INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 5, No. 4, p. 54-59, 2014

RESEARCH PAPER OPEN ACCESS

Bacteriological analysis of drinking water sources in CKNP region of Gilgit –Baltistan, Pakistan

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Key words: Karakoram, National Park, CKNP, *E. coli*, Water quality, Bacteria, water sources, glaciers, Enterococci, *Salmonella*.

http://dx.doi.org/10.12692/ijb/5.4.54-59 Article published on August 18, 2014

Abstract

The study was focused on the Bacteriological characteristics of drinking water within the selected villages fall in Central Karakoram National Park (CKNP) Gilgit-Baltistan, Pakistan. Different water sources were taken in to account including streams, springs, rivers and other storage structures viz; wells and Tanks. A total of 51 water samples were collected from 17 different localities and transported to lab in battery operated portable refrigerators. All necessary data including coordinates was mustered. Sources were examined with a strategy to sample from source mid and last points. The idea was to evaluate the stage and subsequent level of contamination. The level of contamination was ranged from 0-160 CFU for *E-coli,* 0-85 for *Enterococci* and total bacterial count ranged from 2-180 CFU, whereas no any *Salmonella* species was detected in one liter. The well and surface water was highly contaminated and the spring sources were less or no contaminated depending upon protected and open sources respectively. While the contamination level showed a culminated trend from mid to last usage points.

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Introduction

Bacteriological contamination in potable water is not only the result of natural factors. It has been aggravated by anthropogenic activities especially in the developing countries. Water of good drinking quality with balanced minerals is of prime importance to carry on normal human physiological activities. The sporadic eruption of water borne diseases has coerced the experts to assess the relevant sources for the responsible pathogens and water quality indicators. Contaminated drinking water contributed to a number of health issues in developing countries like more than one billion cases of diarrhea that occur annually (WHO 2013). Access to safe water is a basic human need and, therefore, a basic human right. Contaminated water deteriorates both the physical and social health of all peoples. According to WHO, more than 80% of diseases in the world are attributed to unsafe drinking water or to inadequate sanitation practices (**Petersen**, 2003; WHO 2003). Globally, 1.1 billion people rely on unsafe drinking water sources from lakes, rivers, and open wells (WHO, 2000).

According to world health organization (WHO), there were estimated 4 billion cases of diarrhea and 2.2 million deaths. The research area is also a home to mighty glaciers which are deemed to be the water towers and are largest, next to polar region. The Central Karakoram National Park represents the largest source of fresh water in Pakistan and it harbors the one of the largest mountain glacier systems in the world. (Siachin 75 km, Baltoro 57km, Hisper-Biafo 122 km). These glaciers are said to be the life-blood of Pakistan and all originating within Pakistan boundaries and feeding the mighty Indus and its tributaries. They are the key source of drinking water, domestic use, irrigation, wetlands and hydro power generation. (Ahmed and Joyia 2003).

The role of sanitation and safe water in maintaining health has been recognized for centuries. The provision of water, sanitation and good hygiene services is vital for the protection and development of human resources (Fewtrell *et al.,* 2004).

Therefore, it has become necessary to monitor water quality to observe the demand and pollution level of water sources. Several water analyses have been regularly conducted by different scientific groups across the country. The present work is a primary attempt to examine the water quality of various potable water resources within the buffer zone of CKNP. The main focus is to collect the information from the selected areas within CKNP, that how the water resources are being utilized and what is the microbiological picture of drinking water.

Material and methods

Research site

Water Samples were collected from various localities within CKNP, including Sikandarabad, Minapin, Pisan (Rakaposhi area, Nagar). Hoper valley Nagar, Bagrote and Haramosh valleys, Gilgit. Figure 2 shows the sampling sites in the central Karakoram National Park. Table 1 shows the points/sources from where samples were collected within above mentioned localities.

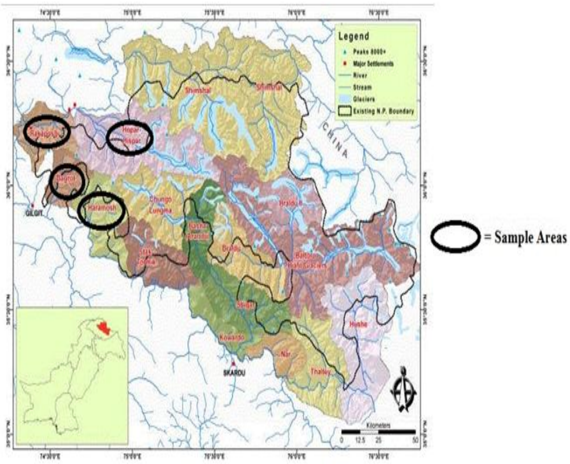

Fig. 1. Map of CKNP (Central Karakoram National Park) Gilgit-Baltistan, Pakistan.

Sample collection

Total 51 water samples were collected in from July 2013 to November 2013 from different localities with diverse type of water sources having distinct ecology and topography. All the samples were collected in 1000 ml pre sterilized Glass bottles and were transported in battery operated refrigerators to Water Quality Lab Karakoram International University (KIU), Gilgit, Pakistan and processed immediately.

All necessary details were mustered in a pre-designed data sheet including the GPS values in order to have a record for monitoring purposes and to develop a permanent system of surveillance. Sampling was done in closer conformity with general guide to the sampling techniques and recommendations for preservation and handling of samples, (ISO 5667-1, 5667-2)

Microbiological parameters

The collected water samples were analyzed for various microbiological (Bacteriological) parameters. The procedure for analysis was followed as per standard methods for the examination of water and waste water (APHA, 2000; AWWA, 2000). The parameters analyzed were *E.coli, intestinal Enterococci,* Total Bacterial Count and *Salmonella*.

The membrane filtration (MF) technique, (ISO 7704) was used to filter 100 ml of volume from water samples to ascertain *E-coli, Intestinal Enterococci and Salmonella*. The Chromogenic (EC X-GLUC Agar) was used for the detection of *Escherichia coli* (ISO 9308-1). The determination of *Enterococci* was carried out by filtering 100 ml of water from respective samples and subsequent culturing on Slanetz and Bartley agar (ISO 7899-2). The conformity test for *Enterococci* was done using Bile Esculin Azide Agar (BEA). For detection of *Salmonella* in 1 liter Hektoen Enteric Agar, Rappaport vasillaidis Broth were used after passing the filtered paper in to enrichment media containing buffered peptone (ISO 6579-1981). Total Bacterial count (Heterotrophic Plate Count, APHA 9215-B) was revealed through pour plate technique by pouring 1ml sample in to Petri dishes and adding yeast extract agar as a growth medium accordingly. Control Petri plates for all parameters were also kept in incubation in order to avoid any contamination chances in medium. All the bacterial cultures were aided by incubating the relevant Petri dishes to required growth temperatures and their number was counted on total Colony forming units (CFU) basis.

Results and discussion

Table 1 shows the result of all the samples collected from various localities having three different type of sources. In the history of water quality testing labs in Gilgit Baltistan, Chromogenic (EC X-GLUC Agar) was used for the first time as medium to culture *Escherichia coli*. Which is said to be the most efficient selective media for the isolation of said water quality indicator (ISO 16649-2,2001). Moreover, the source mid and last point assessment differentiates the current study with similar previous approaches in the area (Ahmed and Shakoori, 2002). The *E.coli* percentage was at higher end ranging from 1 to 160 CFU in mid and last usage points as compare to the sources. Springs with protected structures were least contaminated in Bagrote Valley as compare to the protected spring sources in Hoper valley. The water quality condition of wells as a storage structure was worst, feeding water from streams and allied irrigation channels made it more vulnerable to Bacteria. The average count within the samples collected from wells was 125 CFU (Table 2).

Table 1. Bacteriological Parameters In Drinking Water Collected From Different Localities/Sources Of Central Karakoram National Park (CKNP), Gilgit-Baltistan,Pakistan.

Site ID	Site Name	Water Class	*E.Coli*/ 100ml	*Enterococci* / 100ml	Total Bacterial Count	*Salmonella* in 1 Liter
SIK1	Sikandarabad Ithen	stream	25	16	40	Absent
SIK2	Sikandarabad Khantip	well	60	80	120	Absent
SIK3	Sikandarabad Tehsil Area	well	120	85	130	Absent
HAK1	Hakalshal,Hoper	spring	2	Absent	16	Absent
HAK2	Hakalshal Mid tape,	spring	Absent	Absent	10	Absent
HAK3	Hakalshal Last Tape	spring	15	4	25	Absent
BRO1	Broshal Tank, Hoper	spring	49	7	120	Absent
BRO2	Broshal Doulat House	spring	79	19	121	Absent
BRO3	Broshal School Tap	spring	21	11	65	Absent

RAT1	Ratal Tank, Hoper	spring	3	6	44	Absent
RAT2	Ratal Ghulam House	spring	Absent	4	25	Absent
RAT3	Ratal Roadside Tap	spring		3	21	Absent
PIS1	Sholay,Pisan	spring	4	Absent	65	Absent
PIS2	Ismail House,Pisan	spring	1	3	16	Absent
PIS3	Dainy,Pisan	spring	Absent	2	6	Absent
MIN1	Sholay,Minapin	spring	6	6	42	Absent
MIN2	Dasguni,Minapin	spring	2	15	85	Absent
MIN3	kot masjid,Minapin	spring	1	12	14	Absent
SAN1	Sanikar Tank	spring	Absent	Absent	Absent	Absent
SAN2	Sanikar Mid Public Tape	spring	Absent	4	4	Absent
SAN3	Sanikar Lower Tape	spring	Absent	Absent	1	Absent
HOP1	Hopey Tank	spring	Absent	Absent	1	Absent
HOP2	Hopey,Ihsan Ali House	spring	Absent	4	2	Absent
HOP3	Hopey,Ghulam Raza House	spring	Absent	1	1	Absent
DAT1	Datuchi Tank	spring	Absent	Absent	4	Absent
DAT2	Datuchi, Ali Ghulam House	spring	Absent	Absent	3	Absent
DAT3	Datuchi,public Tape	spring	Absent	Absent	5	Absent
FAR1	Farfu Tank	spring	Absent	Absent	4	Absent
FAR2	Farfu Azhar House	spring	Absent	Absent	Absent	Absent
FAR3	Farfu lower Tap	spring	Absent	Absent	2	Absent
BUL1	Bulchi Tank	spring	Absent	Absent	4	Absent
BUL2	Bulchi,M.Hussain House	spring	Absent	Absent	1	Absent
BUL3	Bulchi,Adil House	spring	Absent	Absent	5	Absent
CHI1	Chira Tank	spring	Absent	7	1	Absent
CHI2	Chira,Ashur Ali House	spring	2	Absent	4	Absent
CHI3	Chira,Mehboob House	spring	1	3	2	Absent
BRU1	Brumday Source	stream	75	38	80	Absent
BRU2	Brumday Mid	stream	27	25	40	Absent
BRU3	Brumday Last	stream	130	35	40	Absent
SHA1	Shatot Source	stream	10	17	5	Absent
SHA2	Shatot Mid	stream	93	35	48	Absent
SHA3	Shatot last	stream	27	24	24	Absent
HUR1	Hurban Source	stream	100	40	45	Absent
HUR2	Hurban Mid	stream	155	60	44	Absent
HUR3	Hurban last	stream	160	20	140	Absent
SAS1	Sassi Source	stream	65	26	30	Absent
SAS2	Sassi Mid	stream	6	13	35	Absent
SAS3	Sassi last	stream	34	24	100	Absent
HAN1	Hanuchal Source	stream	3	Absent	80	Absent
HAN2	Hanuchal Mid	stream	50	Absent	100	Absent
HAN3	Hanuchal last	stream	50	19	180	Absent

Statistical analysis

Statistical analysis shows that there is a significant relationship between mid and last point contamination with type of distribution medium. Fecal contamination at the points of corrosion in Galvanized Iron (GI) pipes and presence of livestock along the sources, further deteriorated the drinking water quality. Majority of water samples except the sources of Bagrote Valley were higher than the permissible limit predetermined by WHO for *E-coli* and total bacterial count in drinking/surface water. The contamination level was quite alarming in streams and wells specially *E. coli* and *Enterococci* in the study area. Moreover, there is significant relationship among the level of contamination with respect to the water class, where the stream water and wells have not shown a vivid difference in terms of *Enterococci* contamination (table 2).

Mean Contamination results on Table No -1 reveal that there is no any significance difference among the *E. coli, Enterococci* and Total bacterial Count (TBC) with respect to sample points (Source, Mid and Last). But the occurrence of infestation is vivid in sources with different origin, type of source and the protection and accessibility to the drinking water source. Some other factors including anthropogenic interaction and deterioration of medium can be more influential in the presence of mentioned parameters.

Table 2. Variation in bacteriological parameters in relation to water class.

Water Class	Total Bacterial Count	*E.Coli*/100ml	*Enterococci*/100ml
Stream	64.44 ± 6.55[a]	63.12 ± 7.27 [a]	24.48 ± 2.161[a]
Well	125.00± 2.78 [b]	91.33 ± 12.86[a]	83.83 ± 0.98[b]
Spring	21.74 ± 3.31[c]	5.76 ± 1.61[b]	3.41 ± 0.48[c]
LSD	0.00	0.01	0.00

Means (SE) values followed by same letter (s) across columns are not significantly different with respect to water class at $P \leq 0.05$.

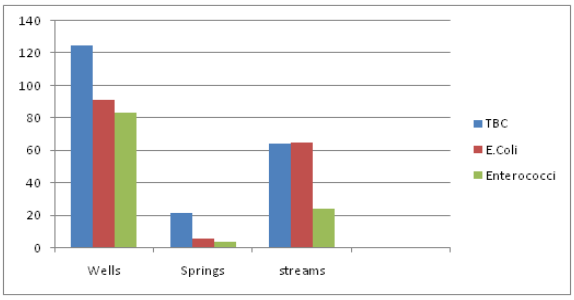

Fig. 2. Mean Bacteriological contamination level (CFU) at various sources within CKNP.

Factors influential in water contamination and management

The poorly managed resources and improper distribution of drinking water from the source to last usage point is a key factor in determining the overall microbial quality of water. The farming practices in tandem with anthropogenic activities from March to October, and open grazing practices during autumn and winter has culminated the contamination of sources. Proper protection and surveillance of sources and the distribution medium is utmost necessary to get the desired quality of drinking water in home taps. The streams and other forms of surface water which feds wells are used for irrigation purposes too. The seclusion of the two distinctive systems is indispensable to minimize the risk of water borne diseases which are common in the study area. Some better sources (springs) have been abandoned due to myths depicting ill effects of its usage other than biological and chemical contamination. Proper counseling and awareness among local populace is inevitable to keep them on better drinking water sources

Acknowledgements

Study is part of PhD research and was possible due to generous financial grant from Italian government and the government of Pakistan through SEED project in collaboration of Karakoram International University, Gilgit-Baltistan. The author is highly indebted to the supervision of Dr. Andrea Lami, Paleo- Limnologist, Institute of Ecosystem Studies, Council of National Research, Italy. We are also thankful for CKNP management team for their ongoing support during field visits.

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