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DRINKING WATER QUALITY AND POSSIBILITY OF WATER BORNE DISEASES IN VILLAGE KHILLAH, MUZAFFARABAD, AZAD JAMMU AND KASHMIR, PAKISTAN

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ABSTRACT

Study was conducted to find out the health of drinking water of village Khillah, Muzaffarabad, Azad Jammu and Kashmir (AJK) in 2015-16. The bacteriological analysis especially, the presence of Coliforms (*E. coli*) along with levels of physico-chemical parameters; temperature, pH, turbidity, alkalinity, calcium ions, magnesium ions, chloride ions total dissolved solid, total suspended solids, total organic solids and total inorganic solids were monitored during eight months by using standard methods. All physico-Chemical parameters of water stayed behind standards set by World Health Organization (WHO). On the other hand, all drinking water sources of Khillah village were highly contaminated by Coliforms and contamination was greater during monsoon.

Keywords: Coliform, Physico-chemical parameters, Drinking water, Village Khillah, Correlation.

INTRODUCTION

Safe and adequate water supply is necessity for human, animal and plant life. Drinking water should be free from disease causing organisms, poisonous substances and excessive amounts of minerals and organic matters and must be free from turbidity, taste and odor (Patil *et al.*, 2012). WHO (2000) reported that with shortage of water about 40 percent of the world population of developing countries has no access to clean water or sanitation. Unfortunately, water can be polluted by widespread environmental factors aided by human activities and consumption of water from most sources is therefore, unhealthy without some sort of treatment (Pruss *et al*. 2002; WHO, 2009; Payment and Riley 2002; WHO/UNICEF, 2010). In Pakistan, drinking water from their source to distribution is profoundly contaminated with coliforms and fecal coliforms (Nabeela *et al*., 2014). Similarly, a number of studies revealed water quality and water borne diseases as a major concern of AJK (EPA, 2004). Drinking water of the district Bagh (AJK) has largely contaminated with fecal thermo-tolerant coliform which are increasing the risk of waterborne infection (Akbar *et al*., 2013). Water sources are exposed to contamination with fecal pathogens and the enteric pathogens, which pose serious public health risks (Hitzfeld *et al*., 2000; Pruss *et al*., 2002; Kistemann *et al*., 2002; Albek, 2003; Okoh *et al*., 2007; Igbinosa and Okoh, 2009). Environmental Protection Agency (EPA, 2004) of GoAJK revealed that 24 percent drinking water of AJK were contaminated with *E.coli* (high risk) and 7 percent water fall at very high risk category, with contamination levels greater that 101 *E.coli*/100 mL (WHO, 2000), these fecal contamination levels may be significantly higher in the summer seasons.

In the same way a good knowledge of the chemical qualities of raw water is necessary so as to guide its suitability for use. Present work is therefore, an attempt to assess the quality of drinking water sources and all possible (fifteen) sources of drinking water of village Khillah (Muzaffarabad) were examined and compared its qualities and contamination (Coliform) with standard table water.

MATERIALS AND METHODS

The study area and sampling sites

The study area and sampling sites of Khillah region lies within the Himalayans region and is located on latitude 34° 20′ 11″ N and longitude 73° 30′ 58″ E in Azad Jammu and Kashmir (Fig. **1**). Village Khillah is characterized by a temperate climate, with heavy rainfall. Fifteen sampling sites (Drinking water) were selected and monitored for period of eight months (July, 2015 to February, 2016). Water parameters were analyzed monthly to determine a total of twelve physico-chemical parameters, as well as the presence of *E.coli* (fecal coliform). The samples were collected in pre-sterilized, capped bottles (1500 mL) at dawn and dusk in first week of every month. After collection, samples were immediately transported to the laboratory and analyzed within 4 h of collection.

Bacteriological analysis

Analysis for *E. coli* / Coliform was done by using one step-simple water test for biological contamination. UNICEF media bottle prepared by Pakistan Council of Research in Water Resources Khabayan-e-Johar, H-8/1, Islamabad, Pakistan, was used for test. After opening the bottle (media) was filled with sample water up to the mark as mentioned on bottle. Closed the lid tightly and the bottle was placed at room temperature for 24 h. After 24 h, changed color (black) of water is the indication of high coliform contamination.

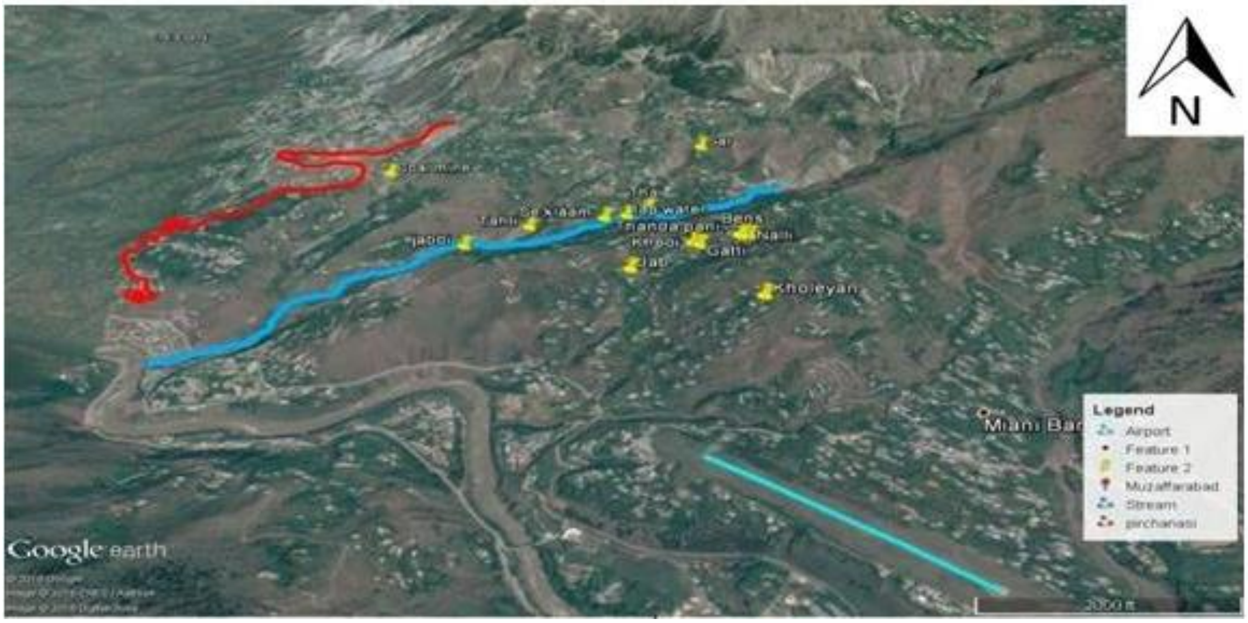


Fig. 1. Sampling sites of village Khillah.

Physico-Chemical Analyses

Temperature, pH, turbidity and conductivity were measured on spot by using digital meters Walk LAB Microcomputer Thermometer IN9000 (0 °C to 100 °C), portable Wagtech pH meter and NTU 101 (Turbidity Meter) respectively.

Total Inorganic Solids (TIS), Total Organic Solids (TOS), Total Suspended Solids (TSS), and Total Dissolved Solids (TDS) were separated by filtering the water through a 0.45 µ filter paper and determined according to standard procedures (APHA 1989). Chloride ions and water hardness were determined by EDTA titrimetric methods (APHA, 1989).

Statistical Analysis

Data was analyzed using descriptive statistics and Pearson's correlation. MS excel and Minitab software were used to analyze the association between these variables.

RESULTS AND DISCUSSION

Temperature

The mean value of water temperature during the whole study period was recorded as highest in August (20.38 ± 0.48°C), followed by July (20.17 ± 0.37°C) and September (20.07 ± 0.29 °C), while, minimum value of water temperature (17.37 ± 0.59°C) was recorded in November (Table 2). A significant correlation ($p < 0.05$) was noted between water temperature and alkalinity while, there is no significant correlation of water temperature with other parameters (Table 3). Temperature of water is one of the most important ecological factor that affecting organisms and the functioning of ecosystem. However, there is no guideline recommended for drinking water, but it is suggested that temperature below 15°C is normally preferred for drinking because above 15°C, bacterium having rapid growth in water (WHO, 2009).

Turbidity

Turbidity of studied water sources was recorded moderate and within permitted limit (5 NTU) of WHO (2009) that is 2.96 ± 0.27 NTU (thanda pani), to (2.56 ± 0.25 NTU (spring Sar) (Table 2). Suspended particles of clay, silt and colloidal organic materials cause turbidity in water (Baig *et al*., 2012; Ottawa, 2012).

pH

The mean value of pH during the whole study period remained within the permissible limit (6.5-8.5) of WHO (2009), as it ranged between 7.10 ± 0.18 (Kholeyan) to 6.53 ± 0.1 (stream water) (Table 2).

Alkalinity

The mean value of alkalinity during the whole study period was recorded as highest in spring kholeyan (5.43 ± 0.50 mMol/L), followed by spring Nalli (4.95 ± 0.47 mMol/L) and Jabbi (4.67 ± 0.51 mMol), while, lowest value of alkalinity was recorded in stream water (2.43 ± 0.18 mMol/L) (Table 2). Alkalinity depends upon the geological strata of the area; therefore its values vary from area to area and remain comparable within the same areas (Khan *et al.*, 2012). Chlorides, bicarbonates and sulfates ions are mostly contributing to alkalinity. Higher alkaline water has a higher pH and generally contains elevated level of dissolved solids.

Total Inorganic Solids (TIS)

The mean value of TIS during the study period was recorded as highest in Thanda Pani (1000 ± 267 mg/L), followed by Spring Khooi (687.5 ± 161.94 mg/L) and Stream water (562.5 ± 113.29 mg/L) while lowest value of TIS was recorded in spring Sar (312.5 ± 131.52 mg/L) (Table 2).

Total Organic Solid (TOS)

Total organic solid referred to the organic contents of water indicating that the water may have been polluted by wastes (Manoj and Puri, 2012). The TOS fluctuates with sweeping down of debris from surrounding areas by rain, flood and human activities (Rafael *et. al.*, 2013). The water which consists of high organic solid is not suitable for drinking purpose. The value of TOS recorded as highest in spring Gatti (500 ± 133.63 mg/L), followed by Thanda pani (437.5 ± 175.19 mg/L) and Spring Jab (375 ± 205.9 mg/L) while, its lowest value is recorded in spring Tahli (125 ± 81.83 mg/L) (Table 2).

Total Suspended Solids (TSS)

Total Suspended Solids are undissolved, non-filterable inorganic (silts, clays etc.) and organic (algae, zooplankton, bacteria and detritus) materials in water (KWW, 2001). The mean value of TSS during the whole study period was recorded as highest in Stream water (550 ± 199.10 mg/L), followed by Spring Nalli (500 ± 173.20 mg/L) and Spring Jab (425 ± 95.89 mg/L) while, its lowest value is recorded in spring Tahli (300 ± 37.79 mg/L). Suspended material is good for adsorption of chemical and biological agents (John *et al*., 1989). Water with high suspended solids may be substandard for bathing also (APHA, 1989).

Total Dissolved Solids (TDS)

Total Dissolved Solids are the total amount of dissolved minerals, salts or metals in a given amount of water. Fresh water may be considered to have TDS of 1500 mg/L (DPR, 2002). TDS effect on color, taste and odor of water (Baig *et al.*, 2011). The maximum permissible level for TDS in drinking water set by WHO is 1000 mg/L (Bello *et al*., 2013). Studied water, have less values of TDS ranged between 437.5 ± 239.74 mg/L (spring Kholeyan) to 875 ± 226 mg/L (Thanda Pani). A significant correlation ($p<0.05$) was noted between TDS and TSS (Table 3).

Calcium (Ca^{+2}) and Magnesium (Mg^{+2} ions)

The hardness of water is mainly due to amount of calcium and magnesium ions. All analyzed water resources fit in in the soft water category. The mean value of calcium ions was 0.97 ± 0.04 mg/L (Spring Sar) to 2.97 ± 0.67 mg/L (Spring Gatti) and the mean value of magnesium ions was 3.32 ± 0.26 mg/L in Spring Bens, followed by Thanda Pani (3.25 ± 0.22 mg/L) and Stream water (2.15 ± 0.17 mg/L) and lower than values setup by WHO (Ca^{+2} 75mg/L and Mg^{+2} 50 mg/L (Kahlown *et al.*, 2006). These values were also lower than mineral waters for Ca^{+2} (Nestle, 40-70 mg/L, Sparkletts, 30-45mg/L and Kinley, 30-100mg/L) & for Mg^{+2} (Aquafina, Sparkletts, Nestle and Kinley water 13 mg/L,7-14 mg/L,4-15 mg/L and 12-25 mg/L, respectively). A significant correlation ($p < 0.05$) was noted between calcium ions and TDS (Table 3).

Table 1. Fluctuations in *E. coli* concentration during the whole study period.

Months	Thai	Gatti	Khooi	Tahli	Sar	Kholeyan	Thanda pani	Bens	Nalli	Jabbi	jab	Se-klaam	Coal mine	Stream	Tap
July	+	+	-	-	+	+	+	+	-	+	+	-	+	+	+
Aug.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Sep.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Oct.	-	-	+/-	-	+/-	+	+	+	-	+	-	-	-	+	+
Nov.	-	+/-	+/-	-	+/-	+/-	+/-	+/-	+/-	+/-	-	-	-	-	-
Dec.	+	+	+	+	+	-	+	-	-	+	+	-	+	+	+
Jan.	+/-	+/-	+/-	+/-	+	+/-	+/-	-	+/-	+/-	+/-	+/-	+/-	+/-	+/-
Feb.	-	+	+/-	+/-	-	+/-	+/-	-	+	-	+	+	+	+	-

(+) shows present, (+/-) represent mild and (-) represent absent.

Table 2. Comparison of mean values of different water quality parameters.

	pH	Turb. (NTU)	Alkal. (mMol/L)	Cl^{-1} (mg/L)	Ca^{+2} (mg/L)	Mg^{+2} (mg/L)	AT (°C)	WT (°C)	TSS (mg/L)	TDS (mg/L)	TOS (mg/L)	TIS (mg/L)
Thai	6.65±0.74	2.68±0.26	3.65±0.46	0.046±0.006	1.65±0.20	2.67±0.18	15.25±2.77	18.85±0.14	400±106.9	437.5±239.7	250±94.9	375±125
Gatti	6.63±0.08	2.72±0.23	3.89±0.34	0.05±0.007	2.97±0.67	2.75±0.25	17.41±2.78	18.97±0.24	300±65.46	500±188.98	500±133.6	375±125
Khooi	6.88±0.10	2.66±0.21	4.04±0.37	0.05±0.008	2.25±0.13	2.92±0.16	16.91±2.69	19.67±0.49	300±53.45	500±188.982	312.5±91.49	687.5±161.94
Tahli	6.55±0.16	2.68±0.27	3.69±0.36	0.11±0.056	1.62±0.19	3.2±0.31	17.53±2.69	19.61±0.29	300±37.79	812.5±282.48	125±81.831	500±133.63
Sar	6.73±0.20	2.56±0.25	3.16±0.28	0.11±0.064	0.97±0.04	2.22±0.16	16.55±1.97	18.55±0.12	300±100	500±188.98	187.5±91.49	312.5±131.52
Kholeyan	7.10±0.18	2.8±0.23	5.43±0.50	0.05±0.003	2.9±0.26	2.92±0.22	17.98±2.32	20.17±0.22	350±73.19	437.5±147.52	375±125	375±125
Thanda pani	6.63±0.11	2.96±0.27	4.31±0.42	0.06±0.004	2.52±0.32	3.25±0.23	17.12±2.61	18.9±0.69	375±95.89	875±226.58	437.5±113.29	1000±267.26
Bens	6.77±0.11	2.81±0.25	4.47±0.36	0.04±0.008	2.67±0.26	3.32±0.26	17.8±2.33	19.42±0.20	375±79.61	625±182.981	437.5±175.19	687.5±248.88
Nalli	7.00±0.06	2.76±0.26	4.95±0.47	0.04±0.006	2.85±0.27	2.82±0.25	17.6±2.41	18.15±0.55	500±173.20	562.5±290.28	312.5±91.49	375±125
Jabbi	6.88±0.11	2.76±0.24	4.67±0.51	0.04±0.006	1.62±0.23	2.9±0.32	18.12±3.23	17.83±0.34	400±106.90	750±133.63	375±205.93	937.5±319.56
Jab	6.70±0.10	2.75±0.26	4.30±0.25	0.04±0.007	2.6±0.26	2.87±0.17	20.03±1.80	18.71±0.26	425±95.89	687.5±131.52	375±81.83	812.5±230.24
Se-Klaam	6.93±0.11	2.75±0.26	3.90±0.30	0.05±0.005	1.54±0.12	2.96±0.33	17.18±3.04	19.41±0.21	350±62.67	625±226.58	375±81.83	437.5±113.29
Coal Mine	6.87±0.19	2.7±254	4.04±0.45	0.04±0.007	2.12±0.30	3.25±0.22	20.83±2.59	19.92±0.32	325±83.98	625±245.49	250±94.49	375±125
Stream	6.53±0.18	2.68±0.25	2.43±0.18	0.04±0.003	1.15±0.12	2.15±0.17	15.61±2.98	16.72±1.69	550±199.10	500±188.98	375±125	562.5±113.29
Tap	6.73±0.03	2.82±0.25	3.64±.43	0.04±0.004	1.57±0.14	2.8±0.18	14.8±2.61	16.66±2.00	350±111.80	500±188.98	312.5±91.49	500±188.98
WHO	6.5-8.5	5	200	10-25	75	75			500	500		
Nestle	6.5-8.5			77-150	40-70	4-15						
Kinley	6.5-7.5			50-150	30-150	12-25						
Aquafina	6.6-8.5			20	54	13						
Sparkletts	7.4-7.7			3-10	30-45	7-14				175-225		

Chloride ions (Cl^{-1})

Chloride is normally most dominant anion in water. The permissible limit of Chloride concentration in drinking water is 25 mg/L. Excess of chlorides is dangerous and unfit for the human use. These import a salty taste to water, excess of which becomes objectionable. Chlorinating also produces harmful bi-products called trihelomethane (THMs) which are link to incidence of cancer (Trojan and Max, 2010). The mean value of chlorides ions during the study period was recorded as 2.97 ± 0.67 mg/L (in Spring Gatti), followed by spring Kholeyan (2.9 ± 0.26 mg/L) and Spring Nalli (2.85 ± 0.27 mg/L) and Spring Sar (0.97 ± 0.04 mg/L) (Table 2) was lower than set by WHO (10-25 mg/L).

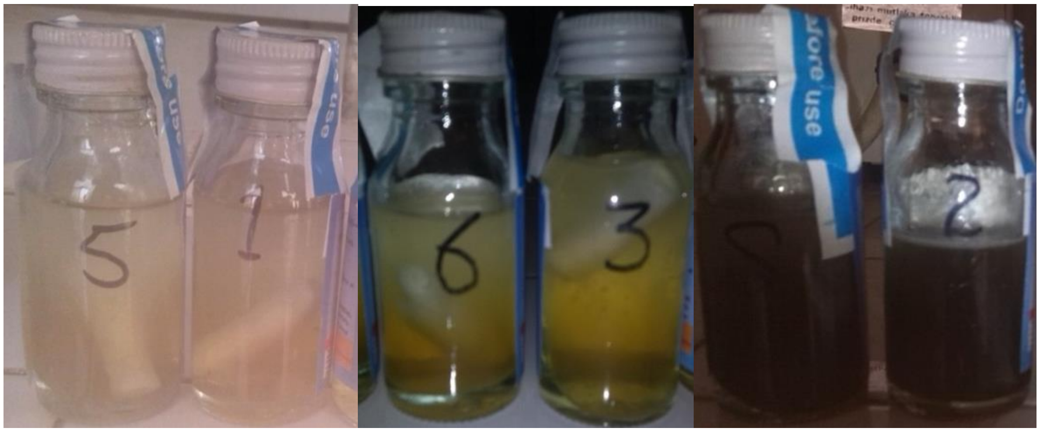
***E. coli* and coliforms**

Coliform bacteria known as indicator organism. Its presence provides indication that other disease causing organisms may also be present in the water body. According to WHO (2004) guiding principle the fecal contamination levels of safe drinking water must be 0 *E.coli* / 100 ml. However, for developing countries acceptable limits has recommended by WHO is 0-10 *E.coli* /100 ml in drinking water. All analyzed water sources of recent survey were contaminated by *E. coli* and during monsoon its concentration is elevated. High coli forms during monsoon could be attributed to increase in temperature which affects the rate of proliferation of microorganisms (Bello *et al*., 2013) and drainage and recirculation of rainy water to drinking water resources with rain water. Another possible cause of high coliform concentration could be closeness and inappropriate of latrines system as well as droppings of domestic animals (Capriole *et al*., 2005). Water samples were examined for the presence of *E. coli* and the analysis confirmed that all the water sources i.e. Se-klaam, Khooi, Tahli, Gatti, Sar, Kholeyan, Thanda pani, Bens, Jabbi, Jab, Stream, Nalli, Thai, Coal Mine and Tap water were highly contaminated with *E. coli* during monsoon and the contamination gradually declines in post monsoon (Fig. **2**; Table 1).

Table 3. Correlation of Physico-chemical parameters in spring water.

	pH	Turb.	Alkal.	Cl^{-2}	Ca^{+2}	Mg^{+2}	AT	WT	TSS	TDS	TOS
Turb.	0.020										
Alkal.	0.550	-0.098									
Cl^{-1}	-0.874	0.060	-0.391								
Ca^{+2}	-0.208	-0.674	0.146	0.140							
Mg^{+2}	0.340	-0.530	-0.133	-0.276	0.506						
S^{-2}	0.250	-0.52	-0.190	-0.165	-0.123	0.486					
AT	0.358	-0.416	0.620	-0.223	0.652	0.349					
WT	0.507	-0.202	0.710*	-0.369	0.350	0.116	0.929				
TSS	-0.220	-0.504	0.290	0.207	0.853	0.315	0.421	0.121			
TDS	-0.377	-0.802	0.165	0.340	0.686*	0.107	0.327	0.105	0.711*		
TOS	0.198	0.500	0.628	0.018	-0.518	-0.688	-0.076	0.149	-0.179	-0.188	
TIS	0.116	-0.058	-0.014	-0.152	0.031	0.022	0.459	0.587	-0.455	-0.208	-0.236

*, Correlation is significant at 0.05 significance level.



(A) (B) (C)

Fig. 2. Samples with absence (A), mild (B) and high (C) coliform concentration.

CONCLUSION

The study carried out in the village Khillah of District Muzaffarabad on ground water samples confirmed that: all the Physico-chemical parameters were within permissible limits. All water samples were highly contaminated during summer season. It is recommended that water should be boiled before drinking and other domestic uses especially during monsoon. Awareness program should be planned in study area to avoid the fecal contamination around water resources.

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