TC bacteria were quantified by Membrane Filtration (MF) method (Greenberg et al. 1992). The samples (100 mL for each sample) were filtered using sterile filter paper with pore size of 0.45 µm by applying vacuum suction and incubated in an incubator at 37° C for 24–48 h in M-endo agar media. After incubation, bacteria were enumerated by counting the colonies.

Results and Discussion

Earthquake affects water supply system in terms of quality and quantity [4]. The massive earthquake of 25 April 2015 damaged pipeline supply at many places in the Kathmandu valley. In this circumstance, the only option to fulfill the need of drinking water in the valley was different sources available around in the valley. These sources were; deep boring, dug well (shallow well), stone spouts and spring water. A total 14 samples were collected from deep boring (09), dug well (01), stone spouts (02), and spring water (02). The sampling sources, sampling sites, and analytical results are illustrated in the table 2.

As shown in the table 2, most of the samples are contaminated with *E. coli* and TC bacteria. The reason of maximum bacterial contamination is due to increased water pollution and haphazard disposal of domestic wastes near to ground water sources. As a result, pollutants can easily access to water sources and increase the level of water pollution. Similarly, street runoff also contributes in the increment of water pollution. During post earthquake and even in the normal situation, drinking water in most of the areas of Kathmandu valley is supplied

from the sources mentioned in table 1. Water suppliers unhygienically collect water in the containers (tankers) and supply to consumers as per the demand. As we observed during sample collection, water suppliers were collecting water in the tankers from these sources and supplying to earthquake affected areas in the valley.

Table-2: Water quality analysis

Source	Sampling site	Total coliform (CFU/100 mL)	
		E. coli	Coliform
Deep boring	Manamaiju, Balaju	09	>100
Deep boring	Ganga cinema hall, Balaju	19	23
Deep boring	Matatirtha, Thankot	01	05
Deep boring	Tahakhel, Chapagaun	03	>300
Deep boring	Tahakhel, Chapagaun	01	25
Deep boring	Naya Thimi, Bhaktapur	05	>100
Deep boring	Jhaukhel, Bhaktapur	07	>100
Deep boring	Bode, Bhaktapur	*ND*	50
Deep boring	Sudal, Bhaktapur	*ND*	*ND*
Dug well	Mitranagar, Gongabu	>300	>100
Stone spout	Ranibari, Balaju	>100	>100
Stone spout	Dhobighat, Lalitpur	16	72
Spring water	Taukhel, Godawari	06	>300
Spring water	Godamchaur, Thaiba	>100	>300

ND: Not Detected

The results shows that bacterial contamination was not detected in the sample collected from Sudal, Bhaktapur. This may be due to use of chlorine as a disinfectant prior to distribute the water in the earthquake affected areas of Bhaktapur district. As informed us by water suppliers, chlorine was added in the tankers before supply to consumers. Microbiological (*E. coli* and TC) contamination detected in the water may be due to lapses in the protective measures which should be followed to maintain water quality. According to Nepal national drinking water quality guidelines [5], *E. coli* and TC bacteria should not be present in drinking water.

As shown in figure 2, maximum TC was enumerated in the spring water. The reason of maximum coliform contamination to spring water is due to street runoff, and open defecation practices. The dirt particles and garbage discarded in the open land surface reach to spring water via surface runoff and contaminate the water system. The situation is common in most of the rural areas in the valley. This is the reason of maximum colirom in the spring water.

Fig-2: Presence of coliform in the water samples (average value).

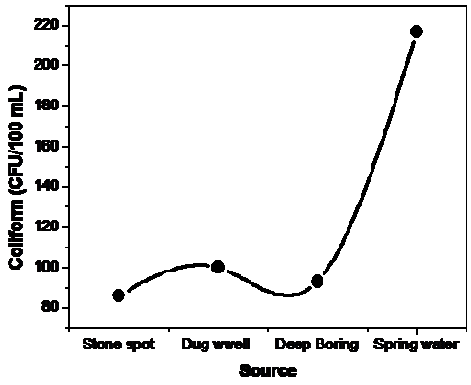
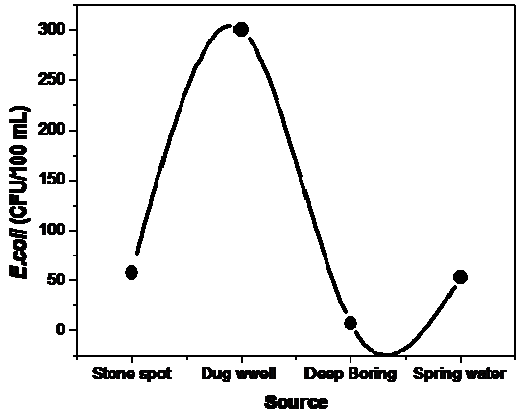


Figure 3 shows the presence of *E. coli* in the samples collected from deep boring, dug well, stone spout, and spring water sources. Dug well shows maximum *E. coli* (>300 CFU/100 mL of water), whereas the bacterial population enumerated in stone spout and spring waters were >100 CFU/100 mL of water. In deep boring it was 19 CFU/100 mL of water. The reason of maximum *E. coli* present in the dug well is due to poor sanitation, open top of the source, seepage from safety tank, and irregularity in the use of

disinfectants. Moreover, due to earthquake, the soil around ground water table becomes loose and porous in structure. Such conditions facilitate percolation of pollutants via soil pores to groundwater table. The porosity in soil particles depends on the intensity of earthquake, and increases with increase the magnitude and strength of the quake.

Fig-3: Presence of *E. coli* in the water samples (average value).



Presence of *E. coli* in drinking water leads diarrheal diseases, kidney failure, and severe anemia. The severity of microbial contamination eventually leads the death of patient [4]. Present study reveals *E. coli* and TC bacteria in the water beyond drinking water quality guidelines.

Conclusions

The water samples analyzed for the enumeration of *E. coli* and coliform bacteria exceeds Nepal national drinking water quality guidelines. The water sources in Bhaktapur area are highly contaminated with *E. coli* and coliform bacteria. Bacterial contaminated water as such is not acceptable for drinking purpose. To make the water drinkable, further treatment is needed using suitable method. The reason of water pollution as identified is mainly due to poor sanitation and unhealthy hygienic practices. Emphasis should be given on sanitation to maintain healthy aquatic environmental quality.

Recommendations

Following recommendations has been drawn for utilization of water supplied from the sources mentioned.

1. Use only purified drinking water.
2. Boiling is one of the suitable and reliable methods of water purification, hence recommended to use boiled water.
3. Always keep covered drinking water containers.
4. Give attention on personal hygiene and never discard waste materials nearby drinking water sources.
5. Be aware “clean water may not be pure”.

Acknowledgements

The authors are thankful to the vice-chancellor and secretary of the Nepal Academy of Science and Technology (NAST) for encouragement and support during entire course of this study.

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