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Risk Assessment by Bacteriological Evaluation of Drinking Water of Gilgit-Baltistan

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Abstract.- In Gilgit-Baltistan, Pakistan glaciers are the main source of water and people use surface water from nallahs (big streams) and springs for both drinking and irrigation purposes. The surface water has many chances of water borne diseases. From out of seven districts the drinking water samples of four districts were bacteriolocically analyzed for fecal coliform contamination. Randomly selected 46 villages and their water samples were analyzed at different points by using membrane filtration technique and specific medium (lauryl sulphate broth). It was found that 25 villages use water from the springs and fecal coliform contamination was from 0 - 500 cfu in 100 ml water at source, from 0 - TNTC in the beginning, mid and at the end of the distribution system. Twenty one villages use water from the nallahs and fecal coliform contamination was from 4 – 500 cfu at the source, 1 -1350 cfu in the beginning of the distribution system, 44 - TNTC in the middle and 110 - TNTC in the end of the distribution system. In most of the springs the bacteriological quality of drinking water was good at source and it becomes contaminated as it becomes in contact with animals. Most of the nallahs water was contaminated at their source.

Key words: Drinking water, analysis of fecal coliform of water, bacteriological analysis of water, water quality, microbiological quality of water of Gilgit-Baltistan.

INTRODUCTION

Water is a vector of transmission of many pathogenic bacteria, viruses and Protozoa (Blumenthal *et al*., 1999; Clesceri *et al*., 1998; Feachman *et al*., 1983) and the contaminated drinking water causes many water borne diseases, most typically diarrhea, vomiting and gastroenteritis (Chanlett, 1992; Zahoorullah *et al*., 2003). According to World Health Organization (WHO) 80% diseases are due to unsafe drinking water (WHO 1997a). Morbidity and mortality due to waterborne diseases is very common and according to WHO (2002a) estimates 4.3% of the total global disease burden out of which 88% is due to microbiological contamination of drinking water, poor hygiene and inadequate sanitation. Every year 1.6 million deaths are due to diarrhea because of contaminated water (WHO, 2005).

Microbial safe drinking water is the basic right of human beings. According to WHO estimates about 1.1 billion people globally drink unsafe water (McMichael *et al*., 2006). In Asia and Africa 800 million people are living without access to safe drinking water (Sadeghi *et al*., 2007).

It is impossible to analyze the drinking water for every possible pathogen. Therefore, normal intestinal flora is used to monitor as indicator to fecal contamination (WHO, 1984a,b; Anwar *et al*., 2010) and for decades fecal group of bacteria has been used as an indicator of water quality with respect to the presence of human pathogens to control waterborne diseases (Ejaz *et al*., 2001). Throughout the world many studies have been conducted to determine the microbiological quality of drinking water to prevent the water borne diseases (Kirschner *et al*., 2004; Araujo *et al*., 19970; Ejaz *et al*., 2001).

In Pakistan the bacteriological contamination of drinking water has been reported to be one of the most serious problems in rural as well as urban areas (Abid and Jamil, 2005; Kahlown *et al*., 2004; Sun-OK *et al*., 2001).

Current WHO bacteriological guidelines for drinking water recommend zero fecal coliform in 100 ml of water (WHO, 1984a,b). Most of the Asian countries as well as Pakistan also followed the same standard for drinking water that it should not be detectable in 100 ml drinking water ((National Standard for Drinking Water Quality, 2008). Gilgit-Baltistan is spread over an area of

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72,496 km^2. administratively distributed into seven Districts (Gilgit, Ghizer, Hunza-Nagar, Diamer, Astore, Skardu and Ganchi).

During winter there is heavy snow fall on the tops of the mountains and it deposits in the spill areas and in summer by melting of these glaciers, water flow down the hills in the form of nallahs and some water penetrate and oozes in valleys in the form of springs.

Gilgit-Baltistan is an isolated region and its drinking water has not been assessed microbiologically to know the potential health risks it contributes to the community. Although some of the studies conducted by Waqar *et al.* (1999) and Ahmed *et al*. (2005) suggests that gastrointestinal diseases are very common and some times there occurs outbreaks (Ahmed and Shakoori, 2002).

MATERIALS AND METHODS

Study area

This study was conducted in various villages of four districts (Ghizer, Gilgit, Hunza-Nagar and Skardu) of Gilgit-Baltistan to access the risks of water-borne diseases among the communities by consumption of bacteriological unsafe drinking water.

Bacteriological analysis

From May 2008 to July 2010, water samples were collected from the source, from water reservoir, mid and from the end of the existing distribution systems (Tap/channel) from various villages of four districts. The water samples were processed *in situ* by using specific membrane filtration technique “DelAgua® water testing-kit”, selective media (Lauryl sulphate broth) for fecal coliform and all the cultured were incubated at 44°C for 24 hours.

RESULTS

Table I shows from Ghizer district the drinking water was bacteriologically evaluated randomly from 16 villages. The villages Dalomal, Borth, Aliabad (Hundrup), Chashi Bala, Chashi Paean, Anotak, Bristotak and Boyarden’s inhabitants use spring water and the fecal coliform contamination level was zero in 100 ml water at the source (spring eye). The contamination level raised from 2 to TNTC in 100 ml of water as the water becomes access to inhabitants and in the mid inhabitants use water with the contamination of 10 to TNTC fecal coliform. When this water comes in the access of inhabitants at the end of the village the fecal coliform contamination becomes 12 cfu to TNTC. The inhabitants of the villages of Shamaran, Yarzarich, Phander, and Payokush the water has 3 to 65 cfu of fecal coliform in 100 ml water at source and this contamination level becomes high from 10 to 250 cfu in the access of the inhabitants and in the mid of the villages they use water with 10 to 200 cfu contamination and at the end 120 cfu to 28o cfu. The inhabitants of Bilhanze, Ishkoman, Daudabad and Mominabad villages consume water from nallahs and water is already contaminated at the source having 80 to 200 cfu of fecal coliform in 100 ml water. This contamination gradually increased in the start of the village, mid and at the end 185 to 300 cfu in 100 ml water.

Table II shows in district Hunza-Nagar the water was evaluated for fecal coliform contamination from ten villages. Naurozabad, Sumair, Gulkin, Galapun and Karimabad inhabitants use water from springs. The microbiological contamination level was zero fecal coliform at the source except Karimabad. This contamination level increased from 23-46 cfu level when this water become in the access of the community and this contamination level further increased from 25-77 cfu fecal coliform in the mid of the villages and at the end it increased from 25-98 cfu contamination in 100 ml water. The inhabitants of Nilt, Shishkat, Mayoon, Hopper and Hussainabad consume water from nallahs. The water at the source has quite high level of contamination *i.e.* 4-75 cfu of fecal coliform. As this water entered into the delivery system the contamination raised from 14 to 195 cfu and the inhabitants of the mid of the village consumes 44–600 cfu in 100 ml water. The microbiological quality of the drinking water becomes much worse at the end of the village having 110 - TNTC fecal coliform in 100 ml water.

Table III shows in district Skardu the water was bacteriologically evaluated for fecal coliform from 9 villages. The samples were processed from

Table I.- **Village-wise fecal coli form contamination in drinking water of district Ghizer.**

Name of villages	Name of source	No. of fecal coliform colonies observed in 100 ml water at			
		Source	Beginning of the delivery system	Middle of the village	End of the village
		03	10	10	350
Yarzarich	Spring	50	50	83	120
Dalomal	Spring	00	-	127	-
Borth	Spring	00	10	10	12
Aliabad Hundrup	Spring	00	-	70	80
Chashi Bala	Spring	00	10	150	200
Chashi Paean	Spring	00	02	250	TNTC
Anotak	Spring	00	TNTC	34	TNTC
Phander	Spring	65	80	135	200
Payokush	Spring	05	250	200	280
Bristotak	Spring	00	14	13	10
Boyarden	Spring	00	-	-	TNTC
Bilhanze Bala	Nallah	200	-	185	200
Ishkoman	Nallah	80		180	190
Daudabad	Nallah	130	140	145	185
Mominabad	Nallah	110	150	180	300

TNTC. Too numerous to count

Table II.- **Village-wise fecal coliform contamination in drinking water of district Hunza-Nagar.**

Name of villages	Name of source	No. of fecal coliform colonies observed in 100 ml water at			
		Source	Beginning of the delivery system	Middle of the village	End of the village
Naurozabad	Spring	00	39	77	98
Sumair	Spring	00	40	69	40
Gulkin	Spring	00	23	25	25
Galapun	Spring	00	25	30	38
Karimabad	Spring	45	46	64	68
Nilt	Nallah	94	100	600	TNTC
Shishkat	Nallah	4	14	415	TNTC
Mayoon	Nallah	25	70	44	333
Hopper	Nallah	72	195	155	800
Hussainabad	Nallah	57	102	98	110

Table III.- **Village-wise fecal coliform contamination in drinking water of district Skardu.**

Name of villages	Name of source	No. of fecal coliform colonies observed in 100 ml water at			
		Source	Beginning of the delivery system	Middle of the village	End of the village
Aliabad	Spring	79	85	353	TNTC
Ghulukhore	Spring	100	60	64	60
Dongs	Spring	00	30	42	38
Bakirabad	Spring	00	00	00	00
Ghanche	Spring	00	27	30	TNTC
Khurid	Spring	500	600	780	TNTC
Chundapa	Nallah	500	1350	TNTC	TNTC
Skamthang	Nallah	300	400	600	TNTC
Hashipee	Nallah	28	30	TNTC	TNTC

Table IV.- Village-wise fecal coliform contamination in drinking water of district Gilgit.

Name of villages	Name of source	No. of fecal coliform colonies observed in 100 ml water at			
		Source	Beginning of the delivery system	Middle of the village	End of the village
Sinakir	Spring	00	TNTC	TNTC	TNTC
Jalalabad	Spring	12	14	19	22
Sasi	Nallah	15	28	37	72
Hopay	Nallah	20	30	34	60
Rahimabad	Nallah	10	30	34	50
Jutal	Nallah	280	286	293	400
Sultanabad	Nallah	100	-	110	175
Danyor	Nallah	35	-	49	161
Oshikhandass	Nallah	280		300	TNTC
Pari Banglah	Nallah	80	180	240	TNTC

source, beginning of the delivery system, mid of the distribution and at the end of the villages. The inhabitants of villages Aliabad Ghulukhore, Dongs, Bakirabad Ganche and Khurid consume water from springs. The fecal coliform contamination was zero at spring eye except the villages Aliabad and Ghulukhore and Khurid where the contamination was 79, 100 and 500 cfu respectively in 100 ml water. In all the villages except Bakirabad the fecal coliform contamination level increased from 30 - 600 cfu as the water becomes in the access of the communities and in the mid it was from 42 - 780 cfu and at the end of the village the contamination level was from 38 cfu to TNTC. The inhabitants of Chundapa, Skamthang and Hashipee consume water from nallahs and the level of fecal coliform contamination was from 28 - 500 cfu in 100 ml water as it enters into delivery system the contamination increased from 30 -1350 cfu and in the end of the village contamination become very worst having TNTC colonies of fecal coliform in 100 ml drinking water.

Table IV shows in district Gilgit water was bacteriologically evaluated for fecal coliform contamination from eleven villages from various points *i.e.* source to the end. The villages Sinakir, Jalalabad consumes water from springs. Sinakir has zero colonies of fecal coliform in the eye of spring in 100 ml water as this water enters into the delivery system the contamination level abruptly become too much high to TNTC and it was same in the mid and end of the village. While in Jalalabad at source there were 12 cfu of fecal coliform and this contamination increased gradually in the delivery system up to 14 cfu, in the mid 19 and at the end 22 colonies in 100 ml of water. Sasi, Hopay, Rahimabad, Jutal, Sultanabad, Danyor, Oshikhandass, Jutial and Pari Banglah communities utilize water from nallahs. The fecal coliform contamination level was already high in the source from 10-280 cfu in 100 ml water. This contamination gradually increased from 28-286 cfu in the delivery system, 34 - 300 cfu in the mid and at the end it is 50 to TNTC colonies in 100 ml drinking water.

DISCUSSION

The population of Gilgit-Baltistan is scattered and settled in the laps of mountains and along the banks of rivers and nallahs in the form of small communities (Villages). Each village has its own water source either in the form of nallah, or spring. The people use water from these resources for drinking as well as for irrigation.

In the present study the drinking water was bacteriologically evaluating by counting the fecal coliform in water of various villages of four districts of Gilgit-Baltistan. Total 46 water sources were analyzed (25 springs and 21 nallahs) for fecal coliform contamination. The drinking water was free of fecal coliform contamination in the source (spring eye) of most of the springs (17 out of 25) in all the four districts is safe for health according to World Health Organization guidelines (WHO, 1993). The water in spring eye was not in contact of humans and other animals. As this safe drinking water com in contact of inhabitants except one village Bakirabad all become contaminated by fecal coliform and in the mid of distribution system the fecal coliform contamination level increased from 2 cfu - TNTC. While in the end of the distribution system the fecal coliform contamination increased much more and that was from 10 cfu - TNTC. Only in 8 springs sources have fecal coliform contamination from 3-500 cfu and in the distribution it increased more. The sources of these are not protected and in the contact of humans and other animals. This fecal coliform contamination indicates that there are many health risks of water borne diseases. As in many studies it has been reported the outbreaks of gastroenteritis diseases (Ahmed *et al*., 2003, 2005; Waqar *et al*., 1999). This microbiological contamination of water indicates that the water has come in the contact of human and other animals fecal and this low level of microbial contamination in drinking water may multiply to infectious doses when associated with food. The susceptible hosts become infected by using this contaminated water and subsequently transmit diseases to other persons (WHO, 1993).

Out of 46 investigated sources 21 communities consume water from nallahs and their water was (100%) contaminated with the fecal coliform at the source from 4 - TNTC and this level of contamination increased when water become in the access of the inhabitants and this microbiological quality became much more worse as it enters in the mid of distribution from 34-TNTC and in the end its quality becomes very worst have fecal coliform from 50 cfu to -TNTC.

All the population of Gilgit-Baltistan consumes very high level of fecal coliform contaminated water. Although springs have safe water for drinking but there are no pipeline distribution system in most of the villages and through out the distribution there are chances of fecal contamination. Moreover the shepherd takes their domestic animals and pets to the meadows where they contaminate the water before it reaches in the consumption of inhabitants. It is already proved in many studies that the human and domestic animals play a key role in declining of the microbiological quality of water (Jensen *et al*., 2002; Schmidt *et al*., 2009).

The farmers use organic fertilizers and the runoff of the fields also mix with the channels. The inhabitants are also not aware of the about the importance of hygiene education.

This level of contaminated water is not acceptable for human consumption and becomes a potential source of water borne diseases and many times there have been outbreaks in the pediatric and adult population reported from a variety of organisms (Waqar *et al*., 1999).

The results of this study also support the previous studies conducted in other laboratories (Shar *et al.*, 2008; Zahara *et al*., 2004; Anwar *et al*., 2010).

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