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Assessment of Water Quality Status in Gilgit-Baltistan

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Pakistan Council of Research in Water Resources (PCRWR)
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Summary

Gilgit-Baltistan (GB) is house of world's second highest mountain peak surrounded with more than 7000 glaciers. The snow and glacial resources of the Himalayan region are a major source of fresh water for the Indus basin irrigation system. The sustenance of millions of people depends on this system.

Considering the reported prevalence of water borne diseases as well as SDG 6.1 reporting requirements, a water quality assessment of GB region was undertaken by PCRWR in collaboration with The Asia Foundation (TAF). In this context, 94 samples were collected from source and point of use (PoU) including snowmelt runoff, springs, groundwater and rivers. These samples were collected from 94 villages in six districts (Gilgit, Skardu, Astore, Hunza, Ghizar and Diamer). All the collected samples were tested for microbiological contamination in the PCRWR Laboratory at Gilgit. The samples for chemical testing were transported to the ISO-17025 accredited National Water Quality Laboratory, PCRWR, Islamabad.

The physico-chemical, heavy metals and microbial parameters were compared with the permissible limits of National Standards for Drinking Water Quality (NSDWQ-2010). Overall, 22% sources were found supplying safe water and remaining 78% were unsafe mainly due to the prevalence of microbial contamination (68%), turbidity (19%), iron (24%), fluoride (2%) and aluminium (7%). The highest unsafe water sources due to microbiological and/or chemical contamination were found in the district Astore (100%) followed by Skardu (80%), Hunza (80%), Ghizar (74%), Gilgit (70%) and district Diamer (67%). The source wise comparison shows that rivers are highly contaminated (100%) followed by snowmelt runoff in surface water channels (82%), fresh spring water (80%), and ground water (29%).

The residents in the villages of GB are either living near springs, lakes and rivers or they are fetching water from some nearby storage tanks. These sources are either community developed or developed by local NGOs and need the facility of basic water treatment such as filtration and disinfection to reduce the risk of waterborne diseases. The mineral mining of mafic, igneous minerals and gemstone deposits may also be adding chemical contaminants such as iron, aluminium etc. Moreover, the activities under CPEC programme, disposal of untreated wastewater and agricultural practices may also add to these potential contaminants in surface water bodies.

The water quality improvement requires arrangements for water filtration, disinfection, wastewater disposal and recycling, capacity building of local agencies for water quality monitoring, awareness raising of villagers towards safe storage practices and environmental protection. The study findings also suggest a well-designed investigation for impacts of mining on water resources, to rule out the heavy metals contamination and to develop mitigation strategies.

Introduction

Water is essential not only for human health but also for poverty reduction, food security, peace and human rights, ecosystem and environmental sustainability. Nonetheless, countries are facing growing challenges linked to water scarcity, water pollution, degradation in water-related ecosystems and international cooperation over trans-boundary water basins. Pakistan is among 37 countries of the world with extremely high levels of water stress, a condition when water demand exceeds the water availability or when poor quality restricts its use.

The World Resources Institute has placed Pakistan in extremely high water stress category by 2040 (Reig *et al.,* 2013). If this situation prevails as such and no actions are taken to improve availability of water and effective water conservation strategies. Similarly, Pakistan Council of Research in Water Resources (PCRWR) reported that if this situation continues i.e. population keeps on increasing and water resources remains constant, Pakistan will be touching the absolute water scarcity line (500 m^3/person/day) by 2025 (Qureshi and Ashraf, 2019).

The level of access to safe drinking water varies from region to region in Pakistan. The Economic Survey of Pakistan, 2019-2020 indicated that supply of drinkable Water and Sanitation Services (WSS) requires special attention as presently a large number of households do not have access to enough potable or freshwater.

Though Pakistan has made some improvements in access to safe water over the years (15% safe in 2001 to 38% in 2021, as reported by PCRWR), (Rasheed *et al.,* 2020), country is still one of the top 10 countries with the lowest access to clean water (World Asia, 2018). Disposal and mixing of untreated wastewater in surface and groundwater as well as insufficient wastewater recycling has further exacerbated the health and environmental risks linked with unsafe water.

Gilgit-Baltistan is the house of world's second highest mountain peak and more than 7000 glaciers. Therefore, it is considered as Pakistan's largest source of fresh water for the Indus basin irrigation system (Ayub *et al.,* 2020). Many lakes and rivers originate from these freshwater glaciers and largest of them is the Indus river which feeds the irrigation system of Pakistan and therefore, glacial reserves of GB are considered to be water towers of Pakistan (Bakht, 2000; Malkani, 2020; Ashraf and Bhatti, 2019).

The communities in Gilgit-Baltistan get water directly from glacial melt running down in the valley streams. Disposal of untreated sewage, mining effluents in the upper Indus catchments, use of pesticides in agricultural fields and other anthropogenic activities have altered the physical, chemical, and biological condition of surface water resources. (Abbas *et al.,* 2015) Consequently, due to the presence of pathogenic organisms in drinking water (as reported by a local respondent), water borne diseases like diarrhoea, cholera, typhoid and hepatitis are common. Encroachment in the areas around the streams, cutting of forest for wood and agricultural land has affected the entire ecosystem.

Moreover, large-scale development work on energy, transportation, infrastructure, and industry under China-Pakistan Economic Corridor (CPEC) framework is being carried out in the upper Indus basin. These may have major impacts on quality of water resources around the country specifically in region of Gilgit-Baltistan. Therefore, it was required to assess the quality of water bodies used for drinking purpose across GB and to recommend further strategies to sustainably manage these vital resources. Pakistan Council of Research in Water Resources (PCRWR) in collaboration with The Asia Foundation has investigated the water quality at source and at point of use (PoU) as well as associated health impacts in six districts.

Study Area

Gilgit-Baltistan also known as northern areas of Pakistan is located at 35.8026° N, 74.9832° E. Geographically, it spreads over an area of 72,971 sq. km. Afghanistan is at its north, in north east it borders with China and in south east there is Kashmir (Wolf, 2017). Gilgit-Baltistan became a single administrative unit in 1970, under the name Northern Areas and while on 29th August 2009, GB Self Governance Order 2009 was passed by Pakistan cabinet granting self-rule to the people of the northern areas (re-named as Gilgit-Baltistan) through an elected legislative assembly (CSCC, 2018). The population of GB is estimated to be between 1.5 to 2 million (Hussain *et al.,* 2018). It is administratively divided into three divisions; Gilgit (districts Gilgit, Ghizar, Hunza and Nagar), Baltistan (districts Skardu, Ghanche, Shigar and Kharmang) and Diamer (districts Diamer and Astore) as shown in Figure 1.

Topographically, the area consists of snow-covered mountains, glaciers and highlands. Springs, waterfalls, lakes and rivers flow out of these snow-covered mountains. The region is dominated by Karakoram and Himalaya mountain ranges. The "Hindu Kush" range lies to the west. Along other high mountain peaks like Nanga Parbat, it is house of the world's 2nd highest peak K2 and queen of hills the Nanga Parbat. The world's longest glaciers outside the Polar Regions are in Gilgit-Baltistan such as Biafo, Baltoro, Batura, Saltoro, Rimo, Terung, Hispar, Chogo Lungma and Panmah Kurakaram range. During winters, there is heavy snow fall on the top of these mountains while in summer by melting of snow and glaciers water flows down the hills in the form of streams and some water penetrate and form springs in valley (Ahmed *et al.,* 2012).

Climate is greatly influenced by the orography of this region which create rain shadows in most places, whereas relatively high precipitation falls in Astore district. During summers areas like Gilgit and Chilas are hot and sunny during day time but cold at night. Astore, Shigar, Hunza, and Nagar valleys however, have mild temperatures during summers.

Gilgit-Baltistan do not receive much of the rains during monsoon as mountain ranges of Karakoram and Hindukush create a barrier between the monsoon dominated lands of South Asia to their south and the vast deserts of Central Asia to their north. Atmospheric temperature reaches to maximum in July and August with an average of 20-25 ºC across valleys and minimum temperature in January with an average of 0 to -10 ºC.

Gilgit-Baltistan (GB) is also rich in minerals and other natural resources. Gemstones, marbles and many other economic minerals are significant for commercial industry. Gemstones of GB especially from Hunza and Skardu regions are famous worldwide. Therefore, mining is a huge industry in GB region where gem exploration utilizes water and produce wastewater which is ultimately disposed off into the nearby water channels and streams.

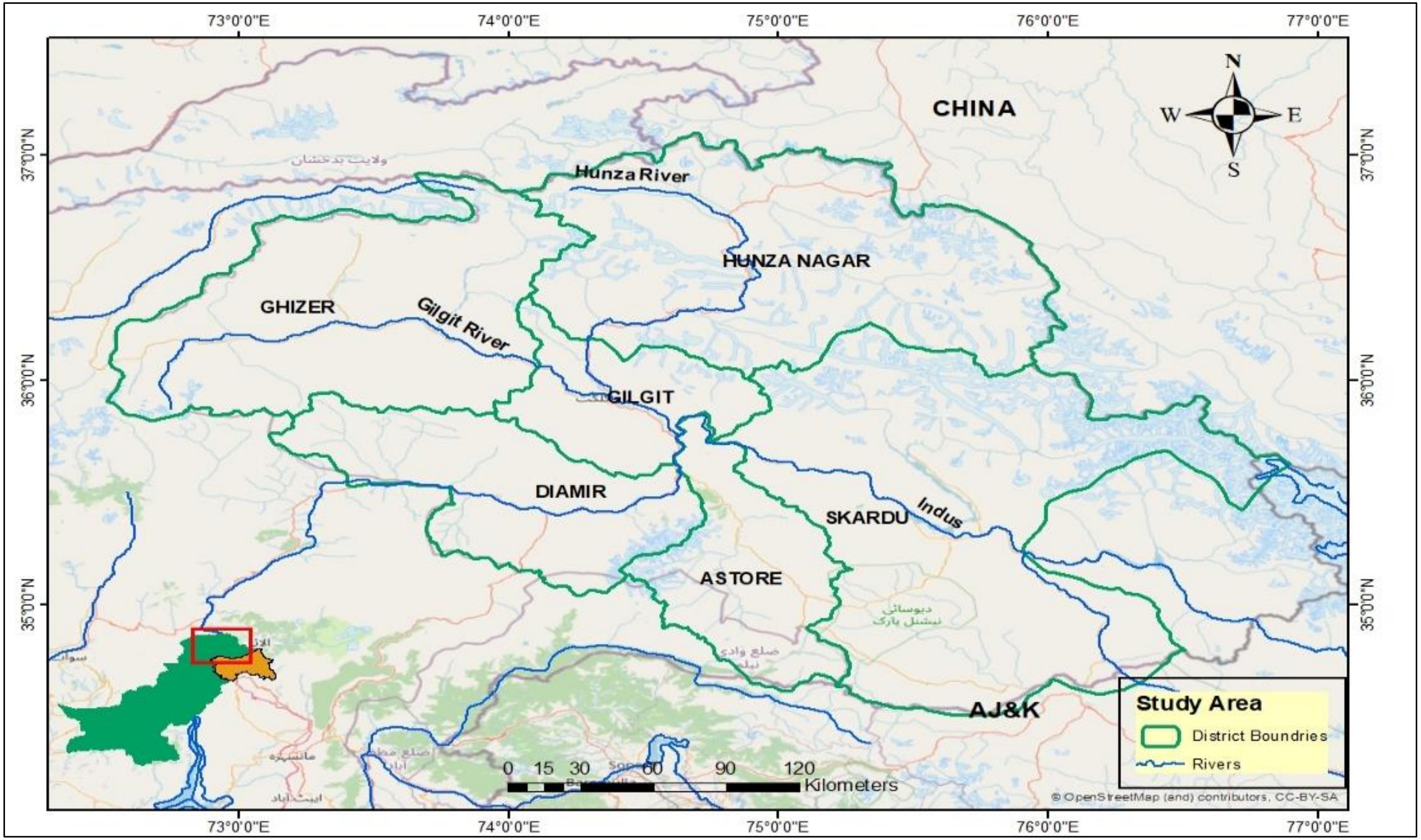

Figure 1: Map of Gilgit-Baltistan

Water Resources of Gilgit-Baltistan

The Indus basin is the largest irrigation system of the world. It is mainly fed by the Indus, the most important river in Pakistan, originating from the Tibetan plateau. It flows northwest through Ladakh district and GB just in south of the Karakoram Range then it passes through deep valleys near the Nanga Parbat. Due to freezing temperatures, flow of river decreases greatly in winters while increases in summer. The drainage basin is mainly fed by the Indus, Shyok, Nubra, Hushe, Shigar, Hunza, Shimshal, Chuparsan, Yasin, Ishkomen and Astore rivers apart from some glacial streams. There are several glacial and snow lakes in the GB mainly in district Ghizar and at Deosai high altitude plains shown as in Figure 2. (Nancy Cook and David Butz, 2013)

Figure 2: Rivers in Gilgit-Baltistan

Domestic Water Supply System of Gilgit-Baltistan

Principal source of domestic and household water in the GB is glacial and snowmelt runoff in the form of streams, rivers, lakes and springs. Supply of fresh and flowing water is abundant during summer especially from April to August and then gradually decreases from September to November. Lateron there is snowfall during December to February which results in the shortage of drinking water in the rural areas. Villages at higher altitude use snowmelt, if no other water source is available. Snowmelt water is usually turbid, whereas spring water is clear and warm in winters and cold in summers therefore, spring water is preferred by inhabitants to be used for drinking either as piped or un-piped water (Figure 3).

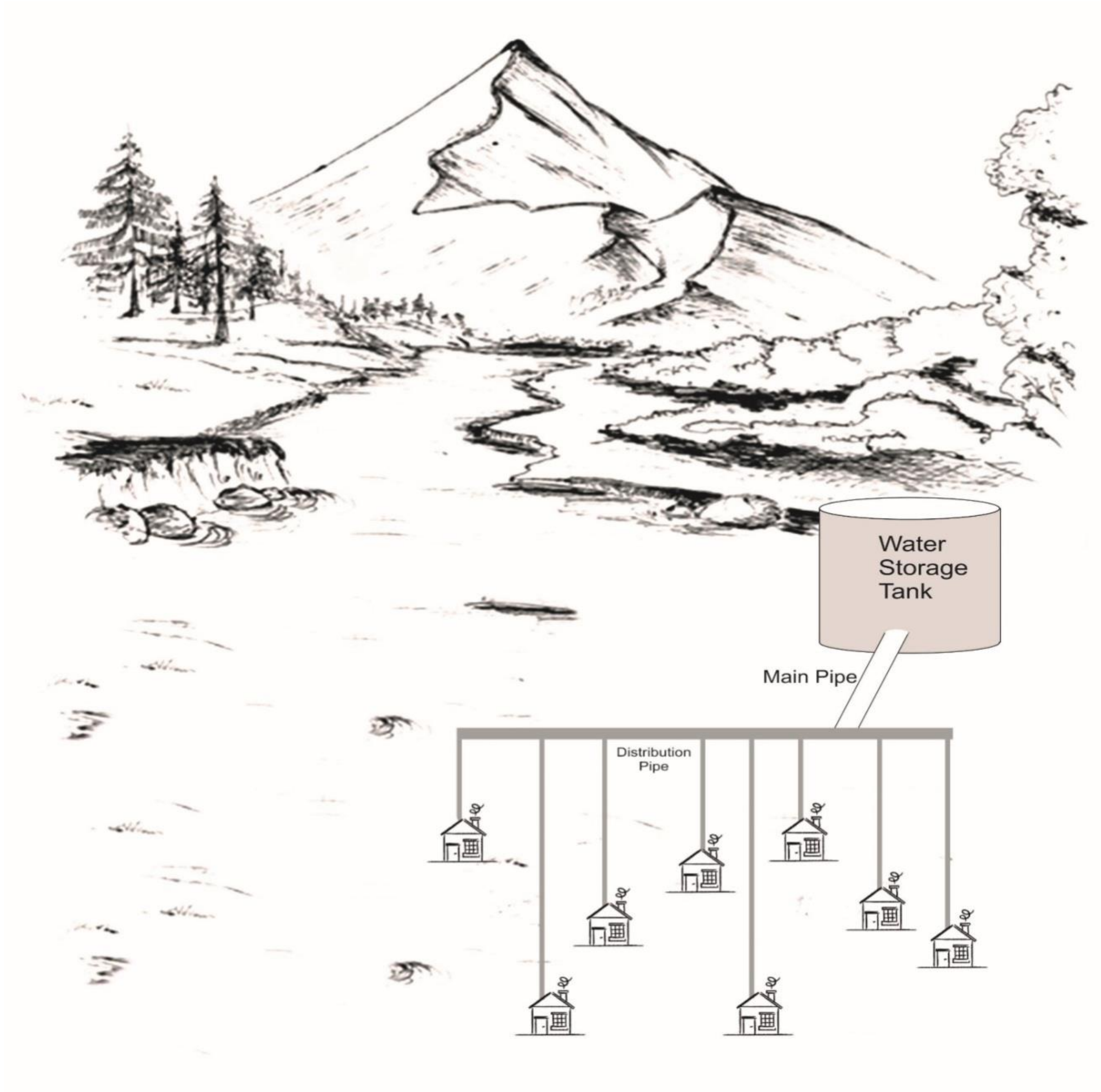

Figure 3:Schematic diagram of Gilgit-Baltistan water supply system

The Multiple Indicator Cluster Surveys revealed that 79% of the population of GB used an improved source of drinking water; 95% in urban areas, while 76% in rural areas. At division level, Gilgit division has the highest (89%), while Diamer division has the lowest percentage (47%) of improved water coverage (Planning & Development, 2017)

The common water supply system in most villages is piped water supply. Where water shortage is an issue, there is a tradition to store water in large pits during summer. Water stored in pits is used for drinking and other domestic purposes. Water pits situated near the water channels are usually covered. As natives use the same channels for drinking and washing, they fill the pits early in the morning with fresh water to avoid contamination from washing clothes, irrigation waste and other wastewater generating activities.

Figure 4: Piped water distribution in Jutal area

In Chilas most of the piped water is supplied to main yards from where local villagers can fill water. People need to walk more than 30 minutes to get drinking water from these piped facilities while in Diamer surface water is used either directly from rivers, lakes or through pipes from pond and canals (Figures 5 to 8). In villages where water is short, communities have developed indigenous systems for water distribution to overcome shortages. Communities have also developed systems to determine the quantity of water to be used by a single household.

Figure 5: Piped water supply in Chilas city

Figure 6: Water supply in Diamer

Figure 7: Young girls fetching water from broken water supply lines

Figure 8: Water supply by WSSA

Water accessibility and the quality of the available water is one of major challenges in GB. Approach to isolated and freezing glaciers in northern areas is another challenge, thus it is difficult to frequently assess quality of natural water used for drinking purpose. Therefore, only a few studies have been conducted regarding the spread of gastrointestinal diseases (Ahmed *et al.,* 2012).

Water Quality Assessment

Sampling Design

The sampling is designed keeping in view the diversity of natural waterways and its use for drinking purpose. Six districts were selected from three divisions of Gilgit i.e. Skardu, Ghizar, Gilgit, Hunza, Astore and Diamer for village wise sample collection. Depending on the size of districts, 94 samples either from piped systems or from the sources were collected in September, 2020 at the rate of 10-15 samples per district (Figure 9). Source water was different for each sampling point but PoU at most of the locations was tap water. PoU samples were preferably obtained from taps by natives for their domestic needs. The detail of the sampling locations, information of type of source and approximate number of consumers as per sampling survey is given at Annexure-I.

Sampling Methodology

All water samples were collected, transported and tested for microbial and physico-chemical analysis following the protocols of standard methods for water and wastewaters, 23rd edition (APHA,2017) (listed in Table 1). From each site four types of samples were collected. The details of collection and preservative method used for each sample are given below:

1. Type A – All sites – Pre-sterilized sampling bottles for microbiological analysis
2. Type B – All sites – 2 ml/liter nitric acid (HNO_3) as preservative for trace elements
3. Type C – All sites – 1 ml/100 ml, 1 molar boric acid as preservative for nitrate
4. Type D – All sites – No preservative for other water quality parameters.

All samples were collected in polystyrene bottles of 500 ml. Prior to sample collection, bottles were washed with distilled water and rinsed thoroughly several times with the same water which is to be collected. For microbial analysis, samples were collected in pre-sterilized bottles of 200 ml and tested in the PCRWR water quality laboratory, Gilgit. Water samples (types B, C and D) collected for chemical analysis were transported to National Water Quality Laboratory, PCRWR, Islamabad. Field observations and information regarding each sample (such as sample type, sample ID, sample code, GPS coordinates, date and time of sample collection, physical conditions like water-table depth etc.) were recorded on the sample collection proforma (Annexure-II).

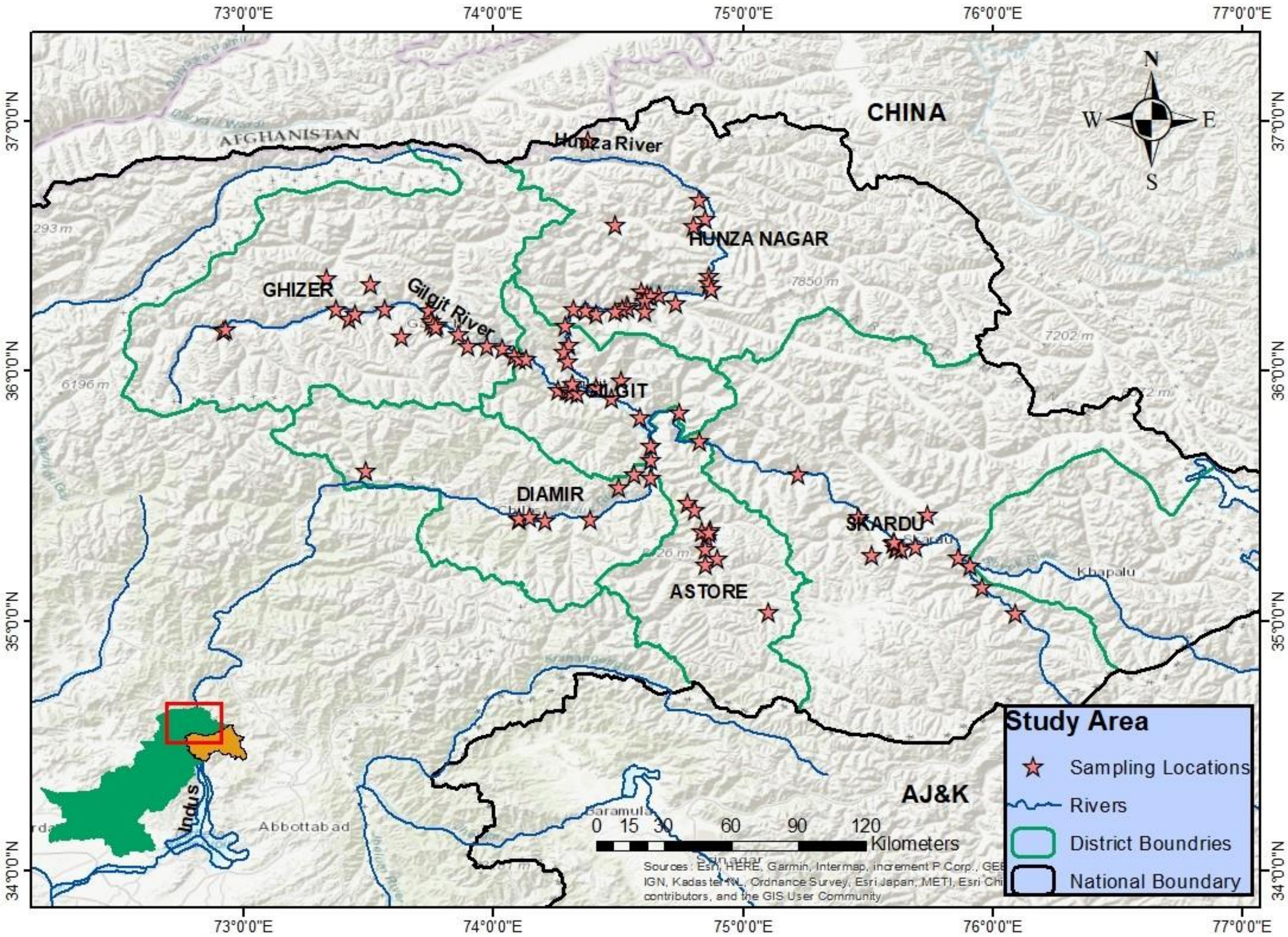

Figure 9: Sampling locations in Gilgit-Baltistan

Figure 10: Water sample collection from Diamer

Figure 11: Water sample collection from Gilgit

Figure 12: Determination of onsite DO and record keeping

Table 1: Water quality parameters and methods used for analysis

Sr.#	Parameters	Analysis Method
1	Alkalinity (mg/l as $CaCO_3$)	Standard Method No. 2320 (B)
2	Arsenic (ppb)	AAS Vario 6, Analytik Jena AG, [Standard Method No. 3111 (B)]
3	Bicarbonate (mg/l)	Standard Method No. 2320 (B)
4	Calcium (mg/l)	Ca-D, [Standard Method No. 3500 (B)]
5	Carbonate (mg/l)	Standard Method No. 2320
6	Chloride (mg/l)	Titration (Silver Nitrate), [Standard Method No. 4500 (cl-B)]
7	Conductivity (μS/cm)	E.C meter, Hach-44600-00, USA [Standard Method No. 2510(B)]
8	Hardness (mg/l)	EDTA Titration, [Standard Method No. 2340 (C)]

Sr.#	Parameters	Analysis Method
9	Magnesium (mg/l)	Standard Method No. 2340 (B)
10	Nitrate as Nitrogen (mg/l)	Cd. Reduction (Hach-8171) by Spectrophotometer [Standard Method No. 4500 (NO_3 B)]
11	pH	pH Meter, Hanna Instrument, Model 8519, Italy [Standard Method No. 45= H^+-B)]
12	Potassium (mg/l)	Flame photometer PFP7, UK [Standard Method No. 3500-K (B)]
13	Sodium (mg/l)	Flame photometer PFP7, UK [Standard Method No. 3500 Na (B)]
14	Sulfate (mg/l)	SulfaVer4 (Hach-8051) by Spectrophotometer [Standard Method No. 4500 (E)]
15	Phosphate (mg/l)	Colorimeters (HACH) [Standard Method No.8190 and 8048]
16	TDS (mg/l)	Standard Method No. 2540 (C)
17	Turbidity (NTU)	Turbidity Meter, Lamotte, Model 2008, USA [Standard Method No. 2130(B)]
18	Fluoride (mg/l)	ion-Selective Electrode [Method Standard No. 4500 (F-C)]
19	Bacteriological Contamination (presence/absence)	PCRWR Qualitative Field Testing Kit (presence/absence)
20	Heavy metals (Aluminium (Al), Cadmium (Cd), Molybdenum (Mo), Arsenic (As), Chromium (Cr), Zinc (Zn), Nickel (Ni) and Barium (Ba)	APHA 23rd edition ICP-OES

Results and Discussion

Major source of water in GB is snowmelt water. Residents of the selected villages either use this water directly from rivers, springs and streams or where it is difficult to fetch water they develop cisterns or ponds to supply water to remote areas. In total, 94 water samples were collected from different water sources including surface water channels (28), spring water (56), groundwater (7), Kharmang river, Attabad lake and Phandar river lake (3). The water quality status of GB with respect to district, parameters and monitored sources is described as below:

District Wise Water Quality Status

The results reveal highly unsafe water quality in district Astore (100%), followed by Skardu (80%), Hunza (80%), Ghizar (74%), Gilgit (70%) and district Diamer (67%) as shown in Table 2 and Figure 13.

Table 2: District wise water quality status of Gilgit-Baltistan

Sr #	District	Total	Samples within permissible limits		Samples exceeding permissible limits		Major Issues
			No.	%	No.	%	
1.	Astore	11	0	0	11	100	Turbidity (9%), Iron (55%) and Microbial contamination (82%)
2.	Hunza	20	4	20	16	80	Turbidity (30%), Iron (20%), and Microbial contamination (70%)
3.	Ghizar	19	5	26	14	74	Turbidity (11%) and Microbial contamination (68%)
4.	Diamer	9	3	33	6	67	Turbidity (22%), Fluoride (11%) and Microbial contamination (67%)
5.	Gilgit	20	6	30	14	70	Turbidity (25%), Iron (20%) and Microbial contamination (60%)
6.	Skardu	15	3	20	12	80	Turbidity (13%), Iron (60%), Fluoride (7%) and Microbial contamination (67%)
	Overall	**94**	**21**	**22**	**73**	**78**	Microbial contamination (68%), Turbidity (19%), Iron (24%), Fluoride (2%) and Aluminium (7%)

Almost in all districts the major contaminant was of microbiological i.e. 82% of samples from district Astore were unsafe for human consumption due to microbial contamination. Similarly, Skardu (60%), Hunza (70%), Diamer (67%), Ghizar (68%) and Gilgit (67%) had the problem of microbiological contamination.

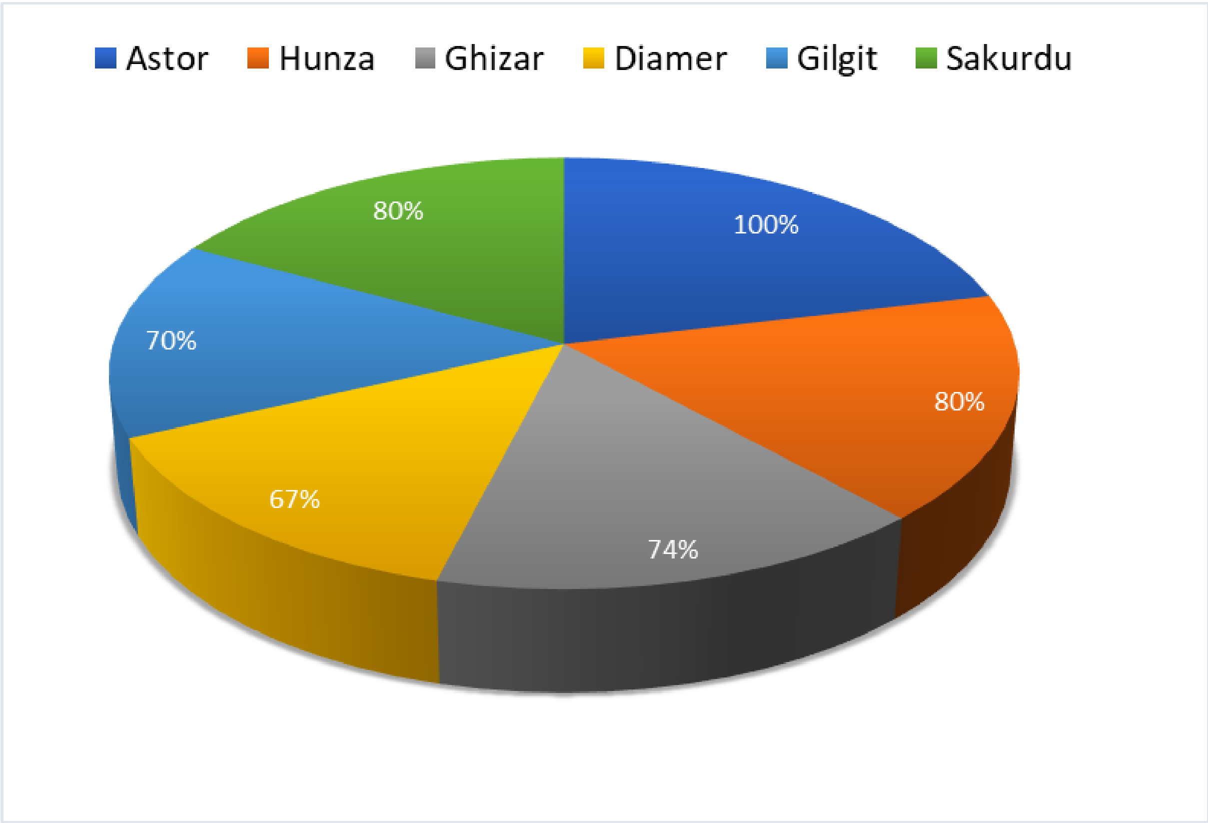

Figure 13: District wise unsafe samples

Parameters Wise Water Quality Profile

The descriptive statistics of monitored water quality parameters are given in Table 3. It shows that quality of water from different sources was safe with respect to hardness, pH and TDS. However, turbidity, fluoride, iron and microbial contaminations were of main concern (Figure 14).

Table 3: Descriptive statistics of major water quality parameters in six districts of Gilgit-Baltistan

Test Parameter	Unit	Min.	Max.	Mean	Samples exceeding the permissible limits	
					No.	%
EC	µS/cm	44.00	1093.00	255.89	-	-
pH	-	6.50	8.85	7.60	1	1
Turbidity	NTU	0.04	270.00	7.57	18	19
Hardness	mg/L	10.00	470.00	116.44	-	-
TDS	mg/L	24.00	601.00	140.67	-	-
Chloride	mg/L	4.00	28.00	3.85	-	-
Nitrate	mg/L	0.03	8.00	0.81	-	-
Fluoride	mg/L	0.03	2.80	0.30	2	2
Iron	mg/L	0.00	1.49	0.15	23	24
Total Coliforms (Microbial contamination)	*CFU/ 100 ml	2	49	7.8	64	68

*CFU: Colony forming unit

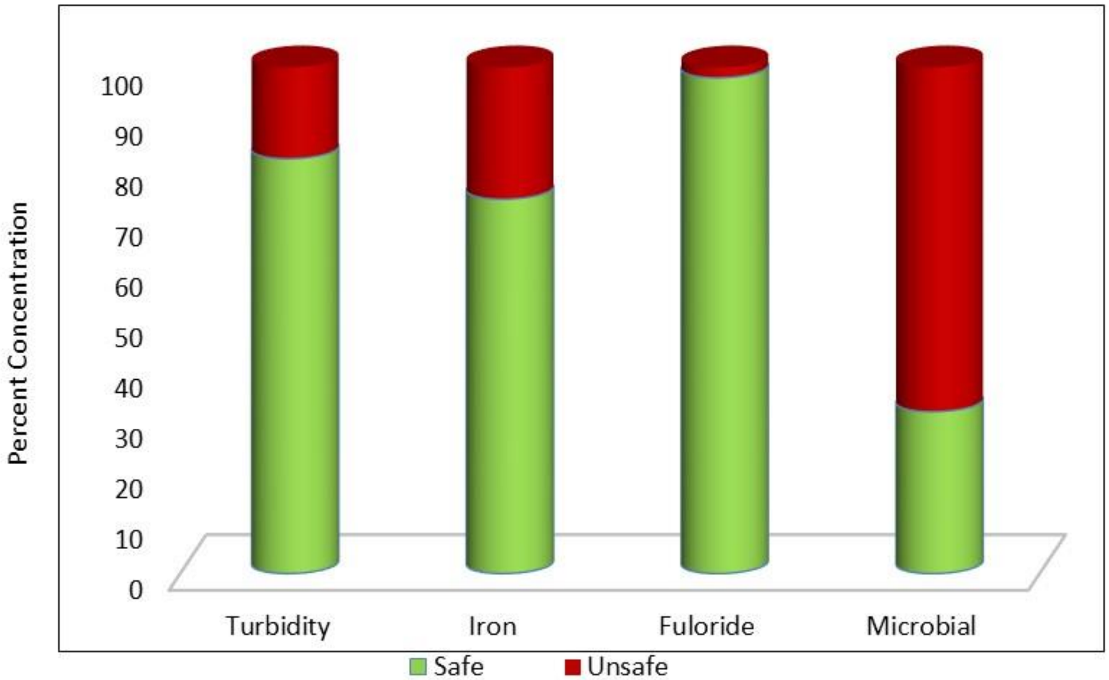

Figure 14: Potential problem parameters in water sources of Gilgit-Baltistan

Parameter wise details summary of results is discussed as below.

Microbial Contamination

Microbial pollution in aquatic environments is one of the critical issues with regard to the sanitary state of water bodies used for drinking water supply due to a potential contamination by pathogenic bacteria, protozoa or viruses. District wise comparison of microbial contamination (Figure 15 & 16) showed that water sources PoU in all districts were found contaminated with total coliforms i.e. Diamer (67%), Astore (82%), Gilgit (60%), Ghizar (68%), Hunza (70%) and Skardu (67%).

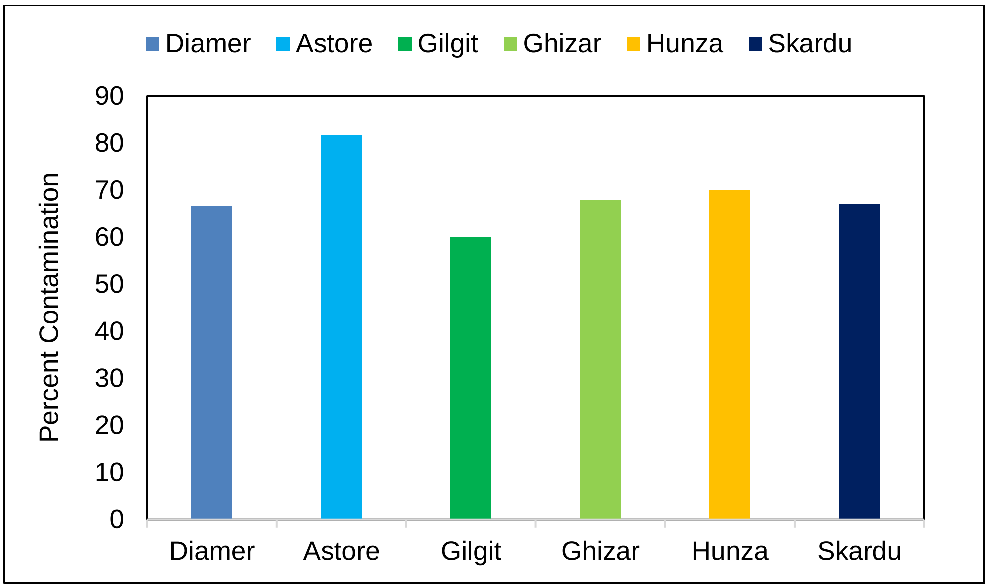

Figure 15: District wise microbial contamination (%)

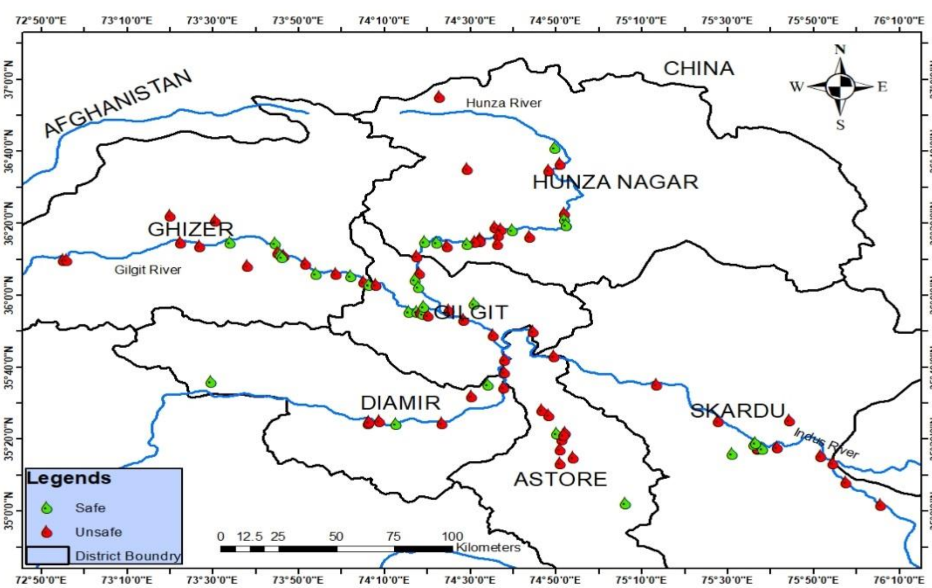

Figure 16: Spatial variation of microbial contamination

The most prevalent microbial contamination reveals the probability of mixing of sewage in drinking water supply pipelines. Very short distance between drinking water supply lines and sewage pipes is evident from Figure 17. The microbial contamination may result in frequent outbreaks of water related diseases like cholera, diarrhoea, typhoid, hepatitis A & E. Some such outbreaks have also been reported that affected many people in the GB.

Figure 17: Drinking water contamination with wastewater channel

Figure 18: Water tap installed on the corner of water drainage line

Total Dissolved Solids (TDS)

Total dissolved solids (TDS) are an overall estimation of the inorganic salts and small amounts of organic matter present in water and reflect an overall measurement of basic chemical water quality. The major constituents are usually calcium, magnesium, sodium, and potassium cations and carbonate, hydrogencarbonate, chloride, sulfate, and nitrate anions. TDS of GB samples are within acceptable range of National Standards for Drinking Water Quality (MOE, 2010) and WHO drinking water guidelines i.e. 1000 mg/L. As shown in Figure 19, TDS of most of the water sources was found comparable between districts except for few Skardu, Gilgit and Hunza. These districts are more populated and natural waters are more affected by anthropogenic activity.

Turbidity Contamination

Turbidity is caused by particles suspended or dissolved in water that scatter light making the water appear cloudy. Particulate matter may include sediment - especially clay and silt, fine organic and inorganic matter, soluble colored organic compounds, algae, and other microscopic organisms. Springs and streams originate from glacier melting and snow melt runoff in GB. Therefore, erosion results in increased turbidity in openly flowing water. During erosion, rock flour and other small soil particles mix with water while flowing down the mountains and turbidity level in water rises specifically in late spring season and during summers. Spring water is mostly preferred for drinking purposes, as it is thought to be clean and clear, relatively warm in winters and cold in the summers. As shown in Figure 20, most of the turbid water was present in Gilgit, Hunza and Skardu. These regions are more populous and agro-industrial activities are also common in these districts.

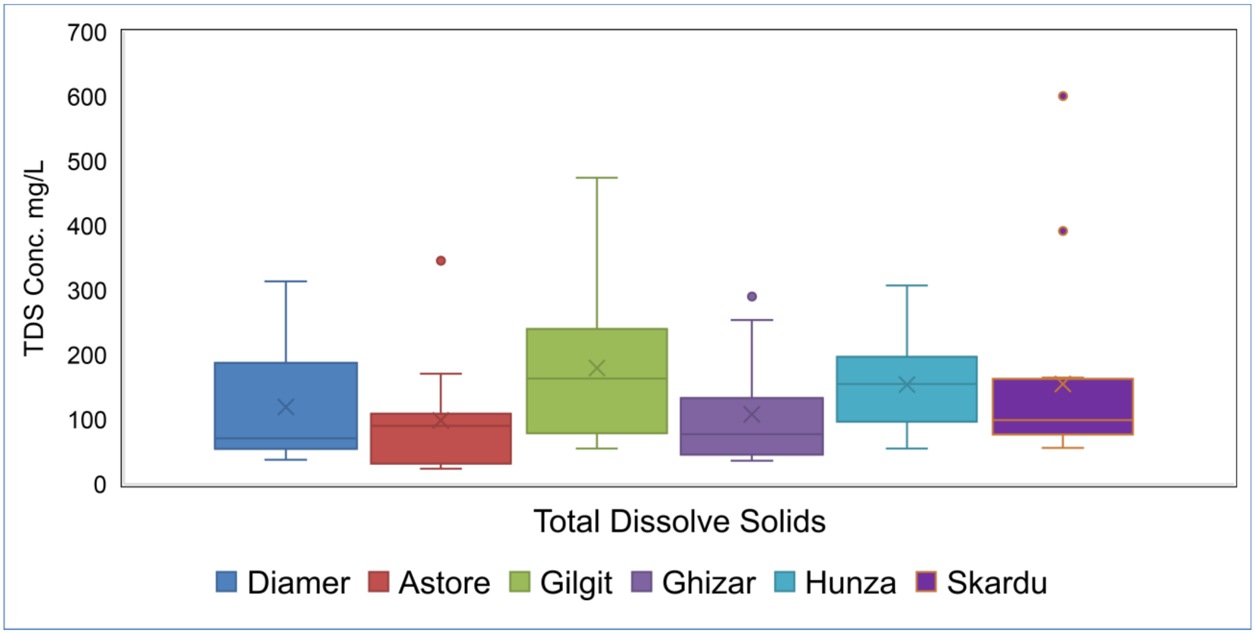

Figure 19 : Level of total dissolved solids in water sources of Gilgit-Baltistan

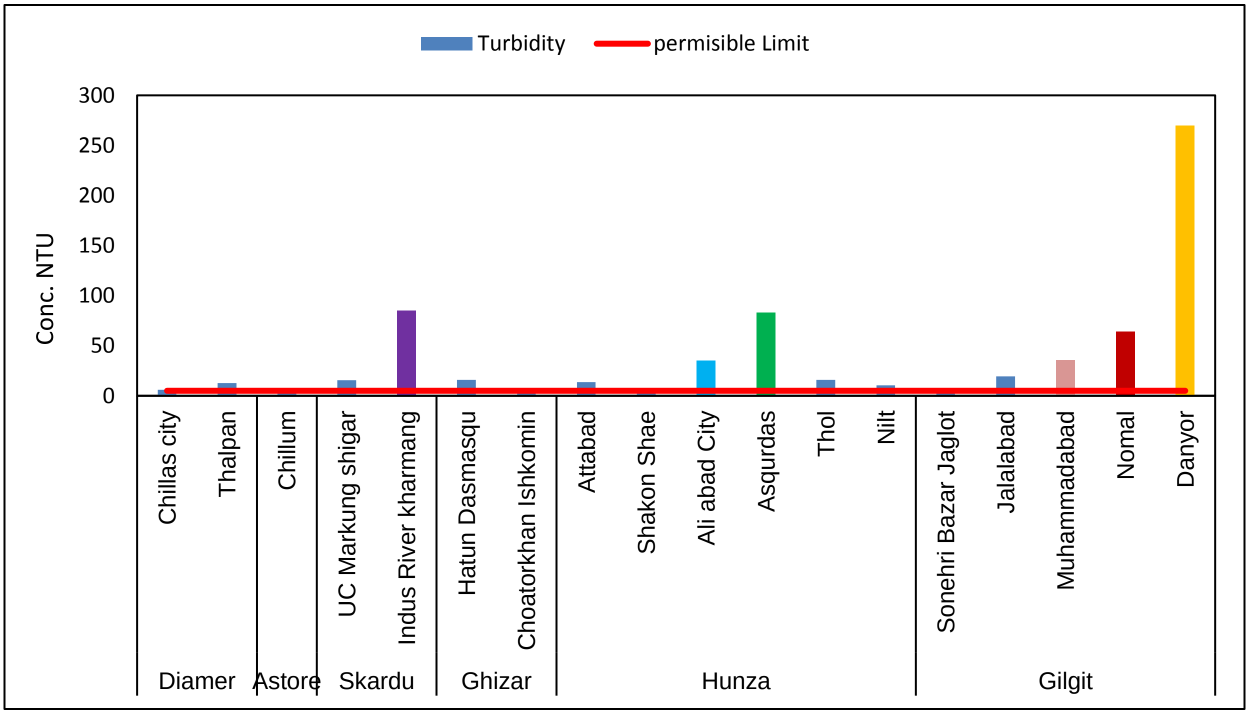

Figure 20: Locations with unsafe turbidity in Gilgit-Baltistan

Fluoride Contamination

Naturally occurring fluorides in groundwater are a result of the dissolution of fluoride-containing rock minerals by water. Anthropogenic sources of Fluoride contamination phosphate fertilizers or sewage sludge, or from pesticides. Excessive fluoride level is another geological problem and consumption of such type of contaminated water may result in dental fluorosis, skeletal and crippling fluorosis. Excessive fluoride levels were found in 2% of the monitored water sources in GB (Table 3).

Iron Contamination

Following microbial contamination, the second most prevalent contaminant across the GB was iron. Mining of iron rich compounds such as pyrite, chalchopyrite, assenopyrite and gemstones like jade as well as rubies along with other minerals and rusted water pipes can be the probable reason for iron contamination. In-depth contaminant source tracking of the region is required to track mineral deposits and disposal requirements for mining waste. Though iron is one of important nutrient essential for human health, yet its higher concentration may cause iron toxicity if consumed for long periods.

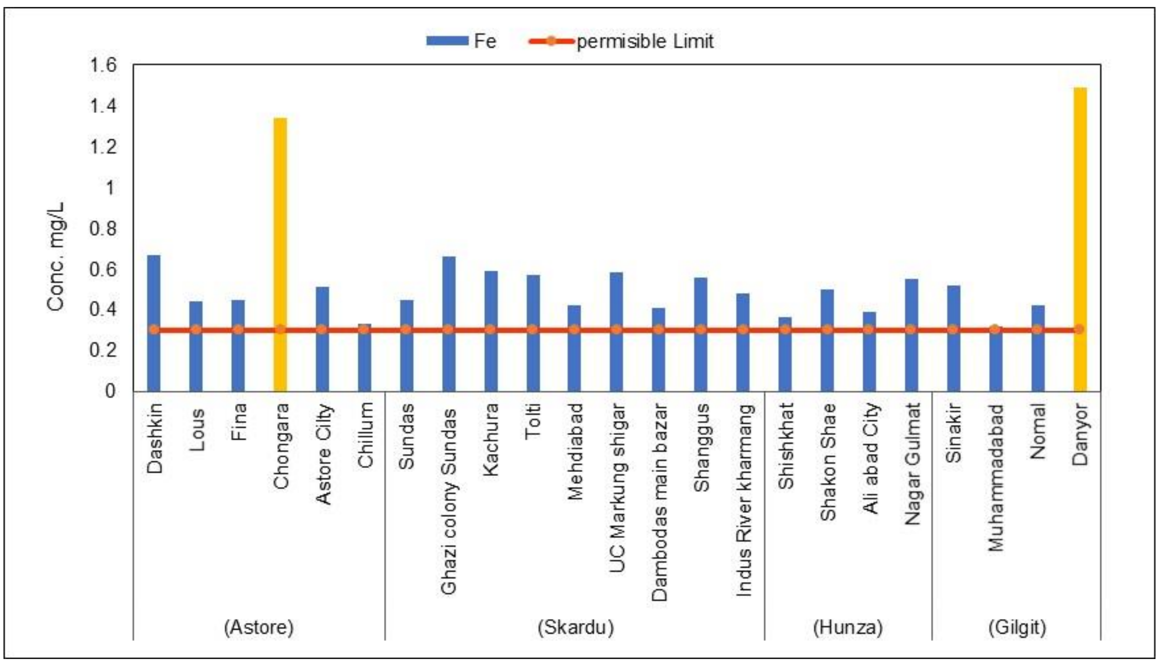

Figure 21: Locations with unsafe Iron in Gilgit-Baltistan

Trace Metals Contamination

Heavy metals are geologically occurring elements having an atomic weight and density five times greater than that of water. Heavy metals are usually present in trace amounts in natural waters but many of them are toxic for human and aquatic life even at very low concentrations. Trace Metals investigated in this study include (aluminium (Al), arsenic (As), cadmium (Cd), chromium (Cr), cobalt (Co), lead (Pb), mercury (Hg), nickel (Ni), selenium (Se), and zinc (Zn)). Increasing quantity of heavy metals in the natural resources specifically water and food is an area of great concern. Test results of heavy metals reveals that arsenic (As), lead (Pb), cadmium (Cd), nickel (Ni), mercury (Hg), chromium (Cr), cobalt (Co), zinc (Zn), and selenium (Se) were found within the permissible limits of National Standards for Drinking Water Quality (MOE, 2010). However, aluminium (Al) was found in excess at six locations of districts Gilgit and Hunza with levels higher than 200 µg/l (Figure 22). Since minerals mining is common in GB, the possible contamination source can be gemstone exploitation like quartz in Gilgit and Skardu; red ruby and spinel (compound of magnesium aluminate) in Hunza (Malkani, 2020).

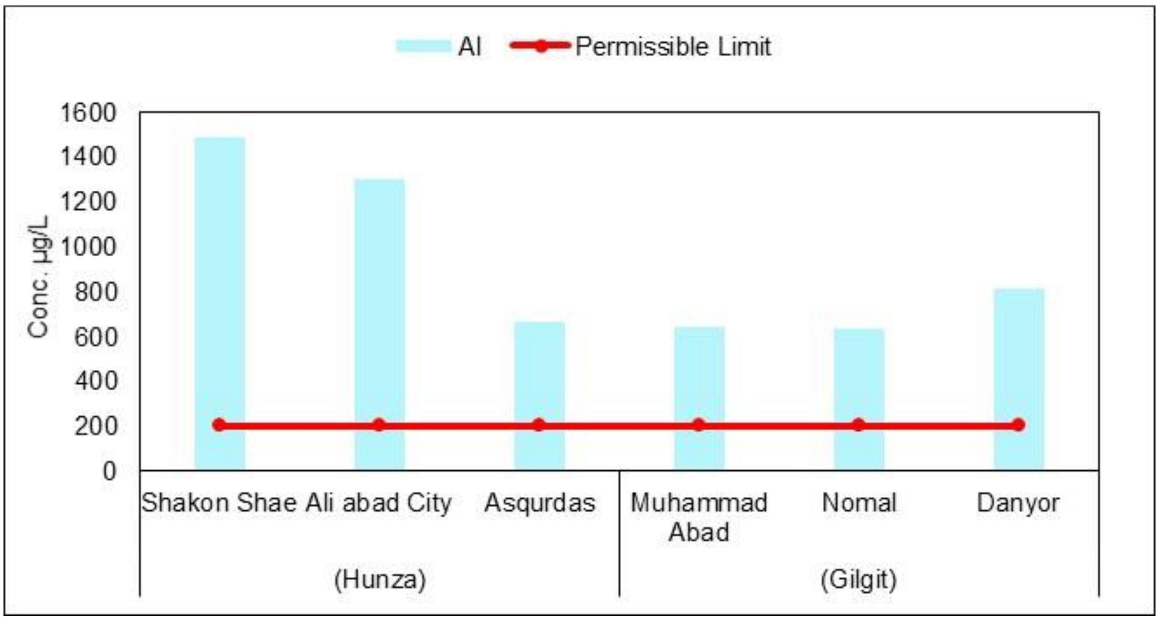

Figure 22: Locations with unsafe Aluminium level in Gilgit-Baltistan

Past studies have also reported that lead, chromium, cadmium, and copper exceeded in permissible limits in eight different villages of central Hunza (Shedayi *et al*., 2015). Box.1 provides a quick view of mineral resources of the Gilgit-Baltistan as a possible insight of the mineral related heavy metals contamination in the water bodies of GB.

Mineral Resources of Gilgit-Baltistan, Pakistan

Sr No.	Minerals	Location (Presence/source)
1.	Arsenopyrite, chalcopyrite, malachite, and pyrite	Originated from Dainyor Nala (15 km north east of Gilgit) and Bagrot Nala (20 km north of Gilgit)
2.	Bauxite	from Chapursan (Hunza)
3.	Gold	Presence in alluvial placer or sediments of Indus and Gilgit rivers and its tributaries which is being recovered by screen washing of stream sediments
4.	Copper	Associated with gossans/red iron oxide/ochre and base metals of Karakoram (Shyok) Suture like Dainyor Nala (north west of Gilgit), Barit, Bulashgah (also magnetite pod in ophiolitic rocks), Majadar and Bor Nala, and Bagrot Nala, Henzil (10 km north west of Gilgit), Sher Qila (33 km NW of Gilgit), Singal (45 km north west Gilgit), Nazbar valley (22 km W of Yasin), Shigari Bala area of Skardu and Golo Das and surrounding areas
5.	Iron	Originated from Indus Suture and its vicinity areas like Chilas, east of Gilgit, western, northern and eastern part of Haramosh massif forming lobe and possibly from Karakoram suture
6.	Lithium/lepidolite	Originated from Shengus of Nanga Parbat Massive (numerous pegmatites intruded in gneissic rocks)
7.	Sheet mica/muscovite	Originated from many pegmatites like Astore, Bagarian and Hawa Gali, uranium from many areas
8.	Graphite	Nagar Hunza, Chalt and Chelish
9.	Mesozoic coal	Chapursan valley
10.	limestone and marbles	Igneous and metamorphic rocks

Source:(Malkani, 2020)

Considering the findings of test data and details given in Box-1, a detailed investigation of heavy metals across the GB specifically at mining sites would help to track contamination sources, impacts on surface water bodies and development of mitigation strategies.

Dissolved Oxygen (DO)

Dissolved oxygen refers to the level of free, non-compound oxygen present in water. DO is an important parameter in assessing water quality because of its influence on the organisms living within a body of water. A dissolved oxygen level that is too high or too low specifically in surface water bodies can harm aquatic life and affect water quality. Dissolved oxygen was measured at six sampling points of rivers and storage ponds and was found within safe range. In Pakistan there are no standards for surface water bodies yet, thus compared with Nepalean, Indian and Bangladeshi standards for DO i.e. > 4 mg/L (Karn, 2001). Figure 23 shows that all sites were found within safe range (8.9-9.8 mg/L) for aquatic life.

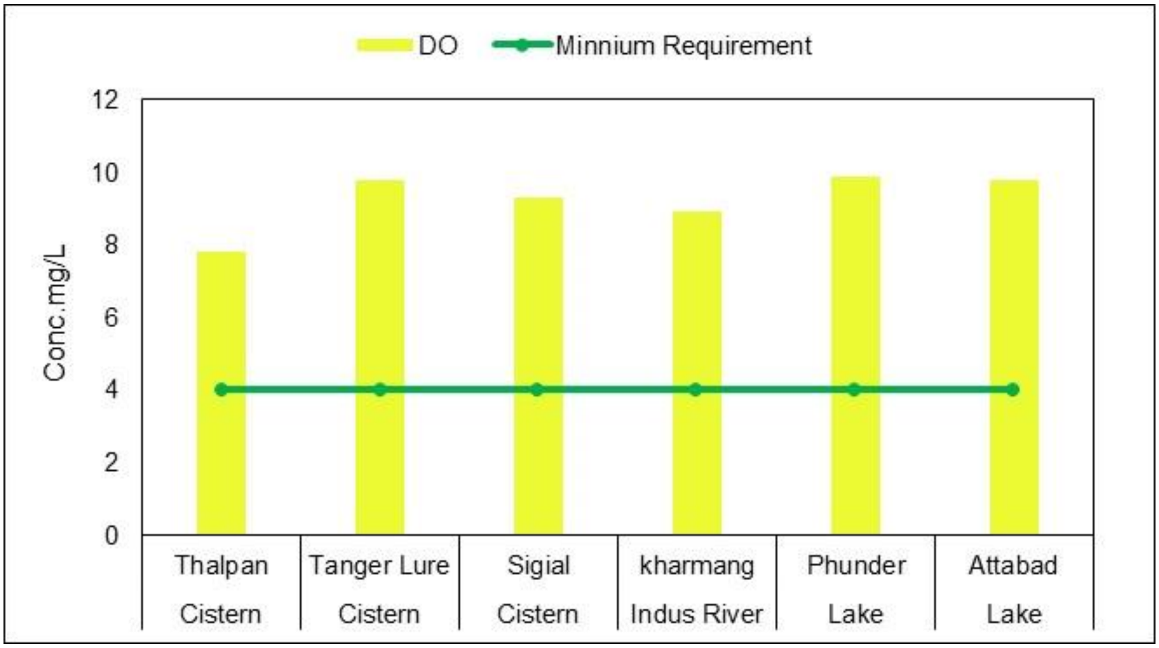

Figure 23: Dissolved oxygen concentration in rivers and lakes in Gilgit-Baltistan

Source Wise Summary of Results

Source wise comparison of test data indicates that samples collected from rivers were 100% unsafe mainly due to microbial contamination which is expected in raw water (Table 4 and Figure 24). However, wastewater from surrounding settlements is also dumped into these rivers adding more microbial contamination. Domestic use of river water without treatment is common in GB. To reduce the possibility of waterborne diseases from utilization of raw river water; filtration and disinfection at consumer's end would be essential.

Table 4: Source wise water quality status of monitored water sources in Gilgit-Baltistan

Source	Point of Use type	No.	Unsafe (No.)	%age Unsafe	Cause of Contamination
Snowmelt Runoff	Tap	28	23	82	Microbial contamination (79%), Excessive Turbidity (25%), Iron (14%)
Spring	Tap	56	45	80	Microbial contamination (70%), Excessive Turbidity (14%), Iron (29%) and Fluoride (04%)
Groundwater (Bore)	Tap	7	2	29	Microbial contamination (71%), Iron (29%)
River	River	3	3	100	Microbial contamination (100%), Excessive Turbidity (67%), Iron (33%)

Compared to surface water, groundwater was least contaminated. Only 2 of the 7 groundwater sources (29%) were found unsafe. Springs and surface water channels were 80 to 82% unsafe attributed mainly to turbidity and microbial contamination and lower iron and fluoride contamination.

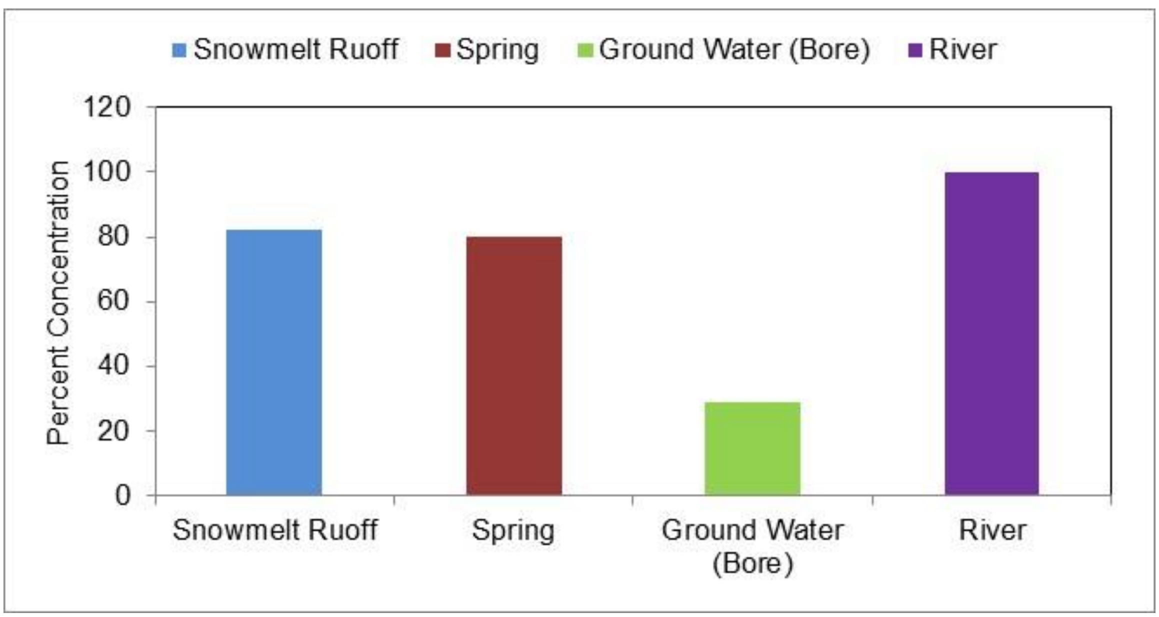

Figure 24: Source-wise percentage of unsafe samples

Overall, microbial contamination is the highest in all type of sources i.e. 68% (unfit due to total coliforms which are present in the environment).

Conclusions

Watershed management is vital to ensure sustainable water supply for ecological and domestic purposes. Healthy watershed ensures acceptable water quality and poses less pressure on water treatment systems. This study reveals that turbidity, microbial contamination, and heavy metals (iron, fluoride and aluminium) in surface water sources of GB were found to be above the desirable limit of Pakistan's Drinking Water Quality Standards. This points out that river water quality deterioration is probably caused by domestic sewage, surface runoff from nearby hills, deforestation etc. It seems that lack of management, lack of public awareness, exploitation of natural resources particularly deforestation have drastic implications for watershed health. Moreover, overgrazing by cattle and livestock, and increased visits for recreation are also causing watershed degradation in the GB region. Moreover, ongoing glacier retreat may also be resulting in transient increase in suspended sediment fluxes and concentrations, and also changes in the water chemistry. Further release of sediment and related transport to surface water can be expected under warming climatic conditions. The study findings therefore, call for an improved understanding of impacts of mining on water bodies and human population, as well as spatial and temporal water quality assessment of glacier fed water bodies.

Recommendation and Way Forward

Disinfection of Unsafe Water

Water purification and disinfection methods (chlorination) should be used either at source of supply network or at household level to prevent potential health risks.

Identification of Alternate Source

In districts with extensive mining activities such as Gilgit, Hunza and Skardu, local people should be educated to use alternate safe water sources. Alternatively, water treatment such as installation of ion exchange system for removal of heavy metals may be arranged.

Proper Disposal of Wastewater

The new water supply schemes should be well designed considering the reasonable distance between water supply and sewage pipelines. Moreover, wastewater disposal system and treatment in populated cities like Gilgit is also recommended to protect the water resources of GB. Lined wastewater channels with proper wastewater treatment either through natural wetlands or by secondary wastewater treatment plant would be fruitful.

Regular Monitoring, Capacity Building and Awareness Campaign

Capacity building of local agencies for water quality monitoring and treatment is also recommended. PCRWR in this context can help through its regional office in Gilgit and can impart training to locals. Moreover, awareness of local residents on safe storage of drinking water safe disposal of wastewater and trash handling can help in maintaining good water quality in surface water bodies in GB.

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Annexure-I

Detail of Sampling Locations, Water Sources and Population Served

Sr. #	Sample Code	Location				Population Served	Source		Suppliers
		Latitude (°N)	Longitude (°E)	Tehsil	Sampling Point (village)		Type	Outlet	
1.	DIA-01	35.40875	74.1027	Chillas	Chilas city	10,000	Snowmelt Runoff	WSS Tank	WSSA
2.	DIA-02	35.413583	74.104167	Chillas	Chilas city complaint office WASA	10,000	Snowmelt Runoff	Tap	WSSA
3.	DIA-03	35.533317	74.504383	Gonar Farms	Goharabad	2,300	Spring	Tap	Community
4.	DIA-04	35.4085	74.389267	Gonar Farms	Gonar farms	3,000	Spring	Tap	Community
5.	DIA-05	35.403767	74.2092	Chillas	Gini	3,000	Snowmelt Runoff	Tap	Community
6.	DIA-06	35.417233	74.147783	Chillas	Thalpan	1,500	Snowmelt Runoff	Cistern	Community
7.	DIA-07	35.588383	74.567533	Dairal	Gayal	9,000	Spring	Tap	AKRSP
8.	DIA-08	35.600017	73.490617	Tangir	Lure	2,000	Snowmelt runoff	Cistern	AKRSP
9.	DIA-09	35.575333	74.630083	Gonar Farms	Thalichi	25,000	Spring	Tap	Community
10.	AST-01	35.470983	74.7786	Astore	Dashkin	5,000	Spring	Tap	AKRSP
11.	AST-02	35.44585	74.80625	Astore	Harcho	2,000	Spring	Tap	WSSA
12.	AST-03	35.365617	74.868317	Astore	Higher sechondary school Lous	4,500	Spring	Tap	WSSA
13.	AST-04	35.335067	74.855417	Astore	Fina	3,000	Spring	Tap	WSSA
14.	AST-05	35.359983	74.836533	Astore	Chongara	5,000	Spring	Tap	WSSA
15.	AST-06	35.355017	74.862633	Astore	Astore City	8,000	Spring	Tap	WSSA
16.	AST-07	35.285717	74.8491	Astore	Gorikot	5,000	Spring	Tap	WSSA
17.	AST-08	35.2244	74.849483	Astore	Sigial	300	Snowmelt runoff	Cistern	Community
18.	AST-09	35.251383	74.900017	Shuntor	Pakora	5,000	Spring	Tap	WSSA
19.	AST-10	35.036033	75.103817	Shuntor	Chillum	1,000	Spring	Tap	WSSA
20.	AST-11	35.6452	74.633733	Nunji	AC dispensary Bunji	15,000	Snowmelt runoff	Tap	WSSA
21.	SKA-01	35.265283	75.516533	Skardu	Skardu main WSS	40,000	Snowmelt runoff	Main Line	WSSA
22.	SKA-02	35.2916	75.614283	Skardu	Skardu (Quaidabad)	500	GW	Tap	Community
23.	SKA-03	35.291983	75.614817	Skardu	Skardu (Quaidabad)	200	Snowmelt runoff	Tap	WSSA
24.	SKA-04	35.289567	75.6345	Skardu	Alamdar chowk Skardu city	2,000	Snowmelt runoff	Tap	WSSA

Sr. #	Sample Code	Location				Population Served	Source		Suppliers
		Latitude (°N)	Longitude (°E)	Tehsil	Sampling Point (village)		Type	Outlet	
25.	SKA-05	35.312083	75.6037	Skardu	Sundas	600	GW	Tap	Community
26.	SKA-06	35.315883	75.608667	Skardu	Ghazi colony Sundas	20	GW	Tap	Community
27.	SKA-07	35.418317	75.465	Skardu	Kachura	3,000	Spring	Tap	AKRSP
28.	SKA-08	35.02965	76.0937	Kharmang	Tolti	1,200	Spring	Tap	WSSA
29.	SKA-09	35.134317	75.961517	Kharmang	Mehdiabad	10,000	Spring	Tap	WSSA
30.	SKA-10	35.2562	75.862683	Skardu	Gol	1,000	Spring	Tap	Spring
31.	SKA-11	35.423583	75.738883	Shigar	UC Markung shigar	5,000	Spring	Tap	WSSA
32.	SKA-12	35.29695	75.6949	Skardu	Hussain Abad	8,000	Spring	Tap	WSSA
33.	SKA-13	35.588317	75.223983	Rundu	Dambodas main bazar	5,000	Snowmelt runoff	Tap	WSSA
34.	SKA-14	35.72045	74.825717	Rundu	Shanggus	1,500	Spring	Tap	WSSA
35.	SKA-15	35.223283	75.910783	Skardu	Indus River kharmang	N/A	River	River	River
36.	GZR-01	36.16415	72.9182	Gopsi	Phunder	N/A	River (Phunder lake)		River
37.	GZR-02	36.1661	72.929433	Gopsi	Phunder vilage	N/A	Spring	Tap	AKRSP
38.	GZR-03	36.24675	73.37165	Gopsi	Khalti	N/A	Spring	Tap	AKRSP
39.	GZR-04	36.370917	73.33285	Yasin	Yasin Khas	N/A	Snowmelt runoff	Tap	WSSA
40.	GZR-05	36.209667	73.33285	Gopsi	Hakis	N/A	Spring	Tap	AKRSP
41.	GZR-06	36.230233	73.446717	Gopsi	Gopis Khas	N/A	Snowmelt runoff	Tap	WSSA
42.	GZR-07	36.24705	73.566717	Gopsi	Sumall	N/A	Spring	Tap	AKRSP
43.	GZR-08	36.242983	73.740633	Gopsi	Hatun Dasmasqu	N/A	Snowmelt runoff	Tap	AKRSP
44.	GZR-09	36.34675	73.507833	Ishkoman	Choatorkhan Ishkomin	N/A	Snowmelt runoff	Tap	WSSA
45.	GZR-10	36.2002	73.750967	Gakhuch	Golodas	N/A	Spring	Tap	AKRSP
46.	GZR-11	36.185283	73.774733	Gakhuch	Silpi	N/A	Spring	Tap	WSSA
47.	GZR-12	36.189267	73.761317	Gakhuch	Main Bazar Gahkuch City	N/A	GW (well)	Tap	Community
48.	GZR-13	36.179533	73.76905	Gakhuch	Main bazar Gahkoch City	N/A	Spring	Tap	WSSA

Sr. #	Sample Code	Location				Population Served	Source		Suppliers
		Latitude (°N)	Longitude (°E)	Tehsil	Sampling Point (village)		Type	Outlet	
49.	GZR-14	36.147317	73.859017	Sigal	Boobur	N/A	Snowmelt runoff	Tap	WSSA
50.	GZR-15	36.137633	73.63245	Sigal	Gulmati	N/A	Spring	Tap	AKRSP
51.	GZR-16	36.101	73.90005	Sigal	Singul	N/A	Spring	Tap	AKRSP
52.	GZR-17	36.0993	73.9765	Punail	Main bazar Goharabad	N/A	Spring	Tap	WSSA
53.	GZR-18	36.09095	74.035717	Punail	Sher Qila	N/A	Spring	Tap	WSSA
54.	GZR-19	36.06355	74.085267	Punail	Gulapur	N/A	Snowmelt runoff	Tap	WSSA
55.	HUN-01	36.686867	74.82875	Gojal	Hussain Abad	300	Snowmelt runoff	Tap	AKRSP
56.	HUN-02	36.612167	74.850033	Gojal	Markhan	1,000	Spring	Tap	AKRSP
57.	HUN-03	36.580983	74.805167	Gojal	Khyber	300	Spring	Tap	AKRSP
58.	HUN-04	36.382983	74.866467	Gojal	Hascol pump KKH road Gulmit	6,000	Spring	Tap	WSSA
59.	HUN-05	36.354583	74.865517	Gojal	Shishkhat	2,500	Spring	Tap	AKRSP
60.	HUN-06	36.327933	74.873633	Gojal	Attabad	N/A	Lake	Lake	Community
61.	HUN-07	36.273267	74.731983	Nagag Khas	Nagar Shabirabad	20,000	Snowmelt runoff	Tap	WSSA
62.	HUN-08	36.318183	74.59425	Aliabad	Shakon Shae	15,000	Snowmelt runoff	Tap	WSSA
63.	HUN-09	36.307083	74.619183	Aliabad	Ali Abad City	18,000	Snowmelt runoff	Tap	WSSA
64.	HUN-10	36.30385	74.6637	Nagag Khas	Nagar Sumayer	14,000	Spring	Tap	WSSA
65.	HUN-11	36.299383	74.63265	Nagag Khas	Asqurdas	10,000	Spring	Tap	WSSA
66.	HUN-12	36.2801	74.610133	Nagag Khas	Murtaza abad	4,000	Spring	TAP	AKRSP
67.	HUN-13	36.264667	74.53645	Aliabad	Nasirabad	8,000	Snowmelt runoff	Tap	AKRSP
68.	HUN-14	36.252317	74.53955	Sikandarabad	Munapin	5,000	Spring	Tap	Community
69.	HUN-15	36.2507	74.518583	Sikandarabad	Pisan	4,000	Spring	Tap	AKRSP
70.	HUN-16	36.23975	74.48805	Sikandarabad	Nagar Gulmat	6,000	Spring	Tap	AKRSP
71.	HUN-17	36.23985	74.607183	Sikandarabad	Thol	4,000	Spring	Tap	WSSA
72.	HUN-18	36.23065	74.411	Sikandarabad	Nilt	4,000	Spring	Tap	WSSA
73.	HUN-19	36.24485	74.369117	Sikandarabad	Sikandar Abad	3,000	Spring	Tap	WSSA
74.	HUN-20	36.250717	74.3214	Sikandarabad	Chalat	5,000	Spring	Tap	AKRSP
75.	GIL-01	35.8339	74.74385	Danyor	Sasee Haramish	1,000	Snowmelt runoff	Tap	WSSA

Sr. #	Sample Code	Location				Population Served	Source		Suppliers
		Latitude (°N)	Longitude (°E)	Tehsil	Sampling Point (village)		Type	Outlet	
76.	GIL-02	35.701783	74.63195	Jaglot	Sonehri bazar Jaglot	30,000	Snowmelt runoff	Tap	WSSA
77.	GIL-03	35.817917	74.588783	Gilgit	Pari Bangla	8,000	Snowmelt runoff	Tap	WSSA
78.	GIL-04	36.048767	74.106	Gilgit	Shakyot	4,000	Spring	Tap	WSSA
79.	GIL-05	36.051167	74.13435	Gilgit	Bargo	4,000	Snowmelt runoff	Tap	WSSA
80.	GIL-06	35.92555	74.26055	Gilgit	Gilgit city mohalla Rafiqabad	20,000	Spring	Tap	WSSA
81.	GIL-07	35.926633	74.293133	Gilgit	Amphari	500	G/W		
82.	GIL-08	35.923217	74.3055	Gilgit	Giligit city near Polo Ground	50,000	Spring	Tap	WSSA
83.	GIL-09	35.913617	74.314333	Gilgit	Nagral	500	G/W	Tap	Community
84.	GIL-10	35.910017	74.33615	Gilgit	Giligit city Jutial public college	10,000	Snowmelt runoff	Tap	WSSA
85.	GIL-11	36.1804	74.2901	Danyor	Jagrot Gah	5,000	Spring	Tap	Community
86.	GIL-12	36.10465	74.301733	Danyor	Rahimabad	3,000	Spring	Tap	WSSA
87.	GIL-13	35.961117	74.513917	Danyor	Sinakir	1,000	Spring	Tap	AKRSP
88.	GIL-14	36.586917	74.48815	Danyor	Jalalabad	10,000	Spring	Tap	WSSA
89.	GIL-15	35.8897	74.47375	Danyor	Oshkanadas	10,000	Spring	Tap	WSSA
90.	GIL-16	35.932667	74.414983	Danyor	Muhammad abad	6,000	Snowmelt runoff	Tap	AKRSP
91.	GIL-17	36.0754	74.2861	Gilgit	Nomal	20,000	Spring	Tap	WSSA
92.	GIL-18	36.041733	74.29905	Danyor	Jutal	5,000	Spring	Tap	WSSA
93.	GIL-19	36.922283	74.378933	Gilgit	Danyor	25,000	Spring	Tap	WSSA
94.	GIL-20	35.947733	74.3201	Gilgit	Chilmish Das	100	G/W	Tap	Community

Annexure-II

SAMPLE COLLECTION PROFILE

Field Questionnaire for Water Quality Survey in Gilgit Baltistan

Date:________________ Form No.________________

District Sampled :________________ Tehsil:________________

Village:________________ Population of Village________________

Part-A: to be filled in by the Field Team

1. Location		**2. Sampled Source:**	
3. Air Temp:		**4. Water Temp:**	
5. Humidity:		**6. Site ID:**	
7. Sample ID:		**8. Sample Time:**	
9. Water Source:	Public WSS (Source) ☐	Public WSS (Consumer's end) ☐	Domestic source (Household) ☐
	Domestic source (Community) ☐	Other ☐	

10. Description of Water Source: (i) Surface Water ☐ (ii) Ground Water ☐

11. Nature of Source:

Hand Pump	Tubewell	Well	W.Supply	Cistern	Tap	Pond	Ind. Effluent
Spring	Nullah	Dam	Irrigation	River	Lake	Sewage	Other

12. Other Information:

Water Table (ft)		Screen Depth (ft)	
Depth of Sample (ft)		Year Installed	
Allied Source		Owner/ Caretaker	
No. of Consumers		Discharge	

13. General Observation and Field Analysis:

Odour? (rotten eggs)	Sat	Unsat	Taste	Sat	Unsat
Colour			pH		
Conductivity (µS/cm)			DO	mg/l	

14. Samples collected for quality control:

Cross analysis ID	________	-E	A	B	C	D
Field Blank ID	________	-F	A	B	C	D
Replicates ID	________	-G	A	B	C	D

15. GPS Reading:

Altitude ________

Latitude ________

Longitude ________

16. Picture taken: Yes | No

17. No. of consumers using Water of Sampled Source:

18. Hygienic conditions near source:

19. Complaints of people at the location regarding water quality e.g. Diarrhea, Hepatitis A, Typhoid etc.

20. Source protected Yes | No

21. Comments: (if any) ________________

Collected by: ________________ **Supervised by:** ________________

Type A - All sites - Microbiological analysis

Type B - All sites - Trace elements (2-10 ml/litre HNO3 as preservative)

Type C - All sites - Nitrate Nitrogen (1 ml/100 ml, 1 M Boric acid as preservative)

Type D - All sites - Other water quality parameters (no preservative)

Annexure-III

Microbiological and Physico Chemical Test Results

Sr#	Sample Code	E.C	pH	Turbidity	HCO_3/ Alk	Ca	Mg	Hard	Cl	Na	K	SO_4	NO_3 (N)	PO_4	TDS	Fe	F	*Total Coliforms*	*E. coli*	Remarks
		µS/cm	*-*	*NTU*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*(CFU/ml)*	*(CFU/ml)*	
		NGVS	*6.5-8.5*	*5.00*	*NGVS*	*NGVS*	*NGVS*	*500*	*250*	*NGVS*	*NGVS*	*NGVS*	*10.00*	*NGVS*	*1000*	*0.30*	*1.50*	*0*	*-ve*	*Safe/ Unsafe*
1	DIA-01	129	7.4	6.05	55	12	7	60	BDL	3	1.0	6		0.39	71.00	0.06	0.05	11	-ve	Unsafe
2	DIA-02	129	7.5	1.52	55	12	7	60	7	3	0.9	4	1.17	0.47	71.00	0.06	0.08	17	-ve	Unsafe
3	DIA-03	219	7.2	1.52	60	20	12	100	BDL	3	2.9	39	1.12	0.41	121.00	0.00	0.15	4	-ve	Unsafe
4	DIA-04	570	7.8	BDL	150	56	17	230	10	35	8.3	122	0.38	0.37	314.00	0.08	2.80	8	-ve	Unsafe
5	DIA-05	174	7.9	BDL	60	16	7	70	10	6	1.8	14	1.06	0.42	96.00	0.00	0.08	-ve	-ve	Safe
6	DIA-06	110	6.9	12.68	40	12	2	40	5	4	2.6	6	1.02	0.47	51.00	0.00	0.09	27	-ve	Unsafe
7	DIA-07	106	7.3	BDL	40	16	4	40	BDL	2	1.7	9	0.67	0.34	58.00	0.00	0.10	-ve	-ve	Safe
8	DIA-08	69	7.3	3.45	30	8	36	40	BDL	BDL	1.1	7	0.37	0.34	38.00	0.00	0.07	-ve	-ve	Safe
9	DIA-09	461	7.9	BDL	130	32	4	230	BDL	6	8.0	71	0.24	0.47	254.00	0.00	0.22	4	-ve	Unsafe
10	AST-01	79	7.4	0.41	20	8	5	40	BDL	BDL	2.0	18	0.32	0.27	44.00	0.67	1.10	20	-ve	Unsafe
11	AST-02	311	7.4	0.26	120	48	7	150	BDL	4	3.1	25	0.96	0.45	171.00	0.00	0.62	31	-ve	Unsafe
12	AST-03	164	7.8	0.27	70	24	BDL	60	BDL	4	2.0	22	0.44	0.15	90.00	0.44	0.08	9	-ve	Unsafe
13	AST-04	82	7.6	0.23	30	12	2	30	BDL	2	1.0	23	0.25	0.02	45.00	0.45	0.03	2	-ve	Unsafe
14	AST-05	199	7.4	0.19	70	20	10	90	BDL	2	3.3	0	0.36	0.19	109.00	1.34	0.91	-ve	-ve	UnSafe
15	AST-06	176	7.6	1.26	50	24	5	70	BDL	BDL	2.6	25	0.09	0.21	97.00	0.51	0.25	6	-ve	Unsafe
16	AST-07	179	7.5	BDL	50	28	2	80	BDL	3	2.5	26	0.25	0.25	99.00	0.00	0.13	14	-ve	Unsafe
17	AST-08	44	7.2	3.94	15	4	BDL	10	BDL	BDL	0.6	8	0.26	0.50	24.00	0.11	0.00	21	-ve	Unsafe
18	AST-09	51	7.4	3.70	10	4	BDL	10	BDL	BDL	10.0	16	0.26	0.38	28.00	0.00	0.00	18	-ve	Unsafe
19	AST-10	59	7.6	5.38	30	4	5	30	BDL	2	0.2	0	0.13	0.45	32.00	0.33	0.08	-ve	-ve	UnSafe
20	AST-11	629	7.3	1.89	30	48	44	300	BDL	10	4.5	27	0.00	0.35	346.00	0.20	1.10	17	-ve	Unsafe
21	SKA-01	143	7.9	BDL	55	20	4	65	BDL	2	1.3	28	0.17	0.28	79.00	0.00	0.16	-ve	-ve	Safe
22	SKA-02	297	7.1	BDL	120	40	10	140	BDL	4	2.4	27	2.25	0.00	163.00	0.09	0.07	-ve	-ve	Safe
23	SKA-03	147	7.9	BDL	80	20	5	60	BDL	2	1.2	0	0.19	0.00	81.00	0.13	0.08	4	-ve	Unsafe
24	SKA-04	140	7.9	0.40	60	8	5	60	BDL	2	1.1	0	0.16	0.00	77.00	0.06	0.10	-ve	-ve	Safe

Sr#	Sample Code	E.C	pH	Turbidity	HCO_3/ Alk	Ca	Mg	Hard	Cl	Na	K	SO_4	NO_3 (N)	PO_4	TDS	Fe	F	*Total Coliforms*	*E. coli*	Remarks
		µS/cm	*-*	*NTU*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*(CFU/ml)*	*(CFU/ml)*	
		NGVS	*6.5-8.5*	*5.00*	*NGVS*	*NGVS*	*NGVS*	*500*	*250*	*NGVS*	*NGVS*	*NGVS*	*10.00*	*NGVS*	*1000*	*0.30*	*1.50*	*0*	*-ve*	*Safe/ Unsafe*
25	SKA-05	712	7.2	BDL	270	112	15	340	28	17	7.1	46	8.00	0.00	392.00	0.45	0.23	-ve	-ve	UnSafe
26	SKA-06	300	7.7	BDL	130	32	15	140	8	5	3.4	18	0.19	0.10	165.00	0.66	0.20	-ve	-ve	UnSafe
27	SKA-07	179	7.2	0.81	80	36	BDL	90	BDL	BDL	3.0	6	0.23	0.05	99.00	0.59	0.12	42	-ve	Unsafe
28	SKA-08	102	7.4	0.04	30	16	2	50	BDL	BDL	1.5	22	0.20	0.41	56.00	0.57	0.11	31	-ve	Unsafe
29	SKA-09	105	7.7	1.55	40	20	BDL	50	BDL	2	0.9	13	0.28	0.00	58.00	0.42	0.13	9	-ve	Unsafe
30	SKA-10	186	7.1	0.18	70	28	2	80	10	5	3.2	0	0.55	0.00	102.00	0.00	0.12	6	-ve	Unsafe
31	SKA-11	229	7.9	15.43	80	24	12	110	8	BDL	2.6	20	0.65	0.00	126.00	0.58	0.16	11	-ve	Unsafe
32	SKA-12	130	7.9	0.78	50	16	7	70	BDL	BDL	2.0	19	0.45	0.00	72.00	0.00	0.15	4	-ve	Unsafe
33	SKA-13	284	7.8	1.98	120	36	12	140	BDL	3	5.7	29	0.19	0.32	156.00	0.41	0.19	19	-ve	Unsafe
34	SKA-14	1093	7.0	BDL	350	160	17	470	19	33	20.0	140	0.00	0.33	601.00	0.56	2.70	11	-ve	Unsafe
35	SKA-15	179	7.9	85.00	70	24	5	80	BDL	3	1.4	17	0.76	0.05	99.00	0.48	0.00	41	-ve	Unsafe
36	GZR-01	141	8.1	1.70	50	20	5	70	BDL	0	0.8	15	0.30	0.59	77.55	0.00	0.40	12	-ve	Unsafe
37	GZR-02	203	7.9	2.80	90	24	7	90	BDL	5	1.3	12	0.50	0.55	111.65	0.00	0.10	11	-ve	Unsafe
38	GZR-03	83	7.3	BDL	25	12	2	40	7	0	1.5	8	0.60	0.44	45.65	0.00	0.10	2	-ve	Unsafe
39	GZR-04	136	7.2	BDL	40	12	10	70	BDL	0	1.0	28	0.50	0.42	74.80	0.00	0.20	2	-ve	Unsafe
40	GZR-05	75	7.4	BDL	30	8	5	40	4	0	1.5	7	0.30	0.60	41.25	0.00	0.10	6	-ve	Unsafe
41	GZR-06	66	6.5	4.15	25	8	2	30	BDL	0	1.3	10	0.40	0.50	36.30	0.00	0.06	7	-ve	Unsafe
42	GZR-07	118	7.4	4.50	40	12	7	60	4	0	0.9	12	0.50	0.52	64.90	0.00	0.40	-ve	-ve	Safe
43	GZR-08	242	7.2	16.00	90	28	7	100	BDL	5	5.3	30	0.40	0.38	133.10	0.00	0.10	-ve	-ve	UnSafe
44	GZR-09	220	7.8	7.10	70	28	7	100	BDL	0	1.0	33	0.20	0.54	121.00	0.00	0.20	9	-ve	Unsafe
45	GZR-10	528	7.9	BDL	120	52	17	200	10	24	6.6	111	1.00	0.95	290.40	0.00	0.42	49	-ve	Unsafe
46	GZR-11	230	7.7	BDL	70	28	7	100	4	4	2.4	26	4.00	0.77	126.50	0.00	0.20	8	-ve	Unsafe
47	GZR-12	462	6.9	BDL	150	48	19	200	20	11	6.6	38	3.30	0.75	254.10	0.00	0.20	-ve	-ve	Safe
48	GZR-13	415	6.9	BDL	150	56	10	180	10	8	5.3	38	0.60	0.68	228.25	0.00	0.12	-ve	-ve	Safe
49	GZR-14	102	7.5	BDL	30	12	5	50	6	2	1.9	13	0.30	0.44	56.10	0.00	0.42	2	-ve	Unsafe
50	GZR-15	78	7.4	BDL	20	8	5	40	4	0	1.4	16	0.40	0.41	42.90	0.00	0.20	5	-ve	Unsafe
51	GZR-16	119	7.6	BDL	40	20	5	70	BDL	0	2.0	26	0.70	0.37	65.45	0.00	0.20	-ve	-ve	Safe

Sr#	Sample Code	E.C	pH	Turbidity	HCO_3/ Alk	Ca	Mg	Hard	Cl	Na	K	SO_4	NO_3 (N)	PO_4	TDS	Fe	F	*Total Coliforms*	*E. coli*	Remarks
		µS/cm	*-*	*NTU*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*(CFU/ml)*	*(CFU/ml)*	
		NGVS	*6.5-8.5*	*5.00*	*NGVS*	*NGVS*	*NGVS*	*500*	*250*	*NGVS*	*NGVS*	*NGVS*	*10.00*	*NGVS*	*1000*	*0.30*	*1.50*	*0*	*-ve*	*Safe/ Unsafe*
52	GZR-17	152	7.7	BDL	60	20	7	80	4	0	3.0	23	0.40	0.19	83.60	0.00	0.22	3	-ve	Unsafe
53	GZR-18	288	7.6	BDL	70	40	2	110	BDL	3	3.3	51	0.40	0.17	158.40	0.00	0.20	-ve	-ve	Safe
54	GZR-19	79	7.2	BDL	20	12	2	40	4	0	1.3	15	0.40	0.34	43.45	0.00	0.04	9	-ve	Unsafe
55	HUN-01	497	8.1	1.20	140	40	36	250	BDL	4	1.1	106	0.30	0.00	273.35	0.09	0.30	-ve	-ve	Safe
56	HUN-02	559	7.8	BDL	150	48	36	270	BDL	4	0.7	115	0.30	0.05	307.45	0.00	0.30	9	-ve	Unsafe
57	HUN-03	294	7.7	BDL	100	28	17	140	BDL	3	0.5	38	0.20	0.00	161.70	0.00	0.65	4	-ve	Unsafe
58	HUN-04	165	7.8	BDL	50	20	7	80	BDL	3	4.7	31	0.40	0.02	90.75	0.00	0.12	7	-ve	Unsafe
59	HUN-05	346	7.7	BDL	70	48	2	130	4	11	7.4	71	0.40	0.16	190.30	0.36	1.20	-ve	-ve	UnSafe
60	HUN-06	244	7.9	13.80	80	28	12	120	4	4	2.3	35	0.30	0.17	134.20	0.00	0.30	35	-ve	Unsafe
61	HUN-07	362	7.8	1.35	80	56	5	160	BDL	4	5.0	79	0.00	0.16	199.10	0.00	0.90	9	-ve	Unsafe
62	HUN-08	164	7.6	6.80	20	12	10	70	BDL	2	8.8	40	6.00	2.11	90.20	0.50	0.00	14	-ve	Unsafe
63	HUN-09	141	7.8	352.00	20	12	7	60	BDL	2	7.0	35	5.00	2.27	77.55	0.39	0.00	16	-ve	Unsafe
64	HUN-10	275	7.7	BDL	70	28	12	120	BDL	0	2.6	53	0.30	0.06	151.25	0.00	1.00	-ve	-ve	Safe
65	HUN-11	181	8.0	83.00	40	12	15	90	6	0	2.0	32	1.20	0.48	99.55	0.21	0.07	2	-ve	Unsafe
66	HUN-12	174	7.9	BDL	50	24	5	80	BDL	0	3.8	33	0.40	0.03	95.70	0.00	0.17	9	-ve	Unsafe
67	HUN-13	365	7.9	BDL	80	40	12	150	BDL	3	5.3	94	0.60	0.06	200.75	0.00	0.80	5	-ve	Unsafe
68	HUN-14	386	7.9	BDL	170	28	24	170	BDL	8	6.8	25	0.80	0.03	212.30	0.00	0.12	17	-ve	Unsafe
69	HUN-15	329	7.8	BDL	130	24	22	150	4	5	5.7	29	0.80	0.00	180.95	0.00	0.11	7	-ve	Unsafe
70	HUN-16	100	7.9	BDL	40	16	2	50	BDL	0	1.5	11	0.30	0.00	55.00	0.55	0.12	-ve	-ve	UnSafe
71	HUN-17	200	7.9	15.76	70	28	5	90	BDL	0	3.2	23	0.30	0.07	110.00	0.12	0.10	4	-ve	Unsafe
72	HUN-18	288	7.8	10.43	90	40	7	130	BDL	0	3.1	38	0.20	0.00	158.40	0.00	1.00	7	-ve	Unsafe
73	HUN-19	292	7.6	BDL	120	32	17	150	BDL	0	3.1	25	0.40	0.00	160.60	0.00	0.00	-ve	-ve	Safe
74	HUN-20	243	7.9	BDL	90	40	5	120	BDL	0	2.6	29	0.40	4.00	133.65	0.00	0.11	-ve	-ve	Safe
75	GIL-01	140	7.6	BDL	30	12	5	50	BDL	11	1.7	40	0.30	0.00	77.00	0.00	0.20	12	-ve	Unsafe
76	GIL-02	143	7.4	7.70	60	12	10	70	BDL	2	2.0	16	0.50	0.00	78.65	0.00	0.14	2	-ve	Unsafe
77	GIL-03	100	8.9	0.55	40	8	7	50	4	0	2.9	6	0.50	0.00	55.00	0.00	0.15	4	-ve	Unsafe
78	GIL-04	243	7.5	BDL	100	28	10	110	4	3	3.3	24	0.30	0.06	133.65	0.00	0.23	-ve	-ve	Safe

Sr#	Sample Code	E.C	pH	Turbidity	HCO_3/ Alk	Ca	Mg	Hard	Cl	Na	K	SO_4	NO_3 (N)	PO_4	TDS	Fe	F	*Total Coliforms*	*E. coli*	Remarks
		µS/cm	*-*	*NTU*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*(CFU/ml)*	*(CFU/ml)*	
		NGVS	*6.5-8.5*	*5.00*	*NGVS*	*NGVS*	*NGVS*	*500*	*250*	*NGVS*	*NGVS*	*NGVS*	*10.00*	*NGVS*	*1000*	*0.30*	*1.50*	*0*	*-ve*	*Safe/ Unsafe*
79	GIL-05	175	7.7	BDL	40	24	2	70	10	4	2.4	20	0.20	0.12	96.25	0.00	0.17	2	-ve	Unsafe
80	GIL-06	102	7.5	BDL	40	8	7	50	6	0	1.5	5	0.40	0.03	56.10	0.00	0.10	-ve	-ve	Safe
81	GIL-07	402	7.6	1.40	170	40	22	190	12	5	6.0	27	1.70	0.06	221.10	0.00	0.15	-ve	-ve	Safe
82	GIL-08	100	7.6	BDL	40	12	7	60	6	0	1.5	9	0.40	0.00	55.00	0.00	0.10	8	-ve	Unsafe
83	GIL-09	709	7.1	BDL	290	80	19	280	24	33	9.1	33	5.30	0.02	389.95	0.06	0.25	-ve	-ve	Safe
84	GIL-10	143	7.6	BDL	40	16	5	60	8	2	2.9	20	0.40	0.03	78.65	0.00	0.17	4	-ve	Unsafe
85	GIL-11	448	7.8	BDL	140	48	19	200	10	3	6.5	55	0.50	0.01	246.40	0.00	0.30	18	-ve	Unsafe
86	GIL-12	638	7.6	BDL	100	80	24	300	12	6	6.9	214	0.30	0.02	350.90	0.00	0.45	10	-ve	Unsafe
87	GIL-13	862	7.5	BDL	100	108	39	430	12	3	20.0	310	0.40	0.00	474.10	0.52	0.50	-ve	-ve	UnSafe
88	GIL-14	365	7.9	19.30	60	2	35	150	8	2	6.4	96	0.40	0.04	200.75	0.00	0.22	4	-ve	Unsafe
89	GIL-15	345	7.8	BDL	130	40	17	170	6	5	9.3	38	0.10	0.07	189.75	0.00	0.30	2	-ve	Unsafe
90	GIL-16	312	7.8	35.50	60	28	22	160	6	0	3.0	94	0.90	0.23	171.60	0.32	0.11	15	-ve	Unsafe
91	GIL-17	193	7.7	64.00	80	24	10	100	4	0	2.9	13	1.20	0.35	106.15	0.42	0.00	-ve	-ve	UnSafe
92	GIL-18	341	7.7	BDL	60	78	BDL	196	8	6	5.3	78	0.30	0.46	187.55	0.00	0.26	-ve	-ve	Safe
93	GIL-19	283	7.7	270.00	70	40	10	140	6	0	3.4	46	3.50	0.49	155.65	1.49	0.00	3	-ve	Unsafe
94	GIL-20	502	7.5	BDL	150	56	22	230	16	7	8.2	79	0.70	0.21	276.10	0.00	0.35	-ve	-ve	Safe
Minimum		44	6.5	0.04	10	2	2	10	4	0	0.2	0	0.00	0.00	24.00	0.00	0.00	2		
Average		256	7.6	23.73	78	30	11	117	9	4	3.7	38	0.81	0.32	140.67	0.15	0.30	12		
Maximum		1093	8.9	352.00	350	160	44	470	28	35	20.0	310	8.00	4.00	601.00	1.49	2.80	49		
No. of samples beyond permissible limit			1	18				0	0				0		0	23	2	64	0	73

*BDL: Below Detection Limit

Annexure-IV

Test results of Trace/Heavy Metals

Sr. #	Sample Code	Al	As	Ba	Cd	Co	Cr	Cu	Mn	Mo	Ni	Pb	Sr	Zn
		µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l
		200	50	700	10	NGVS	50	1500	500	NGVS	20	50	NGVS	5000
1	DIA-01	4.76	2.72	2.63	0.16	0.55	BDL	0.96		BDL	BDL	BDL	54.51	11.21
2	DIA-02	2.53	7.69	2.55	BDL	0.9	BDL	1.04	0.24	0.82	BDL	1.56	54.14	19.38
3	DIA-03	2.88	BDL	12.31	BDL	1.29	BDL	1.59		2.89	BDL	0.31	184.73	2.8
4	DIA-04	7.73	5.45	14.27	0.07	1.83	0.61	1.27	0	20.77	BDL	0.64	250.45	BDL
5	DIA-05	4.89	3.85	1.41	0.02	1.31	0.73	0.83		0.69	BDL	3.79	20.82	BDL
6	DIA-06	2.8	4.56	27.74	0.05	1.07	BDL	1.4	0.12	1.14	BDL	BDL	72.24	BDL
7	DIA-07	3.83	1.67	4.78	0.12	1.17	BDL	1.11		0.32	0.28	1.97	52.21	9.82
8	DIA-08	12.88	3.75	8.16	0.01	1.01	BDL	1.01	0	0.72	BDL	0.70	83.78	BDL
9	DIA-09	11.75	9.73	6.7	0.03	1.27	BDL	1.27		5.2	BDL	1.82	111.64	BDL
10	AST-01	7.75	20.16	2.2	0	1.04	BDL	1.11	0.17	6.73	BDL	0.95	15.83	3.11
11	AST-02	4.87	8.71	6.59	BDL	1.13	0.22	1.49		10.37	0.31	3.04	70.4	BDL
12	AST-03	6.81	28.91	3.83	0.02	1.6	0.16	0.77	0.02	8.23	BDL	2.07	20.33	18.54
13	AST-04	4.71	6	2.33	0.03	0.96	BDL	0.7		1.52	0.25	0.90	14.85	0.35
14	AST-05	2.91	BDL	5.11	BDL	1.53	0.07	0.79	0.14	3.48	BDL	BDL	81.36	6.42
15	AST-06	9.19	4.61	8.84	BDL	1.02	BDL	0.91		1.54	BDL	0.43	94.13	0.01
16	AST-07	3.82	6.8	13.33	BDL	1.28	BDL	1.23	1.04	1.75	BDL	2.00	144.88	9.28
17	AST-08	6.96	1.72	1.35	0.19	0.53	BDL	0.67		0.21	BDL	BDL	10.42	BDL
18	AST-09	13.23	BDL	3.09	BDL	1.01	BDL	1.14	0.07	1.15	BDL	0.41	9.81	4.2
19	AST-10	2.46	BDL	3.55	BDL	1.06	BDL	0.64		BDL	0.07	0.27	43.86	BDL
20	AST-11	12.25	0.85	20.02	BDL	1.35	0.34	1.35	1.09	BDL	0.54	1.92	236.92	BDL
21	SKA-01	7.01	14.87	4.64	0	0.63	BDL	1.31		2.51	BDL	0.72	69.65	BDL
22	SKA-02	8.2	6.04	9.41	0.06	1.95	0.06	2.52	0.03	1.41	BDL	1.44	143.73	3.01
23	SKA-03	9.08	14.64	4.62	0.05	1.69	BDL	0.95		2.28	BDL	BDL	68.95	BDL
24	SKA-04	9.73	15.04	4.68	BDL	1.25	BDL	1.09	0.01	2.42	BDL	BDL	66.04	1.19
25	SKA-05	4.86	14	53.93	BDL	1.83	0.02	1.78		5.37	0.51	1.97	365.82	BDL

Sr. #	Sample Code	Al µg/l 200	As µg/l 50	Ba µg/l 700	Cd µg/l 10	Co µg/l NGVS	Cr µg/l 50	Cu µg/l 1500	Mn µg/l 500	Mo µg/l NGVS	Ni µg/l 20	Pb µg/l 50	Sr µg/l NGVS	Zn µg/l 5000
26	SKA-06	5.3	43.22	101.53	BDL	1.41	BDL	1.05	1.91	7.55	BDL	0.61	180.68	BDL
27	SKA-07	6.53	1.05	3.98	BDL	0.79	BDL	0.84		1.96	0.02	BDL	53.98	BDL
28	SKA-08	1.87	1.48	3.81	0.05	1.44	BDL	0.65	0.08	1.02	BDL	2.21	39.89	5.68
29	SKA-09	5.15	BDL	4.2	0.17	0.57	BDL	3.33		0.69	BDL	1.13	53.44	2.68
30	SKA-10	5.03	0.76	2.64	BDL	1.44	BDL	0.95	0.18	0.05	BDL	0.82	73.7	0.51
31	SKA-11	19.88	7.62	17.63	BDL	1.11	BDL	1.04		1.68	0.42	BDL	157.09	BDL
32	SKA-12	7.87	1.83	11.35	BDL	1.22	BDL	2.02	0.02	1.79	BDL	3.23	57.15	5.57
33	SKA-13	7.61	BDL	33.08	0.06	1.45	BDL	1.67		11.4	BDL	0.16	119.96	46.14
34	SKA-14	8.84	10.66	6.9	BDL	0.93	BDL	1.4	0.14	5.26	BDL	BDL	77.88	BDL
35	SKA-15	186.93	6.57	12.58	BDL	1.01	0.39	1.55		0.13	0.13	1.27	264.19	BDL
36	GZR-01	19.81	7	5.66	0.07	BDL	BDL	BDL	0.43	4.48	BDL	BDL	BDL	BDL
37	GZR-02	6.86	1	4.21	BDL	0.18	BDL	BDL		3.54	BDL	BDL	BDL	BDL
38	GZR-03	11.93	BDL	2.55	BDL	BDL	BDL	BDL	BDL	4.78	BDL	BDL	BDL	BDL
39	GZR-04	8.77	BDL	1.1	0.22	0.16	BDL	BDL		2.29	BDL	BDL	BDL	BDL
40	GZR-05	6.03	BDL	4.19	BDL	BDL	BDL	BDL	BDL	1.32	BDL	BDL	BDL	BDL
41	GZR-06	7.3	BDL	4.14	BDL	0.51	BDL	BDL		1.58	BDL	BDL	BDL	BDL
42	GZR-07	11.58	1.3	1.01	BDL	0.36	BDL	BDL	BDL	3.74	BDL	BDL	BDL	BDL
43	GZR-08	27.97	BDL	11.75	0.02	BDL	BDL	BDL		3.64	BDL	BDL	BDL	BDL
44	GZR-09	30.4	2.2	2.3	BDL	0.36	BDL	BDL	BDL	1.13	1.02	BDL	BDL	BDL
45	GZR-10	9.94	BDL	18.82	BDL	0.57	BDL	BDL		16.69	BDL	BDL	BDL	BDL
46	GZR-11	10.11	BDL	5.16	BDL	0.73	BDL	BDL	BDL	6	BDL	BDL	BDL	BDL
47	GZR-12	8.3	BDL	38.68	BDL	0.18	BDL	BDL		2.94	BDL	BDL	BDL	BDL
48	GZR-13	8.89	BDL	12.17	BDL	BDL	BDL	BDL	BDL	3.12	BDL	BDL	BDL	BDL
49	GZR-14	9.41	BDL	0.14	BDL	0.24	BDL	BDL		4.78	BDL	BDL	BDL	BDL
50	GZR-15	9.98	BDL	5.2	BDL	0.03	BDL	BDL	BDL	1.07	BDL	BDL	BDL	BDL
51	GZR-16	10.31	BDL	3.92	BDL	BDL	BDL	BDL		4.66	BDL	BDL	BDL	BDL
52	GZR-17	8.89	0.9	4.23	BDL	BDL	BDL	BDL	BDL	6.77	BDL	BDL	BDL	BDL
53	GZR-18	11.93	0.7	15.64	BDL	0.12	BDL	BDL		6.75	BDL	BDL	BDL	BDL

Sr. #	Sample Code	Al µg/l 200	As µg/l 50	Ba µg/l 700	Cd µg/l 10	Co µg/l NGVS	Cr µg/l 50	Cu µg/l 1500	Mn µg/l 500	Mo µg/l NGVS	Ni µg/l 20	Pb µg/l 50	Sr µg/l NGVS	Zn µg/l 5000
54	GZR-19	5.62	0.7	2.54	0	0.38	BDL	BDL	BDL	4.56	BDL	BDL	BDL	BDL
55	HUN-01	24.16	0.5	19.77	BDL	0.93	BDL	BDL		1.1	BDL	BDL	BDL	BDL
56	HUN-02	10.56	0.5	13.24	BDL	1.1	BDL	BDL	BDL	1.95	BDL	BDL	BDL	BDL
57	HUN-03	8.31	BDL	8.73	BDL	1.16	BDL	BDL		10.98	BDL	BDL	BDL	BDL
58	HUN-04	9.9	9.5	3.7	BDL	BDL	BDL	BDL	BDL	18.53	BDL	BDL	BDL	BDL
59	HUN-05	11.72	1.6	24.41	BDL	BDL	BDL	BDL		112.46	BDL	BDL	BDL	BDL
60	HUN-06	52.65	4.4	8.29	BDL	BDL	BDL	BDL	0.35	5.82	BDL	BDL	BDL	BDL
61	HUN-07	11.08	1.6	8.71	0.07	0.57	BDL	BDL		2.96	BDL	BDL	BDL	BDL
62	HUN-08	1487.16	BDL	70.98	0.42	BDL	BDL	BDL	46.89	6.26	0.35	BDL	BDL	BDL
63	HUN-09	1299.54	BDL	54.47	0.33	0.09	BDL	BDL		5.74	BDL	BDL	BDL	BDL
64	HUN-10	9.7	21	1.67	BDL	0.1	BDL	BDL	0.48	2.92	BDL	BDL	BDL	BDL
65	HUN-11	667.05	8	9.67	0.32	BDL	1.41	BDL		0.61	2.12	BDL	BDL	BDL
66	HUN-12	11.65	15.8	15.59	0.05	0.76	BDL	BDL	BDL	4.6	BDL	BDL	BDL	BDL
67	HUN-13	11.45	3	6.03	0.2	1.12	BDL	BDL		57.54	BDL	BDL	BDL	BDL
68	HUN-14	12.65	1.8	23.04	0.17	0.57	BDL	BDL	BDL	6.48	BDL	BDL	BDL	BDL
69	HUN-15	12.64	0.6	30.7	BDL	0.97	BDL	BDL		5.83	BDL	BDL	BDL	BDL
70	HUN-16	130.71	0.07	9.21	0.26	BDL	BDL	BDL	1.95	1.38	BDL	BDL	BDL	BDL
71	HUN-17	104.49	BDL	28.29	BDL	BDL	BDL	BDL		1.54	BDL	BDL	BDL	BDL
72	HUN-18	35.76	BDL	11.02	BDL	BDL	BDL	BDL	0.58	3.26	BDL	BDL	BDL	BDL
73	HUN-19	174.78	BDL	12.06	0.06	BDL	BDL	BDL		2.42	BDL	BDL	BDL	BDL
74	HUN-20	13.05	1.3	23.19	BDL	0.16	BDL	BDL	BDL	2.46	BDL	BDL	BDL	BDL
75	GIL-01	15.78	1.7	1.33	BDL	0.57	BDL	BDL		12.55	BDL	BDL	BDL	BDL
76	GIL-02	10.34	BDL	12.17	0.01	BDL	BDL	BDL	BDL	1.58	BDL	BDL	BDL	BDL
77	GIL-03	46.47	BDL	10.05	BDL	0.28	BDL	BDL		0.05	BDL	BDL	BDL	BDL
78	GIL-04	24.22	BDL	13.88	BDL	BDL	BDL	BDL	BDL	5.53	BDL	BDL	BDL	BDL
79	GIL-05	11.17	BDL	12.92	BDL	0.77	BDL	BDL		3.32	BDL	BDL	BDL	BDL
80	GIL-06	13.44	1.6	5.7	BDL	BDL	BDL	BDL	BDL	2.03	BDL	BDL	BDL	BDL
81	GIL-07	11.15	0.18	16.29	BDL	0.12	BDL	BDL		3.11	BDL	BDL	BDL	BDL

Sr. #	Sample Code	Al	As	Ba	Cd	Co	Cr	Cu	Mn	Mo	Ni	Pb	Sr	Zn
		µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l
		200	50	700	10	NGVS	50	1500	500	NGVS	20	50	NGVS	5000
82	GIL-08	17.15	BDL	5.17	0.02	0.12	BDL	BDL	0.11	1.76	BDL	BDL	BDL	BDL
83	GIL-09	10.31	BDL	40.56	BDL	BDL	BDL	BDL		9.66	BDL	BDL	BDL	BDL
84	GIL-10	8.89	BDL	4.35	BDL	0.09	BDL	BDL	BDL	3.59	BDL	BDL	BDL	BDL
85	GIL-11	12.97	BDL	18.09	BDL	BDL	BDL	BDL		5.74	BDL	BDL	BDL	BDL
86	GIL-12	11.83	BDL	14.27	BDL	1.07	BDL	BDL	BDL	16.86	BDL	BDL	BDL	BDL
87	GIL-13	11.29	BDL	13.23	BDL	0.46	BDL	BDL		61.77	BDL	BDL	BDL	BDL
88	GIL-14	35.32	BDL	23.75	BDL	0.91	BDL	BDL	0.17	5.63	BDL	BDL	BDL	BDL
89	GIL-15	2.03	BDL	0.83	BDL	0.32	BDL	BDL		BDL	BDL	BDL	BDL	BDL
90	GIL-16	644.88	BDL	12.28	0.07	BDL	3.96	BDL	17.22	7.87	BDL	BDL	BDL	BDL
91	GIL-17	631.05	0.99	11.13	BDL	BDL	1.43	BDL		3.66	0.14	BDL	BDL	BDL
92	GIL-18	22.13	BDL	12.55	BDL	0.19	BDL	BDL	BDL	5.51	BDL	BDL	BDL	BDL
93	GIL-19	811.09	BDL	12.83	BDL	BDL	5.35	BDL		6.56	BDL	BDL	BDL	BDL
94	GIL-20	12.48	BDL	20.26	BDL	0.87	BDL	BDL	BDL	6.69	BDL	BDL	BDL	BDL
Minimum		2	0	0.14	0.00	0	0	1	0	0	0	0	10	0
Average		75.64	6		0.10	1	1		2.82	7	0		98	8
Maximum		1487	43	102	0	2	5	3	47	112	2	4	366	46
No. of samples beyond permissible limit		6	0	0	0		0	0	0		0	0		0

Annexure-V

Enhancement of Testing Capability in Gilgit Water Quality Laboratory:

Up gradation of Gilgit laboratory is done for microbiological analysis i.e. Total Coliforms, Fecal Coliforms and E-coli. Culture media, chemicals, Filtration assembly, glassware and other supplies required for the testing were installed. Training of WQL Gilgit staff was conducted for Microbial testing in field as well as in laboratory, for testing of Total Coliforms, Fecal Coliforms and E-coli. Detailed training of WQL staff is conducted for sterilization, media preparation, use of autoclave, inoculation of water samples using membrane filtration technique, reporting of results and proper disposal of contaminated material.

Microbiological analysis training in Gilgit (WQL)

Establishment of Research Information Cell:

For the setting of research information cell (RIC) linkage was developed between PCRWR, GIlgit (WQL) and Karakoram University. Research publication of PCRWR and other organizations were arranged and proper catalogue is maintained to facilitate students for their research.