SHORT COMMUNICATION

Microbial water quality risks to public health: potable water assessment for a flood-affected town in northern Pakistan

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ABSTRACT

Introduction: In mid-July 2010 flash flooding in Pakistan destroyed the basic water, environmental sanitation and livelihood infrastructures in 82 districts. Two months later, the local press of Swat (northern Pakistan) reported that several residents of Marghazar town became ill and were hospitalized after drinking contaminated water. A non-governmental organization (Oxfam GB) team took action to determine the causes of this incident and analyzed the community drinking water supply.

Methods: Standard methods were used to analyze six physio-chemical and four microbiological water quality parameters at five selected sampling locations in the water supply system.

Results: The samples from sites numbers (SN)02, 03, 04 and 05 were found to be microbiologically unfit for drinking due to the presence of *Escherichia coli*, *Shigella*, *Salmonella* and *Staphylococcus aureus* (range 18–96 $\pm$ 14 cfu/100 mL). However, the pH,

conductivity, total dissolved solid, total hardness as calcium carbonate and nitrate as NO_3^{-2} of all the samples were within WHO permissible limits. Higher turbidities were recorded at SN04 and 05 of 6 ± 0.23 and 9 ± 1.23, respectively.

Conclusion: Quantitative results revealed the presence of pathogenic organisms and water quality risk factors due to the damaged water and environmental sanitation infrastructure. Continued water quality monitoring, the application of household based disinfectants, and healthy domestic hygiene practices are highly recommended in similar circumstances.

Key words: domestic hygiene, Escherichia coli, microbiological testing, Salmonella, Shigella, Staphylococcus aureus, water contamination.

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Introduction

Contaminated drinking water is a major source of pathogenic organisms; the microbial pollution of a water supply presents a threat to human safety[1,2]. Pathogens are transmitted to water from the feces of warm blooded animals and some reptiles. The bacterium Escherichia Coli (E. coli) is a key fecal indicator organism for the presence of other pathogenic organisms in drinking water[3,4].

Water contamination in Pakistan is of particular concern. Currently, almost half of Pakistan's population has no access to clean potable water[5]. Approximately 70% of Pakistan's surface and sub-surface water supply sources are not fit for drinking due to heavy organic, inorganic and biological contamination[6,7]. In recent years Pakistan has faced catastrophic natural disasters, notably the 2005 earthquake and 2010 floods. In the aftermath of the 2010 floods, the water quality monitoring reports of many organizations (Oxfam, Lasoona and Water Aid) indicated the presence of pathogenic organisms in drinking water in Swat (northern Pakistan).

The UK based humanitarian organization Oxfam intervened in northern Pakistan after the 2010 floods to rehabilitate the damaged community water and sanitation schemes. At that time the Pakistan Health Department had registered many gastrointestinal and diarrheal cases due to the destruction of the WASH (Water, Sanitation and Hygiene) infrastructures

and the consequent threats to public health (Executive District Officer Swat; pers.comm; 2010).

The aims of this study were to: (i) assess damaged community water and sanitation systems in the priority area of concern during the 2010 emergency; and (ii) assess the drinking water quality by analyzing some important physio-chemical and biological parameters.

Methods

Geographical setting and sampling sites

Districts affected by the 2010 flood, and the eastern rivers tributary system of Pakistan are shown (Fig1). District Swat was among the most severely affected areas. Marghazar town is located at the hub of Swat River and the Islampur Stream of Swat in northern Pakistan (Fig2). Because of its proximity to these rivers and its low lying topography, this town was severely affected by the 2010 floods and many houses, water and environmental sanitation infrastructure were washed away. Five sites were selected for water sampling and testing in the Marghazar town water supply system (Fig 2).
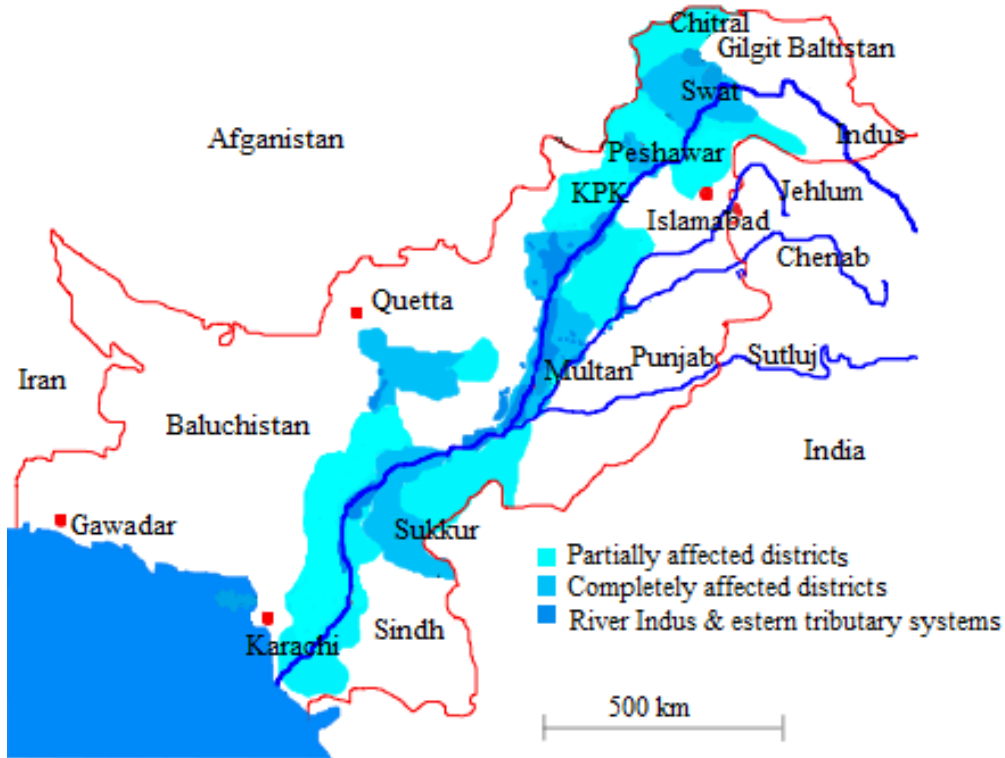
Figure 1: Map of Pakistan showing flood affected regions and the eastern rivers network[8].
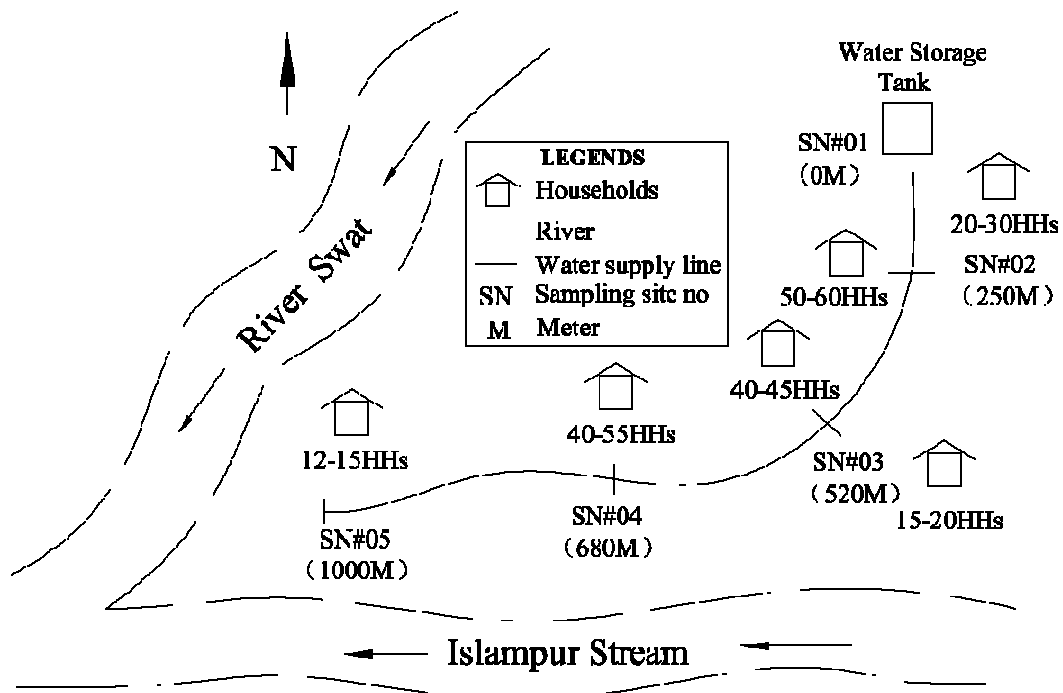
Figure 2: Schematic map of Marghazar's town showing the population distribution and water sampling sites.

Analytical methods

A portable testing kit (University of Surrey, UK) was used to assess the microbiological quality of drinking water using methyl lauryl sulphate broth media with standard procedures adopted by Fewtrell & Bartram[9]. Microbial organisms can be measured as colony forming units (CFU) using a plate counting method[10]. Turbidity, pH, conductivity and total dissolved solids (TDS) were checked using respective portable meters (Wagtech International, UK). Total hardness as calcium carbonate and nitrate as NO_3^{-2} were measured using a Photometer (WAG-WE10441; Wagtech International, UK) at 420 nm wave length. Statistical analysis was performed by taking the mean of three time-assessed values and applying the standard deviation to the data.

Results

Total plate counts in the drinking water samples ranged from 18 to 96 ± 7 cfu/100 mL, whereas the WHO permissible limit is 0 cfu/100 mL per water sample in ideal conditions. Sample numbers 04 and 05 had higher plate counts of *E. coli* with 84 ± 3 and 96 ± 4 cfu, respectively. Similarly, in samples from SN02 and 03 large counts of *E. coli* were recorded: 18 ± 2.02 and 62 ± 2.43, respectively. Other coliform groups such as *Shigella*, *Salmonella*, *Staphylococcus aureus* were also present at all sampling sites except SN01, which indicated that all water samples from consumer points were highly contaminated (Table 1).

Selectively tested physio-chemical parameters (pH, turbidity, conductivity, TDS, total hardness as $CaCO_3$ [mg/L] and nitrate as NO_3^{-2} [mg/L]) at all the five sampling sites were within the WHO permissible limits, but turbidity at sampling sites SN04 and 05 was just above the standard and located 680 m from the water storage tank (WST; Table 2).

Moreover, slight variations in physio-chemical parameters were recorded in Marghazar town main WST at SN01 to 05.

Discussion

According to WHO, public health risk categories are 0 cfu/100 mL (conformity); 1–10 cfu/100 mL (low risk); 10–100 cfu/100 mL (intermediate risk); 100–1000 cfu/100 mL (high risk), and >1000 cfu/100 mL (very high risk)[11]. The present microbial assessment results (Table 1) indicate that Marghazar town's water supply network was at a WHO-categorized intermediate risk with bacterial contents recorded at 10–100 cfu/100 mL, and this could have caused the hospitalization of many people. Drinking water quality at differing risks-levels was also reported in disasters such as the Indian Ocean tsunami 2004[12], the Kashmir (Pakistan) earthquake 2005[13] and the Haiti earthquake 2010[6].

Microbiologically contaminated potable water has a direct effect on public health and poses a severe threat to human beings with continued usage. According to WHO more than 80% of communicable human diseases are water borne[11]. Water quality results of *E. coli*, *Shigella*, *Salmonella* and *Staphylococcus aureus* in Marghazar samples demonstrate the incident caused the intrusion of sewage water from the open drain sanitation system into the drinking water supply network. During the emergency this might have been a source of diseases such as typhoid fever, cholera, dysentery, food poisoning, gastroenteritis, diarrhea and ameobiasis[14]. Household visits revealed that health was not the householders' priority area of concern at the time of the emergency as they had other pressing needs. Consequently, people were not concerned about the poor quality of drinking water due to flood pollution.

Table 1: Results of microbiological examination of water samples in different samplings sites

Microbiological parameters (cfu/100mL)	Water Sampling Sites					WHO standard
	01	02	03	04	05	
Escherichia coli	Nil	18±2.02	62±2.43	84±2.44	96±3.74	0cfu/100mL
Shigella	Nil	27±1.92	80±3.22	67±3.16	77±2.98	0cfu/100mL
Salmonella	Nil	21±2.04	66±3.45	42±3.56	42±3.34	0cfu/100mL
Staphyllococcus aureus	Nil	19±2.09	31±2.40	46±2.87	53±3.23	0cfu/100mL

Table 2: Results of physio-chemical examination of water samples in different sampling sites

Physio-chemical parameters	Water Sampling Sites					WHO standard
	01	02	03	04	05	
pH	7.1±0.11	6.9±0.43	6.9±0.54	7.1±0.21	7.4±0.28	6.5-8.5
Conductivity (μs/cm)	213±5.45	216±6.34	218±4.45	207±7.23	218±8.12	1000
TDS (mg/L)	160±3.34	162±3.65	166±3.40	141±2.43	146±5.02	1000
Turbidity (NTU)	4±0.92	4±0.58	5±0.96	6±0.23	9±1.23	5
Total hardness as $CaCO_3$ (mg/L)	192±3.34	160±4.23	132±5.65	160±5.22	112±2.45	500
Nitrate as NO_3^{-2} (mg/L)	12±1.32	14±1.67	16±1.32	16±1.20	21±0.96	45

Physio-chemical parameters were within permissible limits of WHO and US-EPA, except for turbidity. Turbidity was found to be higher towards the end of the water supply system (SN04 & 05) because silt containing sewage water had leaked from the joints of the water distribution line. Disinfectants, for example chlorine and ozone among others, cannot completely kill pathogens in drinking water containing turbidity[2] as some microorganisms produce cysts to overcome the disinfection process[15]. Hence, the higher pathogen concentrations recorded in Marghazar town's WSS indicate a need for a treatment system that simultaneously removes both pathogenic organisms and turbidity. Mahmood Q et al and Baig et al have developed and experimentally tested household biosand with innovative adsorbent materials to remove both pathogens and turbidity[6,7]. This was pilot tested after the 2005 earthquake in the same geographical region. Implementation of the same household treatment in Marghazar town could have solved the water quality issue.

Conclusion

The water quality results suggested that the hospitalization of Marghazar town residents reported was due to their drinking contaminated water from an existing, damaged water supply system. Regular monitoring of drinking water quality and the promotion of hygienic household behavior during an emergency response is highly recommended.

Acknowledgements

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