DRINKING WATER QUALITY STATUS IN GILGIT, PAKISTAN AND WHO STANDARDS

Arshad Ali Shedayi[1,2], Nazia Jan[2], Ming Xu[1'3], Saba Riaz[4], Sumera Ehsan[5]

[1]Institute of Geographic Sciences and Natural Resources Research, University of Chinese Academy of Sciences, Beijing, China

[2]Department of Biological Sciences, Karakoram International, Gilgit, Pakistan

[3]Department of Ecology, Evolution and Natural Resources, Rutgers University, USA

[4]Department of Botany, GC University Lahore, Pakistan

[5]Department of Environmental Sciences, PMAS Arid Agriculture University Rawalpindi, Pakistan

Corresponding author: arshadbio@kiu.edu.pk

ABSTRACT: *This study is aimed to determine the drinking water quality as per WHO standards from Danyore village of Gilgit-Baltistan, where drinking water is not treated before it is used. Samples were taken from ten different points and analyzed for physical, chemical and bacteriological parameters by using different kits such as Hydrolab MS 5 (Multiprobe Snode), Lovibond minikit and Pour plate method. The data showed variation in the investigated parameters of the samples such as Temperature 5.6 - 22.5ºC, pH 5.0 - 7.8, Specific conductivity (SP) 305.2 to 493.3 µs/cm, Turbidity 17.1-96.0 NTU, Total dissolved solids (TDS) 200-300 mg/L, Level of dissolved oxygen (LDO) 5.5-9.36 mg/L, Salinity 150-250 ppm, Total alkalinity 30-43 mg/L, Total Hardness 160-190 mg/L. Total coliform/ml were observed in the microbiological water analysis. In channel total coliform were higher ranged than in tap water. The concentrations of some of the investigated parameters in the drinking water samples were within the permissible limits of the World Health Organization (WHO) drinking water quality guidelines while some were showing variation from those guidelines and showing a threat for human health. Both tap and channel water failed to meet the zero/100ml coliform as per WHO set standards for drinking water. Especially the channel water samples showed highly contaminated by E.coli and found unsafe for human consumption and may cause health disorders. Proper sanitation, waste disposal management, installment of water treatment plants and intensive research on water quality and water born diseases are recommended.*

KEY WORDS: Physico-chemical, Bacteriological, TDS, LDO, Specific conductivity, Alkalinity, Hardness, $CaCO_3$, pH, *E.coli*

INTRODUCTION

Glaciers and snow deposits are the principal water source in Gilgit-Baltistan. The melted water enters streams, which subsequently feed main-made channels-Kuhls- that bring water into settlement for agriculture, domestic requirements and livestock [1]. The rural areas of the region depend mainly on their irrigation channels for the supply of water for domestic use. Water from the pits is generally reserved for drinking and cooking purposes. The supply during the winter month is reduced due to reduced snow and glaciers-melt, which affect the quality of stored water. In summer the pit water is replenished more frequently [2]. Due to the diversity of the natural forms of the existence of water and diversity of forms of water using by humans (biological and technical), the vast multiplicity (physical, chemical, biological, and technological) of water properties was explored. Correspondingly, different classifications of natural waters (e.g. for consumption) were developed. (In essence, every specific sort of water requires a special method of quality analysis [3]. The natural water analyses for physical and chemical properties including trace element contents are very important for public health studies [4]. Tahir [5] studied pollution problems in water supply systems of Rawalpindi and Islamabad city. The supply systems of both cities were found fit with respect to alkalinity, hardness, TDS.

Xijing *et al.*,[6] analyzed and assessed water quality of the stored drinking water from China. pH and total alkalinity has higher values in the contained in concrete water cellars with cement or grey tile catchment surfaces. Total hardness has higher values in the drinking water contained in soil water cellars. Din *et al*., [7] found that the chemical quality of most CDA (Islamabad) tube-wells was satisfactory during September to December. However, some samples were found with 1.4 ppm strontium concentration. Tahir *et al*., [5] analyzed the drinking water quality in the rural areas of Rawalpindi district. The results showed higher concentration levels of nitrate, iron and sodium in many water samples. Malick *et al.,* [8] analysed water for physio-chemical parameters such as Temperature, pH, turbidity, EC and TDS in Karachi. Results showed that the treated water from the treatment plants meets WHO guidelines.

Ahmed and Ali [9] investigated pollution in Ravi River and a decreasing trend in dissolved oxygen and an increasing trend in biological oxygen demand and total dissolved solids were observed over time. The discharges of untreated wastewater from the city and nearby industrial estates into the river were the main causes of water quality deterioration. Nasir and Saba [10] found 43.2% unsafe for drinking, 10.3% samples contained physico-chemical as well as bacteriological contaminants from Islamabad and 22.4% were unsafe by physico-chemical parameters while 3.6% by both physico-chemical and bacteriological contamination in CDA. Tahir [5] undertook a study on pollution problems in the water supply systems of Islamabad and Rawalpindi. It was found that 76% samples in Islamabad and 82% samples in Rawalpindi were contaminated due to bacterial presence. Ahmed and Ali [9] found that water of Ravi River did not meet the Coliform and faecal Coliform criteria for most water uses. Jahangir [11] found 94% water samples collected from Islamabad/Rawalpindi bacteriologically contaminated and 34% having fecal contaminations.

MATERIALS AND METHODS

Study area:

Danyore is the largest village of Gilgit-Baltistan. It is situated at a distance of 12 km from centre Gilgit.It’s total population is 25,000 in 2600 houses. Danyore is located in the North-East portion of the Gilgit and lies with a latitude 35.9280°N and altitude 74.39355°E. Climate of Danyore varies greatly. In summer it is too hot and in winter it‘s too cold. Average temperature in summer rises from 17.4 to 35 ^{0}C (June-August), in autumn it varies from 6.6 to 25.3 ^{0}C (September-November), in winter it varies from -2.7 to 10.8 ^{0}C (December-February) and in spring (March-May) from 8.8 to 22.8 ^{0}C. Some studies have been conducted on drinking water quality assessment in Gilgit such as physical and chemical assessment by Ahmad and Shah [40], water quality assessment of Gilgit river, using fecal and total coliform as indicators [41] and physic-chemical and bacteriological analysis [26]. Findings in all these studies show the contamination of water and it is unsafe for drinking purpose, especially open channel water.

Sample collection and laboratory analysis:

Transects were drawn according to the area of study. Ten drinking water samples from tap and channels were collected including source and water tank in prewashed (with detergent, diluted HNO_3 and doubly de-ionized distilled water, respectively) polyethylene bottles for bacteriological and chemical test within 3-4 hours after sampling and physical parameters i.e. pH, temperature, turbidity and specific conductivity and some chemical parameters were measured on the spot with the help of digital hydro lab while color, taste and odor were observed with the help of senses.

Figure 1: Sampling points in Danyore Village

Physical parameters (temperature, pH , conductivity) were measured using Hydrolab MS 5 (Multiprobe Snode) unit. Surface reading were taken at a depth of 0.2m from the surface. The parameters concerned were dissolved oxygen (D.O.), pH, temperature and conductivity Chemical parameters i.e total dissolved solids (TDS), salinity and level of dissolved solids (LDO) were also analyzed with the help of hydrolab multi probe unit. The readings were recorded and the process was repeated. Total alkalinity and calcium hardness were analyzed with the help of lovibond Minikit (AF 444). Water samples were collected at 0.2m using horizontally oriented alpha bottle water. Each parameter's value was recorded on the digital display unit water sampler [12]. Tablet count method was used for this purpose. For bacteriological analysis pour plate method was used [13].

RESULTS AND DISCUSSIONS

Good drinking water quality is essential for the wellbeing of all people. Unfortunately in many countries around the world, including Pakistan, some drinking water supplies have become contaminated, which has impacted on the health and economic status of the populations [14]. The important factor affecting water quality is the human activities in the surrounding of water delivery system [15]. Even if no sources of anthropogenic contamination exist there is potential for natural levels of metals and other chemicals to be harmful to human health [16].

1. Physical quality analysis

Table 1: Physical parameters

No.	Sample Point	Time (am/pm)	Temp [°C]	pH [Units]	Sp Cond [µS/cm]	Turbidity [NTU]
1	Source	9:50	5.6	5.0	305.2	61.4
2	Tank	10:17	8.1	7.3	432.8	53.2
3	Tap 1	11:02	13.2	6.1	422.8	96.0
4	Chan 1	11:08	9.0	7.5	436.3	56.3
5	Tap 2	11:46	18.4	7.7	412.1	25.1
6	Chan 2	11:53	9.4	7.8	437.8	40.6
7	Tap 3	13:02	15.9	7.5	432.3	17.1
8	Chan 3	12:47	12.3	7.3	382.7	27.2
9	Tap 4	13:33	22.5	7.3	493.3	229.0
10	Tap 5	13:55	14.6	5.9	433.1	80.6

Color:

The samples studied were all turbid in color. Color arises from absorption of visible light by dissolved and un-dissolved substances. Pure water exhibits a light blue color, which may be changed by the presence of organic/inorganic matter to greenish blue, green, greenish yellow, or brown. Typical color is mostly due to holmic substances or trivalent iron. Generally, the observations of color are made in qualitative terms [17]. WHO [18] and the Water Clinic [19] reported that color in drinking water may be due to the presence of colored organic substances, usually humus, metals such as iron and manganese, colored industrial wastes. Danamenk [20] reported that organic color and staining usually occur in areas with poor drainage. Ronald [21] says color of drinking water should not exceed 15 units. WHO [22] has recommended 15 TCU as the level, above which likely to give rise to consumer complaints because of appearance.

Taste:

The taste of water analyzed was unobjectionable. There are four true taste sensations salty, sweet, bitter and sour. The results of taste examination were also described simply in qualitative terms in the forms of two groups *i.e.* objectionable and unobjectionable [17]. Taste threshold in distilled water for the major cat ions of drinking water i.e. calcium, magnesium, sodium and potassium have been reported to be approximately 100, 30, 100 and 300 mg/l respectively [23].

Odour:

Evaluation of odour was also based on the sense of smell. The odour tests are usefull for evaluating the quality of raw and finished water. A number of organic (mainly) and some inorganic substances contribute to the odour of water. Natural water containing only inorganic matter has usually no odour. The odour of analyzed samples was non objectionable/odorless. A great number of organic and some inorganic substances contribute to the odour of waters. The non-specific fishy, grassy and musty odour normally associated with biological growth tend to occur most frequently in warm surface water in the warmer months of the year [17]. Drinking water should have no observable odour to any consumer [18].

Temperature:

The temperature ranged from 5.6 to 22.5ºC (Table 1). In the source at 9:50am temperature was very low i.e. 5.6°C, in the tank at 10:17am it was 8.1°C little bit increased, tap 1 at 11:02pm (13.2°C), channel 1 at 11:08am (9.0°C) , tap 2 at 11:46am (18.4°C), channel 2 at 11:53am (9.4°C), tap 3 at 12:47pm (15.9°C), channel 3 at 13:02pm (12.3°C), tap 4 at 13:33pm (22.5°C) and in tap 5 at 13 :55pm it was 14.6°C. Highest temperature range was observed in tap 4 i.e. 22.5°C and lowest temperature observed was in source i.e 5.6°C.

This fluctuation in temperature was because of climate change, time, location and aspect of points. Some samples measured early in the morning and some of them were measured in afternoon. According to Jayaraman *et al*., [24] the temperature of drinking water is often not a major concern to consumers especially in terms of drinking water quality. The quality of water with respect to temperature is usually left to the individual taste and preference and there are no set guidelines for drinking water temperature. The result obtained is similar to the results of Parashar et al., [25] "Multivariate analysis of drinking water quality parameters in Bhopal, India". The temperature is important as it is responsible for the chemical and biological activities.

pH (Power of hydrogen):

The pH observed was ranging from 5.0 to 7.8 as shown in Table 1. In the source the pH value was 5.0, in tank it was 7.3, in tap 1 and channel 1(6.1, 7.5), tap 2 and channel 2 (7.7, 7.8), tap 3 and channel 3 (7.5, 7.3) respectively, in tap 4 it was 7.3 and in tap 5 it was 5.9. At first point of the study area i.e source and in tap 5 minimum values of pH were observed, while in all other points it was in normal range. The values were almost similar to that of Jabeen and Shedayi [26] they analyzed pH values in Sultanabad, Gilgit as pH values did not meet WHO guidelines; 45%samples had pH values below 6.0. The pH determination is very important as it affects the chemical and biological properties of water. The practical pH scale ranges from 0 (very acidic) to 14 (very alkaline) with the middle value of 7 corresponding to exact neutrality at 25˚C.The pH of natural water is due to carbon dioxide/bicarbonate and carbonate equilibrium. WHO [22] has recommended 6.5 to 8.5 value of pH for drinking water. While our results show that pH Values were low at two points which is not suitable for drinking, this is because of lower concentration of carbon dioxide, bicarbonates and carbonates and in other points normal values were observed and this water is drinkable. The result obtained is similar to the results of [27]. WHO Guideline [18] some problems could arise within a distribution system with pH level below 7.0.

Specific conductivity:

Specific conductivity values of all analyzed water samples varied from 305.2 to 493.3 µS/cm. In source Specific conductivity was 305.2 µS/cm, tank (432.8 µS/cm), tap 1 (422.8 µS/cm), channel 1 (436.3 µS/cm), tap 2 (412.1 µS/cm), channel 2 (437.8 µS/cm), tap 3 (432.3 µS/cm), channel 3 (382.7 µS/cm), tap 4 (493.3 µS/cm) and in tap 5 it was 433.1 µS/cm. In the source lowest value and in tap 4 highest values of SP conductivity were observed as shown in the Table 1. This is because at source water was more turbid and contaminated than other points. Jabeen and Shedayi [26] analyzed specific conductivity ranged 250-550 µS/cm from Sultananbad, Gilgit, Pakistan. Specific conductivity depends on the ionic strength of water and relates to the nature of various dissolved substances, their actual and relative concentrations and temperature at which the measurement made. This provides rapid and convenient means for estimating the concentration of electrolytes and dissolved minerals. If there is more concentration of electrolytes and mineral there will be more specific onductivity.Standard unit use for conductivity is Siemens per meter (Sm-1=W-1m-1). WHO [22] standard for SP conductivity of most fresh waters is in the range of 50-500 µS/cm. The values analyzed were also in this range. The determination of electrical conductivity provides a rapid and convenient means of estimating the concentration of electrolytes in water containing mostly mineral salts [18].

Turbidity:

Turbidity values were shown in Table 1. In the source turbidity was 61.4 NTU, in tank it was 53.2 NTU, in tap 1 (96.0 NTU), channel 1 (56.3NTU), tap 2 (25.1NTU), channel 2 (40.6NTU), tap 3 (17.1 NTU), channel 3 (27.2 NTU), in tap 4 (29 NTU) and in tap 5 its value was 80.6 NTU.

Turbidity values vary from 17.1- 96.0 NTU. Turbidity is the measure of cloudiness of water. It has no health effects. However; turbidity can interfere disinfection and provide a medium for microbial growth. Turbidity may indicate the presence of disease causing organisms. These organisms include bacteria, viruses, parasites that can cause nausea, cramps, diarrhea and associated headaches [28]. All the samples observed were greater values than the WHO [22] permissible value of 5 NTU. Highest values were observed in source and last point. This indicates that large number of disease causing organism may be present. This result is similar to the result obtained by "Pakistan Council of Research in Water Resources" PCRWR [17].

2.Chemical analysis

Total alkalinity:

The results obtained for total alkalinity shown in Table 2. In source alkalinity level was 30 mg/L with dilution factor 4X, in tank its value was 35 mg/L with dilution factor 3X, tap 1 (37 mg/L) dilution factor 2.9X, channel 1 (40 mg/L) dilution factor (2.5X), tap 2 (43 mg/L) dilution factor (2.4X), channel 2 (35 mg/L) dilution factor (3X), tap 3 (25 mg/L) dilution factor (4.3X), channel 3 (34 mg/L)

Table 2: Results for chemical parameters

No.	Sample points	Total alkalinity		Calcium Hardness		Salinity [ppm]	LDO [mg/L]	TDS [mg/L]
		Dilution factor	Alkalinity [mg/L]	Dilution factor	$CaCO_3$ [mg/L]			
1	Source	4X	30	8x	180	150	5.55	200
2	Tank	3X	35	8x	180	220	9.35	300
3	Tap 1	2.9X	37	7x	170	210	9.36	300
4	Chan 1	2.5X	40	9x	190	220	9.01	300
5	Tap 2	2.4X	43	8x	160	210	8.24	300
6	Chan 2	3X	35	8x	190	220	9.09	300
7	Tap 3	4.3X	25	8x	190	220	8.48	300
8	Chan 3	3.1X	34	8x	160	190	8.29	300
9	Tap 4	4X	25	8x	190	250	6.56	300
10	Tap 5	3.4X	30	8x	180	220	8.95	300

dilution factor (3.1X), tap 4 (25 mg/L) dilution factor (4X) and in tap 5 it was 30 mg/L with dilution factor 3.4X. Alkalinity values vary in all samples. The standard desirable limit of alkalinity in potable water is 120 mg/L. The maximum permissible level is 600 mg/L. The value of alkalinity in water provides an idea of natural salts present in water. Minerals are the cause of alkalinity which dissolve in water from soil. Various ionic species that contribute to alkalinity include bicarbonate, hydroxide, phosphate, borate and organic acids. These factors are characteristics of the source of water and natural processes taking place at any given time [29]. Water hardness-alkalinity had a significant effect copper toxicity to *Chironomus tentans* [30].

Calcium Hardness:

The results of calcium hardness are given in Table 2. In source calcium hardness value was 180 mg/L with dilution factor 8X, tank (180 mg/L) dilution factor (8X), tap 1 (170 mg/L) dilution factor (7X), channel 1 (190 mg/L) dilution factor (9X), tap 2 (160 mg/L) dilution factor (8X), channel 2 (190 mg/L) dilution factor (8X), tap 3 (190 mg/L) dilution factor (8X), channel 3 (160 mg/L) dilution factor (8X), tap 4 (190 mg/L) dilution factor (8X) and in tap 5 it was 180 mg/L with dilution factor 8X. Jabeen and Shedayi [26] observed calcium hardness ranging 160-20 mg/L from Sultanabad, Gilgit, Pakistan. The possible sources of hardness are calcium and magnesium, which are present in many minerals like limestone including chalk ($CaCO_3$), some industrial products and common constituents of food. A minor contribution to the total hardness of water is made by polyvalent ions as zinc, manganese, aluminium, strontium, barium, and irons. A number of studies in various part of the world have demonstrated that there was statistically significant negative correlation between water hardness and cardiovascular disease. However, a variety of other diseases were correlated with hardness of water. These included nervous system defects, anencephaly, prenatal mortality and various types of cancer. In areas with very hard water, household pipes become choked with deposited material. Hard water also deposits incrustations on kitchen utensils as well as increases soap consumption. Such water can thus be both a nuisance and an economic burden to the consumer. According to WHO guidelines standard value for hardness is < 500 mg/L. The values obtained were also less than 500 mg/L so this water is suitable for drinking. Hussain and Mateen [31] analyzed the water quality used for daily life in D.G. Khan. The results showed very high level of hardness concentration in drinking water. Bokina [32] found increased incidence of urolithiasis due to hard water in the USSR where the local tap water contained 300-500 mg of calcium per liter.

Salinity:

Salinity values shown in Table 2. In source salinity was 150 ppm, in tank it was 220 ppm, tap 1 (210 ppm), channel 1 (220 ppm), tap 2 (210 ppm), channel 2 (220 ppm), tap3 (220 ppm), channel 3 (190 ppm), tap 4 (250ppm) and in tap 5 it was 220 ppm. Salinity values vary in all samples. Salinity in water because of the presence of salts. If there is high concentration of salts the pH value increase. Saline water is not suitable for drinking. The degree of physiological result from drinking highly saline water usually represents an osmotic effect of the total dissolved salts rather than a toxic effect of any specific mineral constituent [33].

Liquid dissolved oxygen (LDO):

Results of LDO shown in Table 2. In source LDO was 5.55 mg/L, tank (9.35 mg/L), tap 1 (9.36 mg/L), channel 1 9.01 (mg/L), tap 2 (8.24 mg/L), channel 2 (9.09 mg/L), tap 3 (8.48 mg/L), channel 3 (8.29 mg/L), tap 4 (6.56 mg/L) and in tap 5 it was 8.95 mg/L.The values of dissolve oxygen vary from 5.55-9.36 mg/L. The standard value for liquid dissolved oxygen is 4 mg/l, which gives an indication that drinking water is free from oxygen consuming organic substances. All the above samples analyzed were above the WHO permissible limit and had high dissolved oxygen content. Jabeen and Shedayi [26] recorded dissolved oxygen from 8 to 10 mg/l from Sultanabad Gilgit. The importance of LDO in drinking water is due to its influence of organoleptic properties. The depletion of LDO in drinking water can encourage microbial reduction of nitrate to nitrite and can increase concentration of iron in the solution resulting from corrosion of metal pipes. Presence of LDO in water dependent on several factors such as temperature, composition of water and biochemical processes in distribution system. A LDO content, substantially lower than saturation concentration may indicate occurrence of undesirable processes, which may adversely affect the water quality [34]. The results obtained were similar to the results of Ilyas and Sarwar [35] “Assessment of Physio-Chemical and Biological quality of Drinking Water in the Vicinity of Palosi Drain Peshawar”. Biological factors such as increase metabolic rates and oxygen uptake rates of aquatic organisms may further reduce oxygen level [36].

Total dissolved solids:

Results of total dissolved solids shown in Table 2. In the source TDS was 200 mg/l), tank (300 mg/l), tap1 (300 mg/l), channel 1 (300 mg/l), tap 2 (300 mg/l), channel 2 (300 mg/l), tap 3 (300 mg/l), channel 3 (300 mg/l), tap 4 (300 mg/l), and in tap 4 it was 300 mg/l. Same values were observed in all sampling points except source. Jabeen and Shedayi [26] observed Dissolved solids ranged from 200 to 400 mg/l, from Sultanabad, Gilgit. The concentration of dissolved solids in water has to be considered for drinking purpose and for many industrial applications. Dissolved solids are those solids capable of passing through a standard filter. In water containing no suspended solids, the dissolved solids are identical to total residue. Sodium, calcium, magnesium, potassium, (cations), bicarbonates, chloride, sulfate, nitrate (anions) are the main constituents of TDS. There is no evidence of deleterious physiological reactions occurring in person consuming drinking water supplies up to 1000 mg/l. WHO (22) has recommended less then1000 mg/l as guideline value for TDS. The analyzed samples were also below this range, it means this is suitable for drinking. Hussain and Mateen [31] analyzed the water quality used for daily life in D.G. Khan. The results showed very high level of hardness concentration in drinking water. The TDS in canal water was appreciably lower than those found in sub surface water samples. Bruvold [37] have rated the palatability of drinking water due to the TDS level i.e. Excellent (<300 mg/L), Good (300-600 mg/L), Fair (600-900 mg/L), Poor (900-1200 mg/L, Unacceptable (>1200 mg/L). Water with extremely low TDS levels may also be unacceptable because of its flat, insipid taste. The use of water for agriculture and people will have serious implications on the ecology and environment of Gilgit-Baltistan. The total dissolved solids (TDS) range 60 to 374 parts per million (ppm), which is safe for irrigated agriculture, domestic and industrial uses. The TDS in the upper reaches of Indus River range between 60 ppm during high flow to about 200 ppm during low flow [1].

Table 3 shows number of total coliform bacteria in 1ml of water samples. In water tank total number of colonies of coliforms were 50/ml, channel1there were100/ml colonies, tap 1(15/ml), well (67/ml), channel 2 (70/ml) and tap 2 (5/ml) colonies of coliforms were observed in the water samples. The results show that all sample points analyzed were not in WHO permissible limit which is 0/100ml.This means that water is badly contaminated with either fecal or other pollutants mixed from different polluted sources, field seepages, drainage, livestock wastes and domestic garbages and sewage.

1. Bacteriological analysis

Table 3: Coliform clonies

No.	Sampling points	Time [AM]	Total no of coli form colonies/ml
1	Water tank	9:22	50/ml
2	Channel 1	9:32	100/ml
3	Tap 1	9:41	15/ml
4	Well	9:56	67/ml
5	Channel 2	10:05	70/ml
6	Tap 2	10:20	5/ml

The channels water found highly contaiminated with more number of coliform bacteria as compared to the tap water which show comparatively less coliform nimber, but both sources show high values than the WHO (22) set drinking water standards. The results for bacteriological analysis were similar to that of a similar research conducted by Jabeen and Shedayi [26] in an adjacent Village Sultanabad, in which they found channel water is more contaminated than tap Water. Our results show about 100% water samples donot meet the WHO standard zero/100ml. Malick *et al.*, [8] analyzed the drinking water quality in the city of Karachi. Approximately 50% of the water samples failed to meet drinking water guideline of zero *E. coli*/100 ml. Results showed the presence of Coliform bacteria in the main distribution lines. It indicates that water got contaminated from the surrounding leaky sewerage pipelines. Secondly, the presence of faecal Coliform in the water of branch lines feeding to consumers and stand posts, confirmed the mixing of sewage into drinking water lines making it unfit for drinking. Total coliform bacteria and fecal coliform, Escherichia Coli (*E.Coli*) are two types of fecal indicator bacteria. Several bacteria can be classified as coliform, and are commonly found in soil, on the surface of leaves, in decaying matter, and can grow in water distribution mains [22]. WHO [22] standards require zero Coliform to be fond per 100 ml of safe drinking water [38]. Tahir *et al.*, [39] analyzed the drinking water quality in the rural areas of Rawalpindi. Most of the water samples were found unfit for drinking purpose due to the presence of Coliform and E.coli.

CONCLUSION:

Glaciers are the main source of drinking water in all areas of Gilgit-Baltistan. The glacier water is safe for drinking purpose if turbidity is permissible. Human and other animals are the major cause of interference and water pollution. The fecal coliform quantity indicates that the water especially open channel water is unsafe for drinking purpose and it may cause water born diseases. Many physic-chemical and bacteriological parameters in the study area do not agree with the WHO standatds for drinking water especially open channel water is polluted by anthropogenic activities. Water born diseases are common in the area and becoming risk for human health if proper management is not taken under consideration for future water supply.

RECOMMENDATIONS:

As most of the diseases in the area are due to consumption of unhygienic and untreated water in Gilgit-Baltistan. Bases on the results of this study and many earlier studies, it is recommended that awareness among the people about water quality and treatments should be initiated on priority basis. Water treatment plants should be installed in each town and village and intensive research on water quality and born diseases is recommended.

REFERENCES

1. GWP. The frame work for action for achieving the Pakistan water vision 2025. *Global Water partnership and Pakistan water partnership*.75 p. 2000.
2. Ahmed,S., M. Faiz., and Joyia. Northern Area Strategy for Sustainable Development. Water for People – *Health and Security.* 18p. 2003.
3. Alykov, N.M.,. Determination of Toxic Elements in Mineral Water. All-Russian Conference: *Chemical Analysis of Substances and Materials. Moscow*: 1987-2000
4. Soylak, M., U.Divrikli., S.Saracoglu., L.Elci. Monitoring trace metal levels in Yozgat-Turkey: Copper, iron, nickel, cobalt, lead, cadmium, manganese and chromium levels in stream sediments, *Polish J. Environ. Stud.*, **11,** 47, 2002 .
5. Tahir, M.A. Pollution Problems in the Water Supply Systems of Islamabad and Rawalpindi. *Pakistan Council of Research in Water Resources, Islamabad*,1989.
6. Xijing.Y., Z. Hong and Z. Xingyou. The water quality problems of drinking water utilization in the arid regions of Northwest China. *7th International RWCS, Conference, June 21-25, , Beijing, China*, ppp 1-14,1995
7. Din, M., F.H. Hussain., A. Naila., H.Shabbir. N.N. Rana., K.Anwar. D.Saeed, and S. Zumra. The Quality Assessment of Drinking Water Supplied to Islamabad, *Environmental Pollution, and Proceedings of Third National Symposium on Modern Trends in Contemporary Chemistry,* P-75, 1996.
8. Malik, F.K., W. Akhtar., and J. Seema. Drinking Water Quality in the City of Karachi. *24th WEDC Conference, Sanitation and Water for All. Islamabad, Pakistan,* 1998.
9. Ahmed, K. and W. Ali.. Evaluation of Ravi River Water Quality. *Journal of Drainage and Water Management*. **Vol. 4**, Nos. 1&2, Jan-Dec. Drainage Research Centre (PCRWR). Tandojam, Pakistan. 2000.
10. Nasir J.A., and Noor-Us-Saba. Drinking Water Quality Monitoring in Islamabad, *National Institute of Health & Korea International Cooperation Agency, Islamabad*, 2001.
11. Jahangir, M..Bacteriological Contamination and Upward Trend in Nitrate Contents, observed in Drinking Water of Rawalpindi and Islamabad. *The Network Consumer Protection in Pakistan.* 2001.
12. Nalon, K. M., C. Frey., and J. Jacobson. Surface water field technique. *Water source*
13. Environment Agency.The microbiology of drinking water.part-7. *Methods for the Examination of water and Associated Materials.* 2007.
14. Anonymous., *Report on UN Conf. on Environ. & Development*,. A/CONF. 151/**26**., 1, 277.1992.
15. WSHHSP. Special investigation of drinking water quality in northern Pakistan. Issue paper 10.*Water Sanitation, Hygiene and Health Studies Project, Aga Khan Health Services, Gilgit-Baltistan and Chitral.* 17 p. 1996.
16. Anawara, H.M., J.Akaib., K.M.G Mostofac., S.Safiullahd., S.M Tareq., Arsenic poisoning in groundwater health risk and geochemical sources in Bangladesh. *Environ. Int.*, **27,** 597-604. 2002.
17. PCRWR. Pollution Problems in the Water Supply System of Islamabad under Short Term Research Studies Program (STRESS). *Report of Pakistan Council of Research in Water Resources, Ministry of Science & Technology Islamabad, Pakista*n, Issue.8.p.3, 2002-2003.
18. WHO. Guidelines for Drinking Water Quality, *Health Criteria and Other Supporting Informations,* **Vol.2.**pp.206-253. 1984.
19. Water Clinic. Turbidity, Color, Odor and Taste. http://www.thewaterclinic. com/turbidity,color,odor,taste.html, 2003.
20. Danamark, Taste, Odor and Color in Drinking Water. *Danamark Water Treatment Products.* http://www.danamark.com/taste_Odorand_Color.htm. 2003.
21. Ronald, E.H. *Clean Water for Washington Cooperative Extension EPO994.* http://cru.cahe.wsu.edu/cepublications/eb0994/eb0994.html. 2003.
22. WHO. Guidelines for Drinking-Water Quality, Recommendation, **Vol. 1,** pp. 16-17. 1996.
23. National Academy of Sciences. *Water Quality Criteria*, 1972 (EPA-R-73-033) US Government Printing Office, Washington, DC. , 1973.
24. Jayaraman, P. R., T.Ganga Devi., and T.V. Nayar. Water quality studies on Karamana River, Thiruvananthapuram District South Kerela, India. *Pollution Research*, **22**(I), 89–100. 2003.
25. Parashar,C ., N. Verma ., S. Dixit and R. Shrivastava. Multivariate analysis of drinking water quality parameters in Bhopal, India. *Environ Monit Assess* **140:**119–122, 2008. DOI 10.1007/s10661-007-9853-5
26. Jabeen, F. and A.A. Shedayi. Physico-Chemical and Bacteriological Drinking Water Quality Analysis of Sultanabad, Gilgit, Pakistan. *Natural Resources Management: Reviews and Research in the Himalayan Watersheds II (Special Publication of NUFU HIMUNET Project,* **Vol.II):** 55-60, 2011.
27. Akoto O. and Adiyiah J. 2007. Chemical analysis of drinking water from some communities in the Brong Ahafo region. *International Journal of Environmental Sciences and Technology,* **4** (2): 211-214, 2007.
28. Environmental Protection Agency (USEPA), Chemical contaminants in drinking water. Technical fast sheet on microbes. *EPA* 816-03-016, 2003.

29. Sharma, M.R. Assessment of ground water quality of Hamirpur area in Himachal Pradesh. *Poll. Res.*, **23**(1), 131-134, 2004.
30. Gauss J.D, Woods P.E., Winner R.W., Skillings J.H.. Acute toxicity of copper to three life stages of *Chironomus tentans* as affected by water hardness-alkalinity. Environmental Pollution Series A, Ecological and Biological, **Volume 37,** Issue 2, Pages 149–157, 1985.
31. Hussain,R. and A. Mateen., Analysis of Potable Water in Dera Ghazi Khan, National Workshop on Quality of Drinking Water. *Pakistan Council of Research in Water Resources. Islamabad, Pakistan.* 1998.
32. Bokina A.I. Hygienic Assessment of Drinking Water Hardness as a Factor Favouring the Development of Urolithiasis, *Gigiena-I-Sanifarija* **30**(6):3. 1965.
33. Jaster. E.H., J.D. Schuh and T.N. Wegner. Physiological Effects of Saline Drinking Water on High Producing Dairy Cows, *Journal of dairy sciences* **Vol 61.** 66-71pp. 1987.
34. Hammer,M.j. *Water and Wastewater Technology,* 2nd Ed.Jhon Willey Inc.,New York,USA. 1986.
35. Ilyas.A and T. Sarwar. Aseesment of Physico-Chemical and Biological quality of Drinking Water in the Vicinity of Palosi Drain Peshawar". Department of water management NWFP Agriculture University Peshawar, Pakistan. 2003
36. Flock, M., S.M. Deitche., K. H. Levy, and C. A. Meyer. *Ambient monitoring program annual report.* 2003-2004.
37. Bruvold, W.H, 1965. Consumer attitudes towards mineral taste in domestic water. *Journal of The Amer. Water Works Ass*., Vol. **59**. 1965.
38. USDI., Water treatment Primer for Communities in need – Advanced water treatment research programme. United States Department of the Interior. Report No.68. *National Tech. Inf. Centre, Springfield, Virginia 2216. USA*. 160 pp. 2001.
39. Tahir, M.A., B.A .Chandio., M. Abdullah and A. Rashid. Drinking Water Quality Monitoring in the Rural Areas of Rawalpindi. National Workshop on Quality of Drinking Water. *Pakistan Council of Research in Water Resources. Islamabad, Pakistan,*1998.
40. Ahmed, K. and S. Shah. Physical and microbiological assessment of drinking water of Nomal Valley, Northern Areas, Pakistan. *Pakistan Journal Of Zoology*, ***39***(6), 367. 2007.
41. Ali, S., S. A. Hussain, S. Ali, Q. Abbas, , M. Hussain, W. Ali, ... and J. Hussain. Water quality assessment of Gilgit river, using fecal and total coliform as indicators. J. Bio. & Env. Sci. **Vol. 5,** No. 4, p. 343-347, 2014
42. 4, p. 343-347, 2014