Evaluating Drinking Water Contamination in Post Disaster scenario and its Effects on Human Health: A case study of District Mansehra, Pakistan.

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Abstract

Drinking water contamination and associated health risks persists to be serious issue, particularly in the aftermath of natural disasters, like earthquakes. After the earhquake that hit many parts of Pakistan on October 8, 2005, an outbreatk of water borne diseases threatened human health severely in district Mansehra, Khyber Pukhtunkhwa province. Assessment of the drinking water and probable health threats hence became crucial to analyze the state of water consumed for drinking purpose in affected areas. The present study was thus conducted to assess the state of water quality consumed in selected 32 locations, and emphasis was laid on deriving water samples from numerous sources set up by government and other authorities. Tap-water samples were collected to analyze the water quality at the consumer end, which was subjected to microbiological contamination. It was revealed that out of total number of analyzed samples, only 1 sample was found within the globally acceptable microbiological water quality parameters. Resultantly, the community suffered from numerous water borne diseases like diarrhea, vomiting and Jaundice (with an attack rate of 79%). The main sources of water contamination found were structural, including point sources like expired water storage tanks, and passing of delivery network pipes through drains, thus leading into water contamination. Conclusively, the water quality is declared unacceptable for human consumption.

Key Words: Coliform bacteria**,** *Escherichia coli* (E. coli)**,** UNICEF, water born diseases. Ghari-Habibullah KPK

1. Introduction

There exists a range of health issues that are associated to microbiological contamination of drinking water throughout the world (Reid et al., 2001). So, as water is globally accepted disease transmitter under certain conditions, therefore the associated conditions needs to be controlled regarding public health concerns. Contaminated water as a vector, particularly due to microbiological contamination, cause water borne diseases like diarrhea, vomiting, (typhoid and paratyphoid), Jaundice and others (Ashbolt, 2004). Water borne diseases are those, which normally transmitted through contaminated water and work as active transporter of transferable

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agents (Leclerc et al., 2002). Thus, diseases like diarrhea, vomiting, (typhoid and paratyphoid) and Jaundice comprises up to 80% of the water borne diseases prevailing globally and 40% in the developing world itself, mostly affecting children (WHO, 1997). According to WHO statistics, water borne diseases through microbiological contamination of drinking water, coupled with poor hygiene and inadequate sanitation, cause 2.2 million deaths alone due to diarrhea (WHO, 1997, 2003, 2005), and around 0.06 million annual deaths due to Jaundice (Embrey et al., 2004, p. 215). The hazardous risk to human health through drinking water's contaminations is thus mainly associated with microbiological water contamination. This is normally characterized by the presence of coliform bacteria and other pathogenic organisms, like Faeal coliform bacteria or E. Coli, for which the current standard Maximum Contamination Level (MCL) is zero. It normally comes from human and animal feacal wastes (USEPA), and reported as one of broad class of bacteria in our environment. These bacteria along with viruses, fungi, algae, and protozoa, present in our environment, are the wide variety of pathogenic microbes those disturb the microbiological quality of water and cause diseases in humans (Carrigan & Sakamoto, 1990). Thus, the evaluation of water quality for presence of such coliform bacteria can be confirmed from feacal bacteria's existence, such as feacal coliform or E. coli, that indicates water contamination through direct and indirect contamination by matter originating in the intestines of warm-blooded animals (Hart, 1974).

This issue of bacteriological contamination of water became alarming in the aftermaths earthquake in the world. Earthquakes repeatedly result in incalculable damage to environment, individual lives and risks the health (Zhang et al., 2012). Human health is particularly affected from earthquakes with respect to their destructive effects on water supply infrastructure, which leads to water contamination (Bhat & Revi, 1995). Broken water pipelines passing through garbage and other inadequate trash disposal, poor sanitation, open-air defecation and fecal contamination during drinking water storage and its transport are generally considered to be the reasons behind risen health hazards like diarrhea, cholera and other disorders (Walton & Ivers, 2011). Thus, the outbreak of infectious waterborne diseases and resultant morbidity and mortality stays high in the post disaster situation Salama et al. (2004). Frequent occurrence of waterborne diseases and their intensity also increases the chances of disease(s) transmission to adjacent areas, thereby posing severe public health concerns (Aghababian & Teuscher, 1992). Bacteriological contamination of drinking water is narrated as the most serious issue both in rural and urban settings of Pakistan (Abid & Jamil, 2005).

Khyber Pukhtunkhwa province was the most severely affected province as a result of the devastating earthquake of October 8. Major infrastructural provisions of the north of this province were damaged and the service delivery was consequently disrupted. According to UNICEF (2005), Garhi Habibullah, falling in district Mansehra, stood to be one of the majorly damaged zone, both in terms of infrastructure and services. Major public health infrastructural network was among the severely damaged, causing a completely ceased public water supply to the

inhabitants. Resultantly, water supply stayed dependent upon the non-public sources like streams, shallow groundwater and adjoining streams. UNICEF was the major actor involved in development of alternate water supply schemes and restoration of the broken infrastructure. The schemes aimed at supplying drinking water to dozens of individuals with an aim to 'prevent any significant outbreak of diarrhea or other water borne diseases'. But, instead the situation led into an outbreak of waterborne diseases that left people of Garhi Habibullah into enormous health concerns. The severity of this outbreak pointed towards an immediate need of investigating water quality for human consumption, and to identify reasons responsible for this alarming situation. Present study was hence designed to probe the quality of water being provided through UNICEF schemes, to analyse water samples for presence of coliform bacteria and double check the results with local hospitals records.

2. Materials and Methods

2.1 Study Area

This study is conducted in village Garhi-Habibullah, which is a town and union council (an administrative subdivision) of Mansehra District in the Khyber-Pakhtunkhwa province of Pakistan. KPK province is located in the northwestern region of the country and is the third largest province by the size of both its population and economy, though it's geographically small. Whereas, district Mansehra that constitutes Ghari-Habibullah, in KPK province, lies towards Kashmir frontier (near Muzaffarabad, the capital of Azad Kashmir). Present study was conducted in two zones of Garhi Habibullah, those were fed by two UNICEF drinking water schemes. Zone-1 included areas of Damkacha and Katha Dobandi, whereas Zone-2 comprised areas of Batang, Jabi Haider Shah and Garhi Habibullah city.

2.2 Sampling Procedure

Cluster sampling technique was used by primarily selecting the above stated zones as the study area. 32 tap water samples (16 from each cluster) were further collected from the study area on a random basis. This sample size was selected as per available research time frame and resources. According to WHO recommendations, the water samples were stored at $4^{o}C$ during transportation from study area to laboratory and were analyzed within 6 hours of sampling, using portable water testing equipment (WHO, 2011). For acquisition of human health information, an out patient's department record was collected from two health facilities in Garhi Habibullah (Garhi Habibullah Civil Hospital in Zone-1 and Union Council Medical Dispensary in Zone-2) starting from August 2008- March 2009. The record was segregated for water borne diseases and correlated with the water sample tests. Water samples from 1 to 16 fall in vicinity of Garhi Habibullah Civil Hospital, whereas from 17-32 fall in the vicinity of Union Council Medical Dispensary in the preceding analysis and discussion.

2.3 Bacteriological Analysis

Samples were analyzed for the presence of E. Coli 0157:H7 by using 'Standard Qualitative Analysis Method'. The most probable number 'MPN' index was used, which estimates the mean density of bacteria in the sample (Eaton, Clesceri, & Greenburg, 1995). So, MPN index was deployed to check the exact water quality. Moreover, the standard count; 'total coliform/100ml' of water sample (Macdonald, 1988), was considered to analyze microbial purity of potable water. Water quality for human consumption was then checked using HMSO standards of 'Bacterial Quality for Drinking Water, 1982'. [†]

2.4 Health Record Analysis

To study the occurrence of not only loss (human health) but also the situation or process that inherent such risk, a prospective study was considered (Carroll, 2006). For this purpose, Attack rate and relative risk (at 95% confidence interval) was calculated, which remains the practical statistics for medical research results (Altman, 1990).

3. Results

3.1 Bacteriological Analysis

An outbreak of E. coli O157 infection due to water contamination caused hazardous health risks to inhabitants of Union Council Garhi-Habibullah (Tehsil Balakot, District Mansehra) Pakistan, in the post-earthquake era. The results revealed coliform bacteria at hazardous level in majority of the samples, i.e non-compliance with WHO and HSMO standards. No sample showed 'excellent' results, 1 out of 32 (3.1%) samples showed 'satisfactory' results, 4 out of 32 (12.5%) samples revealed 'suspicious' results and 27 out of 32 (84.4%) samples were 'un-satisfactory' or unacceptable water quality according to WHO and HSMO standards to be used for drinking purpose (see Fig. 1). Thus, an analysis of the drinking water quality of 32 water supply schemes in the study area revealed up to 99% contamination at household level, affirming water quality non-compliant with WHO and HMSO standards.

A detailed description of tabular results of each zone shows minimum MPN value of 3 in Zone 1 and maximum MPN value 1100 in Zone 2 (Table 1), with mean value of 210 and SD = 361.7 (Table 2. Evidently water quality of zone 2 showed contamination of much elevated level in comparison with zone 1, though significant number of samples in both zones is unsuitable for human consumption. Moreover, very high MPN values in zone 2 point towards a very alarming situation in Batang, Jabi Haider Shah and Garhi Habibullah city.

[†] Coliform Count/100 ml; 0 for excellent quality (WHO-0 MPN/100 ml), 1-3 satisfactory, 4-10 suspicious and >10 Unsatisfactory.

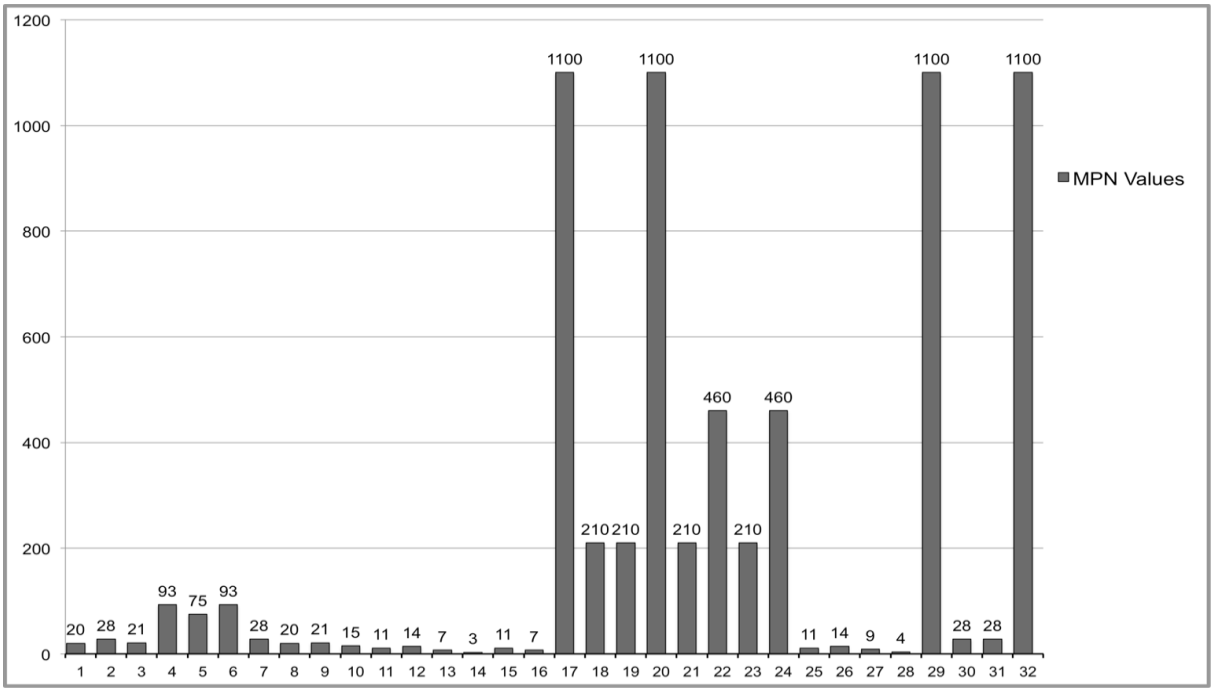

Fig. 1: Water Contamination Level Compared to WHO Limit (0 MPN)

Table 1: Water Contamination in the Area

S. No.	Area	Location	Test Results/ MPN Value	95 % Confidence Limit Lower/Upper	WHO limit
Zone 1					
1	WWS Damkacha	Upper Damkacha	20	7/89	0
2		Upper Damkacha	28	10/150	0
3		Upper Damkacha	21	4/47	0
4		Upper Damkacha	93	15/380	0
5	WWS Damkacha	Lower Damkacha	75	14/230	0
6		Lower Damkacha	93	15/380	0
7		Lower Damkacha	28	10/150	0
8		Lower Damkacha	20	7/89	0
9	WWS Katha Dobandi	Mohallah Tanolian	21	4/47	0
10		Mohallah Tanolian	15	3/44	0
11		Mohallah Tanolian	11	3/36	0
12		Mohallah Tanolian	14	3/37	0
13	WWS Katha Dobandi	Mohallah Mughal	7	1/21	0
14		Mohallah Mughal	3	>0.5/9	0
15		Mohallah Mughal	11	13/36	0
16		Mohallah Mughal	7	1/21	0
Zone 2			1100		0

17	WWS Batang	Upper Batang		150/4800	
18		Upper Batang	210	35/470	0
19		Upper Batang	210	35/470	0
20		Upper Batang	1100	150/4800	0
21	WWS Batang	Lower Batang	210	35/470	0
22		Lower Batang	460	71/2400	0
23		Lower Batang	210	35/470	0
24		Lower Batang	460	71/2400	0
25	WWS Jabi Haider Shah	Jabi Haider Shah	11	3/36	0
26		Jabi Haider Shah	14	13/37	0
27		Charakamar Hari Taki	9	1/36	0
28		Charakamar Hari Taki	4	>0.5/20	0
29	WWS Garhi Habibullah	City	1100	150/4800	0
30		City	28	10/150	0
31		City	28	10/150	0
32		City	1100	150/4800	0

Table 2: Water Contamination in Zone 1&2

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Samples	32	3.00	1100.00	210.31	361.7
Valid N (listwise)	32				

Results obtained in the present study are similar to a study in Peshawar, KPK Pakistan also highlighted 84.35% of the samples collected from household ends to be contaminated with e-coli and could not be considered safe for human consumption. Faecal contamination of drinking water is very alarming and is attributed to certain obvious reasons (Inamullah, 2014). Type of construction, material used and management of water storage facilities and distribution lines are numerous reasons contributing significantly to water contamination. Unawareness about feacal contamination and household water handling also played important role in raised incidents of water borne diseases in the study area.

3.2 Health Effects

Out Patient Department's (OPD) record obtained from the two health facilities showed approximately one-fourth of the patients suffering from water borne diseases. The daily OPD data of Garhi Habibullah Civil Hospital showed that among all the patients, 35% were suffering from diarrhea, followed by 12% and 28% from vomiting and Jaundice respectively, in Zone-1. However, 25% of the patients were suffering from miscellaneous health disorders (Fig. 2). Similarly, the OPD record of Union Council Medical Dispensary confirms that 49% of the patients were suffering from diarrhea, 21% from vomiting and 13% from Jaundice. Only 17% of the patients in zone-2 were suffering from miscellaneous disorders not related to drinking water. Evidently, health record

obtained from both health facilities in Garhi Habibullah is in conformity with the water contamination results. Local population in Garhi Habibullah, especially those living in Zone-2 were at high health risks.

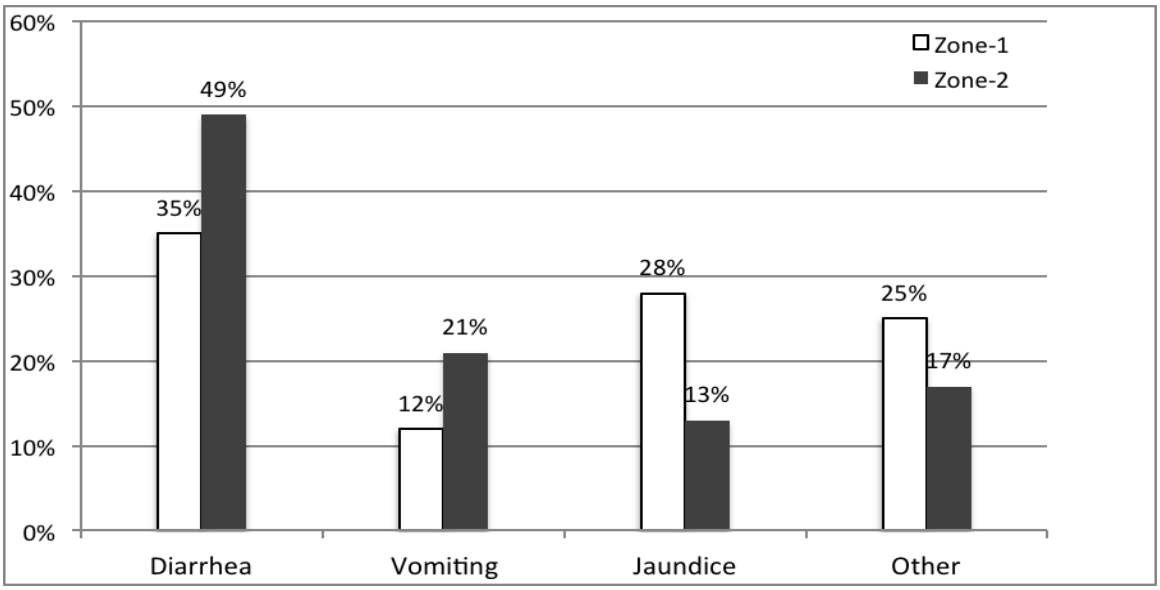

Fig. 2: Health Effects on Local Community

Table 3: Incidence of Water Borne Diseases in the Area

	Proportion ill [a]				
	Zone-1	**Zone-2**	**Attack Rate % Zone-1, Zone-2**	**Relative Risk**	**95% C**
Diarrhea	1103	1805	35, 49	1.3	0.2, 9.6
Vomiting	375	773	12, 21	0.9	0.1, 6.
Jaundice	868	478	28, 13	0.9	0.1, 6.

[a] *All exposure refer to the period Aug. 2008 to March 2009 against selected diseases. CI = confidence interval.*

Prospective analysis is, however, done to check 'proportion of illness' across zones, in the study area. Prospective analysis in research is usually taken to study the development of disease during the study period and relating it to suspected risk without randomized control groups or experimental interventions (De Vaus & de Vaus, 2001). Therefore, proportion analysis in this research shows high risk of diarrhea (RR = 1.3, 95% CI = 0.2, 9.6). Among patients visited the doctor in their respective area, the vomiting patients in Zone-2 were more in number than in Zone-2 (RR = 0.9, 95% CI = 0.1, 6.4). Certainly, the severe water contamination in Zone-2 lead to relative risk (RR = 28,13, 95% CI = 0.1 6.9) than in Zone-1.

Conclusion

The present study aimed at exposing drinking water samples of Garhi Habibullah to bacteriological analysis. Results confirm faecal contamination (E. Coli) in the drinking water to threatening levels. About 99% of the total samples revealed results beyond the acceptable limits. Hence, results totally contradictory to WHO prescribed limit of zero MPN/100ml and HSMO guidelines of water purity. The study revealed extreme above average unacceptable contamination of both 'point and non-point' sources in the drinking water in both Zone-1 and Zone-2, with zone 2 having significantly deteriorated results. This was mainly due to structural failure at storage level e.g., the old expired water tanks still remained the storage chambers. The resulting faecal contamination of drinking water caused dangerous health affects to local inhabitants, who were suffering from coliform bacteria (E. Coli) related diseases i.e., vomiting, (typhoid and paratyphoid) Jaundice and Diarrhea. The results of this study are in line with other studies. The study in district Peshawar, KPK Pakistan confirms feacal contamination through non-/point sources before reaching at consumer level (InamUllah, 2014). Another bacteriological study in Lahore, Pakistan also confirms presence of fecal coliform (E. coli) in drinking water at consumer level, which was contradictory to the established standards of World Health Organization. Presence of coliform bacteria and resultant faecal pollution in drinking water at household level indicated the health risk associated (Hussain et al., 2011). (Shedayi et al., 2015) through microbiological water analysis of drinking water for total coliform/ml in Gilgit, Pakistan confirmed presence of total coliform in higher ranges in tap water. The level of contamination was reported far beyond WHO permissible limit of 0/100ml.

Therefore, drinking water quality tests and continuous assessment should be conducted at regular intervals to check the quality of drinking water. Detailed studies should be undertaken along the distribution lines starting from the sources to the households to find out the actual points of contamination and their sources in the distribution networks. Consequently, distribution system should be enhanced and remedial measures be taken for proper installation of pipes and joints etc. Standardized materials should be ensured for construction of pipes and other storage facilities.

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