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Drinking water quality and risk of waterborne diseases in the rural mountainous area of Azad Kashmir Pakistan

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Abstract

A study was conducted to evaluate drinking water safety at three different levels including sources, system and household in district Bagh, an earthquake affected area of Azad Jammu and Kashmir Pakistan. Portable water testing kit (Oxfam-DelAgua) was used for the detection of thermo-tolerant fecal coliform (*Escherichia coli*). A total (n=254) number of drinking water samples were examined for the presence of fecal coliform. It was found that, 68.5% (174 out of 254) of the overall samples tested were contaminated with *Escherichia coli*. The 52% (40 out of 77) of the water samples at source level, whereas 69% (58 out of 84) of water sample collected from system and 71% (66 out of 93) at household level were found contaminated with *Escherichia coli*. It was concluded that unprotected drinking water sources, improper management of waste, vulnerable sewage and ignorance regarding health and hygiene are the main reason of water contamination in the area.

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Introduction

Water is an important component of human body and is the need of life (Muhammad *et al.*, 2012). Presence of deleterious chemicals and pathogenic microbes can cause a serious health problem, leading to infections and death (Lima *et al.*, 2005). The drinking water contaminated with any pathogenic bacteria is unsafe for human consumption and household use (Muhammad *et al.*, 2012). Access to safe drinking water is not only the prime need for survival and health but is also basic human rights (WHO, 2000). Safety of drinking water remains an important public health concern particularly in emergency situations (Ferretti *et al.*, 2010). Pathogens that cause diarrheal diseases are being linked with contaminated water consumption, such pathogens are the main cause of gastrointestinal infections. The childhood mortality rate due to diarrheal diseases is 2.5 million each year (Muhammad *et al.*, 2012; Oswald *et al.*, 2007). Each year approximately five million children die due to the use of unsafe water (Shar *et al.*, 2010). Approximately 1.8 million kids died in developing countries (excluding china) caused by biological agents or microorganisms originating from food and water in year 1998 (Akbar and Anal 2011). Vulnerable and Unsafe drinking water supplies are contributing in high rate of human morbidity and mortality worldwide. It has been a national concern in United States of America to provide safe drinking water since before the 20th century (Sobsey 2006). Unprotected or protected communal water sources are the key means of potable water in many developing countries (Gundry *et al.*, 2004; WHO, 2000). It has been estimated that 1/3 of the total world population use ground water for drinking purpose (Nickson *et al.*, 2005). Obtaining safe water from a communal source remains a prime concern of the people in developing countries (Joyce *et al.*, 1996). Vulnerable sewage and sanitation lines and direct discharge of waste to natural reservoirs and water bodies are the major cause of fecal contamination (Huttly, 1990).

A group of bacteria called coliform are the primary indicator of water pollution. The presence of these microbes is associated with the presence of disease causing microorganisms (Muhammad *et al.*, 2013; Shar *et al.*, 2010). Bacteriological examination of water samples are usually undertaken to estimate the water quality. Most of the waterborne disease is related to faecal pollution of water sources. Therefore water microbiology is largely based on the need to identify indicators of faecal pollution such as *Escherichia coli* (Barrell *et al.*, 2000). The detection and enumeration of coliform bacteria for the evaluation of microbiological drinking water quality has been exist from since 1912 (Bancroft *et al.*, 1989). Drinking water should be pathogens free and with good organoleptic characteristics (Nevondo and Cloete, 1999). Contamination of drinking water during or after the collection from a safe source has been identified as a problem in rural areas particularly. A vast variety of pathogens are associated with water to cause severe diseases such as diarrhea, Poliomyelitis and hepatitis. The microbes such as, *Vibrio cholera*, *Rotavirus*, *Astrovirus*, *Cryptosporidium*, *Gardia*, *Entameoba histolytica*, *Shagella* etc are important pathogens, can cause severe damage to human health associated to unsafe water (Gundry *et al.*, 2004; Hamer *et al.*, 1998). In developing countries huge population are suffering from health problems associated with unavailability of drinking water or contaminated drinking water (Leeuwen, 2000).

In Pakistan it has been estimated that 40% of all deaths and 30% of all diseases is associated to unsafe water. Every fifth person suffers from illness due to polluted water. It has been estimated that three million Pakistanis suffer, while 0.1 million die from waterborne diseases annually (Haydar *et al.*, 2009). It has been estimated that 44% of the Pakistani population does not have access to safe drinking water, while the figures rise to 80 percent in rural area population. Almost 1.1 billion people are lacking adequate access to water, whereas 2.4 billion people live without ample sanitation (Rosemann, 2005). The objective of this study was to evaluate and highlight the bacteriological quality of drinking water at three different levels such as, sources, water supply system and household and possible exposure to the pathogenic bacteria during daily consumption of water in the remote mountainous area of Azad Kashmir Pakistan.

Study area

The study conducted in different areas of district Bagh, Azad Jammu and Kashmir Pakistan. Topography of the study area is mountainous and majority of the people used to live in small scattered villages dependent on natural springs particularly well and flowing water channels generally as their primary source of water (drinking and household use). The area was severely affected by October, 2005 earthquake (Figure1). In the current study a detail survey regarding the existing drinking water quality of the area in term of microbiological contamination was conducted.

Materials and methods

The drinking water samples were collected aseptically from the water at source, supply and household level and were examined for the presence of thermo-tolerant coliform. Water of each sample was also tested for its acidity, alkalinity, turbidity and organoleptic characteristics on the collection spot. Oxfam-DelAqua portable water testing kit based on membrane filtration method was used for the detection and isolation of *E. coli* present in drinking water samples following Oxfam-DelAqua water testing kit manual (Oxfam-DelAgua, 2004). The target bacteria were recovered on 47 mm diameter filtration membrane (Millipore) with a pore size of 0.45 µm. Membrane lauryl sulphate broth (MLSB) (Sigma) was used for bacterial growth. The growth media was prepared and sterilized at the field laboratory according to manufacturer instruction before use each time. Media plates were prepared by pouring MLSB on absorbent pads earlier placed aseptically in small sterile media plates (50 mm).The filtration assembly were sterilized each time with the help of methanol on the sample collection spots and all procedures were aseptically handled to avoid contamination.

Each drinking water source and supply system were selected for water quality analysis keeping in mind its active use for drinking and household purpose and the dependency of the local population on it for community drinking water supply schemes. The microbial and physical water quality of drinking water at sources level was examined, whereas the same tests were also conducted for water in supply systems and household storage associated to the respective water sources, the water samples from supply systems include water in pipe lines and supply water pots, while the samples from household were collected from storage and handling containers at household. The water filtration assembly of the kit was sterilized each time by adding a few drops of methanol to the sampling cup and ignites it to flame for a while, the filtration apparatus were placed over the sampling cup before complete burn up of methanol. Burning of methanol produces formaldehyde gas in the absence of oxygen, which work as an affective disinfectant to sterilize the sampling cup and filtration apparatus (Oxfam-DelAgua, 2004).

Fig. 1. Sampling site within the map of Azad Kashmir Pakistan. (Source: http://www.refworld.org/docid/4517b1a14.html)

For each sample 100 ml of volume were filtered through a filtration membrane with 0.45 µm pore size. The bacteria present in the water sample retained on the surface of membrane, which was placed on the selective medium (MLSB) and incubated at 44ºC for 24h in the small incubator present in Oxfam-DelAqua kit. Appearance of yellow colonies on the red color media plates were counted as faecal thermo-tolerant coliform. Standard turbidity measuring tube (present in Oxfam-DelAqua kit) with a range of 5 to 2000 TU, was used for the measurement of turbidity, while the pH of water were measured with the help of portable comparator cell by adding phenol red tablets into the left hand cell and read the results after shaking by comparing the color with the standard colors present on the side of cell. Temperature of the water samples were measured with the help of probe thermometer manually each time.

Results and discussion

A total (n=254) number of drinking water samples were examined for the presence of *E. coli* (an indicator of bacteriological quality of drinking water), as per the guideline of national and international standards for compliance to fit for drinking purpose in the existing conditions. The water samples analysed were collected from drinking water sources, water supply system and household in the target areas of district Bagh (proper Bagh, Dhir kot and Farward kahuta). The source level samples include, water from natural springs, water canals, hand pumps and wells currently in use for drinking purpose, while the water collected from system include the water carrying bodies such as, pipe line and carrying utensils, whereas samples from household include, storage pots, water tanks and drinking pots. Natural springs were found the main source of drinking in these mountainous areas. Majority of the drinking water sources were found unprotected. It was found that, 31.5% (80 out of 254) of drinking water samples are fit for drinking, whereas 68.5% (174 out of 254) samples were contaminated with *E. coli*. Figure 2 illustrate the colonies of *E. coli* on the surface of filter membrane supplemented with selective growth media. It was observed that 52% (40 out of 77) of the water sources evaluated for the presence of *E. coli* were found contaminated, while the remaining 48% (37 out of 77) were fit for drinking with no presence of *E.coli* . The number of contaminated samples in water samples collected from drinking water supply systems were 69% (58 out of 84). The contamination level in household water samples was 71% (66 out of 93). The water samples at household level showed the highest contamination as compared to system and sources level contamination (Figure 3). The turbidity of all samples checked for microbial water quality were found less than 5 NTU, it is in accordance with the turbidity standard as per WHO parameters (Haydar *et al.*, 2009; Oxfam-DelAgua, 2004). The pH of all the water samples was found in the range of 7.2-8.2, varying from neutral to slightly alkaline. A study showed that, majority of the drinking water from the area is contaminated with fecal coliform. *Escherichia coli* can survive six times more than other microbes in water (Muhammad *et al.*, 2012). It has been observed from the catchment analysis that most of the water sources are unprotected and prone to become contaminate with animal and human activities and excreta. Haydar *et al.*, (2009) reported in a study in the southern Lahore city of Pakistan that, 62.5% drinking water in supply system were contaminated with bacteria before monsoon, whereas the percentage raised to 75% after monsoon raining, which may be possibly due to cross contamination of sewage and drinking water supply. Shar *et al.*, (2010) reported that, ground and surface water of Rohri city Pakistan were contaminated with *E. coli* (12.5%) in pre-storage ground water samples, whereas the contamination were 41.6% in post-storage samples. In Pakistan water quality and hygiene related diseases are the main concern, as it causes the mortality of 116,000 children under 5 each year (Tariq, 2013). Quantitative microbial risk assessment can be useful for estimation of human health risk associated to pathogens present in drinking water (Lieverloo *et al.*, 2007). The current study showed that the drinking water sources of the bagh district particularly and all mountainous area generally in the Kashmir and northern area of Pakistan are unprotected and mostly covered with trashes around the locations. Algal bloom was also observed in some of the water sources which can be a significant cause of cross-contamination of drinking water from sewage water. The high number of contamination at household level shows the unhygienic handling of water during transport and storage process. The possible cause of the contamination of drinking water at different level is the inadequate protection, unhygienic management of the household filth, improper sanitary and sewage system, habit of communal bathing and laundry activities and improper animal wastes management. Handling of drinking water, personal and domestic hygiene are directly linked with the microbial quality of drinking water (Oswald *et al*., 2007). It was observed that, the runoff water from the land irrigation is entering to the drinking water sources, which is a threat of bacteriological and chemical (pesticide and insecticide) contamination. It has been reported by Kress and Gifford (1984) that the heavy rainfall increased the release of bacteria from aged cowpats and animals wastes. Poor sanitation and open defecation is another cause and threat of drinking water contamination in the area.

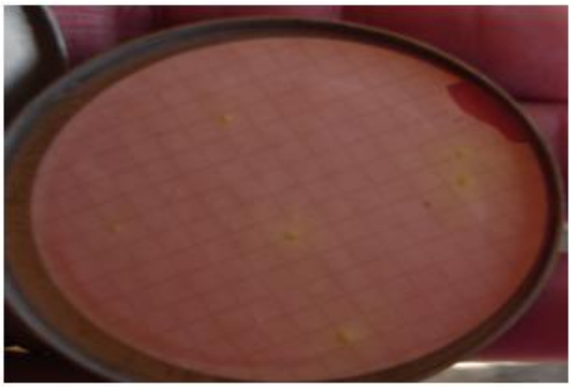

Fig. 2. Yellow colonies of Escherichia coli on the surface of membrane filter.

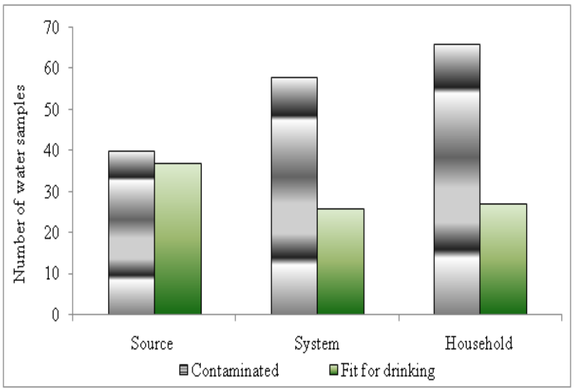

Fig. 3. Number of contaminated and safe water samples of each level.

Conclusion

It is concluded from the current study that, drinking water of the study area at source, supply system and household levels are predominantly contaminated with fecal thermo-tolerant coliform and is risk of waterborne infection. Protection of the drinking water sources and supply systems is necessary to prevent the spread of waterborne infection and improve water quality. Monitoring of microbial water quality with catchment analysis and risk assessment is needed regularly in order to trace out the possible means of contamination and its improvement. Reduction and proper management of animal and human waste can reduce the risk of water contamination in the area. Good health and hygiene practice with community awareness regarding the use of latrine and related waste management facilities is needed to get proper attention. Extension of hygiene education and sanitation found to have vital importance on the provision of safe water supply. Use of disinfectant and boiling of the drinking water can reduce the risk of pathogens intake.

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