Assessment of Drinking Water Quality "Natural Springs and Surface Water" in Gilgit-Baltistan - 2019

Gilgit-Baltistan Environmental Protection Agency (GB-EPA)

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"Natural Springs and Surface Water" in
Gilgit-Baltistan, 2019.

Resource Persons:
Shehzad Hasan Shigri (Director GB-EPA)
Khadim Hussain (Assistant Director R&D/NEQS)
Munawar Hussain Mosvi (Assistant Director EIA/L&E)

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Gilgit-Baltistan Environmental Protection Agency
Shahrah-e-Quaid-e-Azam, Khomer, Gilgit
Phone No. 05811-920676, 920679 Fax No. 05811-922016

Acronyms

Al	Aluminium
As	Arsenic
B	Boron
Ba	Barium
Ca	Calcium
Cd	Cadmium
Cr	Chromium
Cu	Copper
DWSS	Drinking Water Supply Systems
Fe	Iron
GB	Gilgit-Baltistan
GB-EPA	Gilgit-Baltistan Environmental Protection Agency
GBPWD	Gilgit-Baltistan Public Works Department
GDA	Gilgit Development Authority
Hg	Mercury
HM	Heavy Metals
KPK	Khyber Pakhtunkhwa
LG&RD	Local Government and Rural Development Department
MICS	Multiple Indicator Cluster Survey
Mn	Manganese
ND	Not Detected
NDWP	National Drinking Water Policy, 2009
NDWQS	National Drinking Water Quality Standards
Ni	Nickel
PHED	Public Health Engineering Department
PINSTEC	Pakistan Institute of Nuclear Sciences and Technology
Sb	Antimony
Se	Selenium
SO4	Sulphate
WHO	World Health Organization
WSC	Water Supply Complex
Zn	Zinc

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Executive Summary

In Gilgit-Baltistan, there are three main sources of drinking water (springs, rivers and streams); according to an estimate in 2004-05, 62% of households had access to tap water inside or within a reasonable distance from their homes via storage and partial treatment at Water Supply Complexes—the highest rate in Pakistan (GB-Economic Survey Report, 2010). According to Multiple Indicator Cluster Survey 2016-17 (MICS) of Gilgit-Baltistan, 79% of household members are using improved sources of drinking water. Public Health Engineering Department (PHED), Gilgit Development Authority (GDA) and Gilgit-Baltistan Public Works Department (GBPWD) are the custodian departments for construction and operation of Drinking Water Supply Systems (DWSS) in urban areas of Gilgit-Baltistan (GB). Majority of the DWSS are gravity-fed. Raw water is transported to DWSS through man-made channels from nearby water streams. Raw water from rivers is being lifted through pumps in storage tanks and is supplied to the consumers. In rural areas of GB, DWSS are maintained by Local Government and Rural Development Department (LG&RD). The Rural Drinking Water Supply Systems, (RDWSS) are gravity-fed and raw water is mostly taped from natural springs or water streams. Drinking water quality, quantity and access defined in National Drinking Water Policy, 2009 (NDWP) of Pakistan is to provide water complying with National Drinking Water Quality Standards (NDWQS), at least 45 liters in rural and 120 liters in urban areas for per capita per day and time for collection of water and fetch back to home shall not be more than 30 minutes (NDWP, 2009).

Problems associated with drinking water sources are highly dependent on the geological characteristics of the water catchment, anthropogenic activities in the watershed and seasonal hydrological variations. Bacteriological contamination of surface water sources in GB has been reported by many researchers. Turbidity and bacteriological contamination in drinking water sources is a function of season, usually zero in winters and accelerate in springs, reach to maximum in summers and reduce gradually in autumn. Such contaminated natural sources of

water demands specialized public health engineering techniques being used worldwide. In order to ensure safe drinking water to the inhabitants of Gilgit-Baltistan it is recommended to provide integrated water supply systems by providing resilient and protected intake structures, sequential treatment systems for turbidity, biological and chemical contamination.

The study was conducted to assess the chemical quality of drinking water in springs and surface water sources of Gilgit-Baltistan. The first part of the report presents brief account of contextual background and relevant actors. Detailed chemical analysis of drinking water sources from across GB was carried out to ascertain existing drinking water quality. Overall 66 samples were collected and tested in GB-EPA laboratory at Gilgit and then sent to Pakistan Institute of Nuclear Sciences and Technology (PINSTECH) Islamabad for further analysis and confirmation of results. Out of 66 samples (spring and surface water) tested, 79% of the samples were found contaminated with heavy metals; 20 % of the samples were not fit for human consumption according to NDWQS and WHO guidelines, 59% samples contained heavy metals within the permissible limits. Heavy Metals (HM) contamination beyond the limits of NDWQS were 23% from Skardu, 23% from Hunza, 15% from Gilgit, 8% Diamer, 8% Ghizer and 23% from Nagar. Overall 21% of the samples were fit for human consumption.

Background

Access to safe drinking water is one of the most pressing challenges facing the world today. According to World Health Organization (WHO) 13.6% of total deaths (1386.4) in Pakistan are attributed to water, sanitation and hygiene (Prüss-Üstün et al., 2008). In recent times, there has been an increasing health related concern associated with the quality of drinking water.

The water supply sector in Pakistan is characterized by extremely low level of coverage particularly in the rural areas; water supply coverage through piped network and hand pumps is around 66%. High arsenic found in major industrial cities of Punjab due to industrial and chemical waste discharge, elevated concentrations of iron reported in Khyber Pakhtunkhwa (KPK) while high turbidity level is observed in Sindh (Soomro et al., 2011).

GB is the water tower for rest of the country; its glaciers provide 50.5billion cubic meters of water to river Indus annually that corresponds to 70% of mean annual flow. Access to water is not an issue in GB, however quality of water has always been a concern in the region. Rapid population growth, economic advances, anthropogenic activities, lack of planning, capacities, and financial resources along with climate change are the fundamental factors for deterioration of surface water quality in GB.

Surface water is the main source of water supply in urban areas of Gilgit-Baltistan. Usage of groundwater for domestic water supply is not common except in the low lying settlements of Gilgit city and a few riverside villages in Skardu, where people draw water from shallow wells. Quantity of water supply reduces in winter season due to reduced glacial melt in most of the urban areas.

This survey was conducted in selected areas to identify concentration of different chemicals and heavy metals in springs and surface drinking water sources of GB. The finding of the study would provide a way forward to plan and implement water supply projects keeping in view the hazards posed by heavy metals to

human health and their occurrence in natural spring and streams, once considered safe and sacred, across GB.

Contextual Analysis

Human gets exposed to heavy metals through inhalation and ingestion; long lasting bioaccumulation and toxicity of heavy metals has demonstrated a great threat for human health and environment. These chemicals enter water sources as a result of erosion process that occurs when the water flows over different land formations containing heavy metals. In mountainous area like GB, springs are formed due to water infiltration into cracks at higher elevations and oozes out at the other end at lower elevations through percolation under gravity. During this phenomena, flowing water erode the ground formation and take away minerals and heavy metals. The toxicity of metals to human depends on duration, concentration and route of exposure. Due to free radical formation, these metals can bio-accumulate in human body and cause various chronic disorders. Exposure to these metals can lead to diseases such as Cancer, Kidney failure, Mental retardation, Muscular dystrophy, Parkinson's disease, Alzheimer's disease and Multiple sclerosis (Duruibe et al., 2007).

Table 1: Heavy metals, Health effects and Regulatory limits (Martin et al., 2009; Mohod et al., 2013; Jaishankar et. al., 2014 and Duruibe et al., 2007)

Element	*Health Effects*	*NDWQS Limit*	*WHO Guidelines*
Arsenic (As)	• Anxiety • Carcinogen • Cell damage • Appearance of corns on soles, palms and torso	0.05mg/l	0.01mg/l
Barium (Ba)	• Cause muscle weakness, blood pressure, diarrhoea, difficulties in breathing, and vomiting and abdominal cramps on short-term exposure • Intake of larger amount can cause paralysis, high blood pressure and heart problems	0.7 mg/l	0.7 mg/l

Element	*Health Effects*	*NDWQS Limit*	*WHO Guidelines*
Cadmium (Cd)	• Carcinogen. • Severe damage to the lungs • Irritates the stomach, leading to vomiting and diarrhoea • Kidney disease, lung damage, and fragile bones	0.01mg/l	0.003mg/l
Chromium (Cr)	• Cause cancer, whereas it is also a vital nutrient in a trace amount • Damage kidney, liver, nerve tissues and cause skin irritation on long term exposure	0.05mg/l	0.05mg/l
Mercury (Hg)	• Mercury is likely to be known as carcinogen • Damage nervous system • High level of exposure can damage kidneys, developing foetuses • Impacts on brain functioning • Vision and hearing disorders	0.001mg/l	0.001mg/l
Selenium (Se)	• For humans it is an essential nutrient in trace amount • Consumption above that level can lead to selenosis • Short-term oral exposure causes nausea, vomiting, and diarrhoea • Hair loss, nail brittleness, and neurological abnormalities. • Respiratory diseases and stomach pains. Longer-term exposure can cause respiratory irritation, bronchial spasms, and coughing.	0.01mg/l	0.01mg/l
Aluminum (Al)	• Toxic and harmful to nervous, osseous and hemopoietic cells • Aluminum may disturb cellular growth, intercellular communication and secretory functions. Aluminum is neuro toxic and cause neuronal atrophy.	0.2mg/l	0.2mg/l

Element	*Health Effects*	*NDWQS Limit*	*WHO Guidelines*
Zinc (Zn)	• Over dose may lead to vomiting, nausea, stomach pain • Long-time exposure can cause anemia and damage pancreas and decrease level of high density lipoprotein cloistral	5mg/l	3mg/l
Manganese (Mn)	• Toxicity to the nervous system	0.5 mg/l	0.5 mg/l
Boron (B)	• Causes nausea, vomiting, diarrhea and blood clotting	0.3mg/l	
Nickel (Ni)	• Cause cancer of throat, nose, stomach and lungs	0.02 mg/l	0.02 mg/l
Copper (Cu)	• High level in drinking water may cause chronic anemia • Coronary heart diseases and high blood pressure	1.5mg/l	1.5mg/l
Antimony (Sb)	• Cause irritation in respiration, genotoxic, pneumoconiosis and antimony spot on the skin	0.005mg/l	0.005mg/l

Objectives

1. The study aims to investigate the level of heavy metal contamination in springs and surface water sources and their potential health risk.
2. To sensitize public and water supply providers and to advocate the policy makers on health hazards of spring water and to devise their possible remedial measures.

Methodology

Simple random sampling method was adopted and collected 66 samples in accordance with Environmental Sampling Rules, 2001 notified by Government of Pakistan. Spring water sources, nullahs, rivers, point sources as well as community taps were selected. Samples were selected on basis of their use for drinking purpose by nearby communities or by visitors. The representative samples (1L each) was collected from springs (51), rivers (5) and streams/nullahs (10). From each sampling point, water samples were collected in cleaned plastic bottles pre-washed with 20% diluted nitric acid and transported in ice box to maintain the temperature. GB-EPA procured equipment Metalyser HM2000 serial No. MY-011-006 made in the United Kingdom was used to test cadmium (Cd), lead (Pb), mercury (Hg), arsenic (As) and zinc (Zn) while Metalometer HM2000 serial No.MM005-007 made in the United Kingdom was used to detect aluminium (Al), boron (B), iron (Fe), copper (Cu), manganese (Mn), chromium (Cr) and nickel (Ni). The samples were then sent to Pakistan Institute of Nuclear Sciences and Technology (PINSTECH), Islamabad for further detailed chemical analysis. Equipment and techniques used for analysis of metals at PINSTECH are shown in table 2.

Table 2: Equipment used for analysis

Metals	***Equipment Used to detect Heavy Metals***
Al, B, Ba, Ca, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, SO4, Si, Sr, Zn	ICP-OES (Inductively Coupled Plasma Optical Emission Spectrometry 6500 from Thermo Fisher Scientific UK)
As, Cd, Hg,Cr, Cu, Pb, Sb, Se	GFAAS (Graphite Furnace Atomic Absorption Spectroscopy), HGAAS (Hydride Generation Atomic Absorption Spectrometry)

Health Risk Assessment

Chronic daily intakes (CDI) of metals

Heavy Metals enter into human body through different pathways, which are inhalation, skin contact and food intake. Oral intake of heavy metals is considered more significant as compared to other routes of exposure.

By using following formula Chronic Daily Intake (CDI (µg/kg-day)) can be calculated;

$$CDI = \frac{Cm \times Iw}{Wb}$$

Whereas;

- Cm (µg/l) is the concentration of HM in drinking water.
- IW (L/day) is the daily average intake of water (assumed to be 2 L/day for adult and 1L/day for child).
- Wb is the average weight of body (assumed to be 72 kg for adults and 32.7kg for child)

Health risk indexes (HRIs) of metals

Estimation of chronic health risks, HRIs can be calculated by using following formula:

$$HRI = \frac{CDI}{RfD}$$

Where, the oral toxicity reference dose (RfD, µg/(kg·day)) values for Cd, Cr, Cu, Mn, Ni, Pb and Zn are 5.0E-01, 1.5E+03, 3.7E+01, 1.4E+02, 2.0E+01, 3.6E+01 and 3.0E+02 respectively. The HRI value less than one is considered to be safe for the consumers. A reference dose is the United States Environmental Protection Agency's maximum acceptable oral dose of a toxic substance.
(Muhammad et al., 2011; Khan et al., 2013 and US-EPA 2011).

Results and Discussions

Among the samples tested, 20% of samples were found unfit for human consumption, 59% of the samples were containing more than one heavy metal at a time and 21% samples were free of any contamination. Table 3 presents summary results.

Table 3: Cumulative (i.e. springs, rivers and streams/nullahs) district-wise summary of test results

District	*Water Sources Tested*	*Sources Contaminated with Heavy Metals exceeding permissible limits*	*Sources having Heavy Metals within Permissible Limits*	*Sources Safe for Drinking Water*
Ghizer	10	1	6	3
Gilgit	18	2	11	5
Astore	5	0	5	0
Nagar	6	3	3	0
Hunza	14	2	10	2
Skardu	9	3	3	3
Diamer	4	1	2	1
Total	66	13	39	14

Detailed Chemical Analysis of Selected Drinking Water Sources in Skardu

In Skardu district, samples collected and tested from Tungus, Gol and Sildi Shigar were free of heavy metals and are safe for human consumption. Samples collected from Astak, Sermik and Hussainabad contains heavy metals, but the concentration found was below the permissible limits set by NDWQS as shown in table 4. Such sources are safe for occasional use but not recommended for long-

term consumption as the metals may accumulate in human body and can have adverse health impacts.

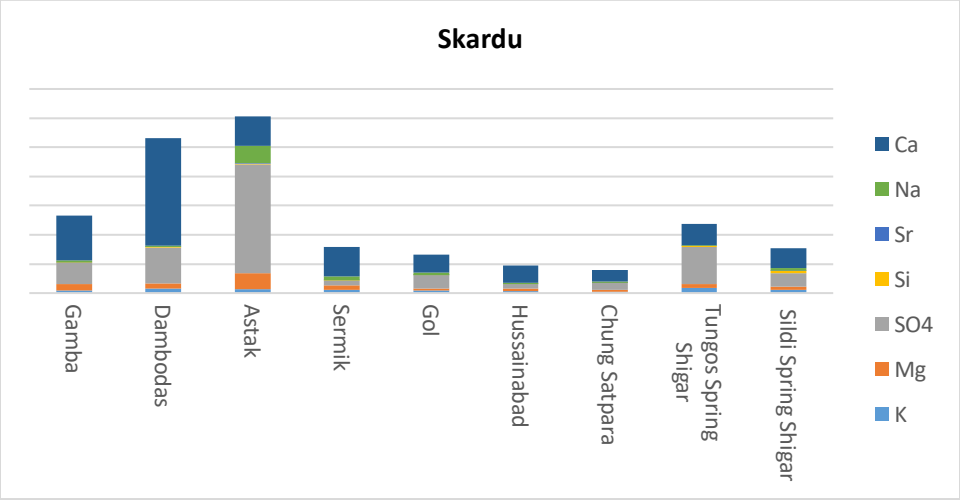

Figure 1: Concentration of Chemicals in water sources of Skardu (not listed in NDWQS)

Moreover, presence of more than one heavy metal at a time in a sample even below NDWQS limits can lead to adverse health effects. The remaining three samples (Chong Satpara, Dambudas and Gamba) contain Mercury (Hg) and Arsenic (As) with higher concentration exceeding the permissible limits of NDWQS and WHO guidelines (2004), therefore these water sources are not safe for human consumption (drinking).

Table 4: Concentration of Heavy Metals (mg/l) in drinking water sources of Skardu

Sample Location	Source	Concentration of Heavy Metals (mg/l)					
		Ba	As	Zn	Hg	B	Sb
Gamba	Spring	0.01	0.002	0.03	0.06	ND	ND
Dambodas	Spring	0.03	0.11	0.04	0.0007	ND	ND
Astak	Spring	0.01	0.002	ND	ND	0.23	0.0009
Sermik	Spring	0.06	ND	ND	ND	ND	ND
Gol	Spring	ND	ND	ND	ND	ND	ND
Hussainabad	Spring	0.01	ND	ND	0.0009	ND	ND
Chung Satpara	Spring	ND	0.017	ND	0.0036	ND	ND

Sample Location	Source	Concentration of Heavy Metals (mg/l)					
		Ba	As	Zn	Hg	B	Sb
Tungos Spring Shigar	Spring	ND	ND	ND	ND	ND	ND
Sildi Spring Shigar	Spring	ND	ND	ND	ND	ND	ND

(Ba: Barium As: Arsenic Zn: Zinc Hg: Mercury B: Boron Sb: Antimony)

Detailed Chemical Analysis of Selected Drinking Water Sources in Hunza

Sample taken from Main Ultar Nullah was found unfit for human consumption as it is highly contaminated with Barium (Ba), Manganese (Mn), Aluminum (Al), Chromium (Cr) and Nickel (Ni) exceeding the NDWQS and WHO guidelines. Similarly, Altit Nullah contains Mercury (Hg), which is considered as one of the most perilous element for human health and environment.

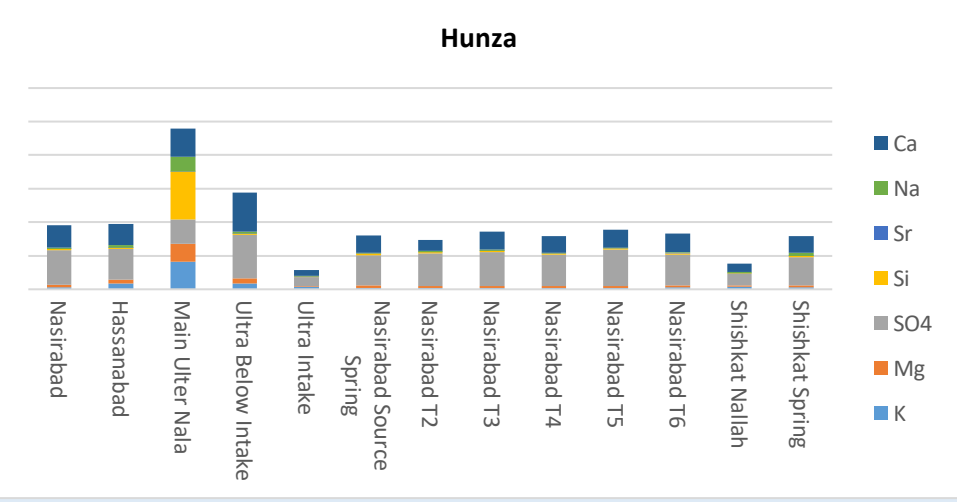

Figure 2: Concentration of Chemicals in water sources of Hunza (not listed in NDWQS)

Only two samples (Shiskat Nullah Gojal and Shishkat Spring Gojal) were found free from heavy metals and are safe for human consumption. Remaining sources Ultar Nullah Intake, Nasirabad tap sample T3, Nasirabad T4, Nasirabad T6,

Hassanabad, Nasirabad source, Nasirabad T2 and Nasirabad T5 contains concentration of heavy metals within NDWQS limits.

Table 5: Concentration of Heavy Metals (mg/l) in drinking water sources of Hunza

Sample Location	Source	Concentration of Heavy Metals (mg/l)									
		Ba	As	B	Zn	Hg	Mn	Al	Cr	Ni	Cu
Nasirabad	Spring	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hassanabad	Spring	ND	0.017	ND	ND	ND	ND	ND	ND	ND	ND
Main Ultar Nullah	Stream	1.51	ND	ND	0.31	ND	2.11	161.67	0.09	0.1	0.07
Ultar Nullah Spring below intake	Spring	0.04	ND	0.03	ND	ND	ND	ND	ND	ND	ND
Ultar Nullah intake channel near Baltit Fort	Stream	0.04	ND	ND	ND	ND	0.03	1.07	ND	ND	ND
Nasirabad Source Spring	Spring	ND	0.003	ND	ND	ND	ND	ND	ND	ND	ND
Nasirabad T1	Spring	ND	0.006	ND	ND	ND	ND	ND	ND	ND	ND
Nasirabad T2	Spring	ND	0.003	ND	ND	ND	ND	ND	ND	ND	ND
Nasirabad T3	Spring	0.01	0.002	ND	ND	ND	ND	ND	ND	ND	ND
Nasirabad T4	Spring	0.01	0.003	ND	ND	ND	ND	ND	ND	ND	ND
Nasirabad T5	Spring	ND	0.003	ND	ND	ND	ND	ND	ND	ND	ND
Nasirabad T6	Spring	0.01	0.003	ND	ND	ND	ND	ND	ND	ND	ND
Shishkat Nullah Gojal	Stream	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Shishkat Spring Gojal	Spring	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Altit Nullah	Stream	ND	ND	ND	ND	3.5	ND	ND	ND	ND	ND

(Ba: Barium As: Arsenic Zn: Zinc Hg: Mercury B: Boron Mn: Manganese Al: Aluminum Cr: Chromium Ni: Nickel Cu: Copper)

Detailed Chemical Analysis of Selected Drinking Water Sources in Nagar

Among the samples collected from district Nagar, Hopper-Hisper river was contaminated with Barium (Ba), Manganese (Mn), Chromium (Cr) and Nickle (Ni) exceeding the regulatory limits. Hakochar 1 and 2 contains the concentration of Mercury (Hg) and Boron (B) beyond National Drinking Water Quality Standards.

Remaining samples collected from Nagar-1 Pono, Pissan 1 and 2 contains the concentration of heavy metals within the permissible limits shown in table 6.

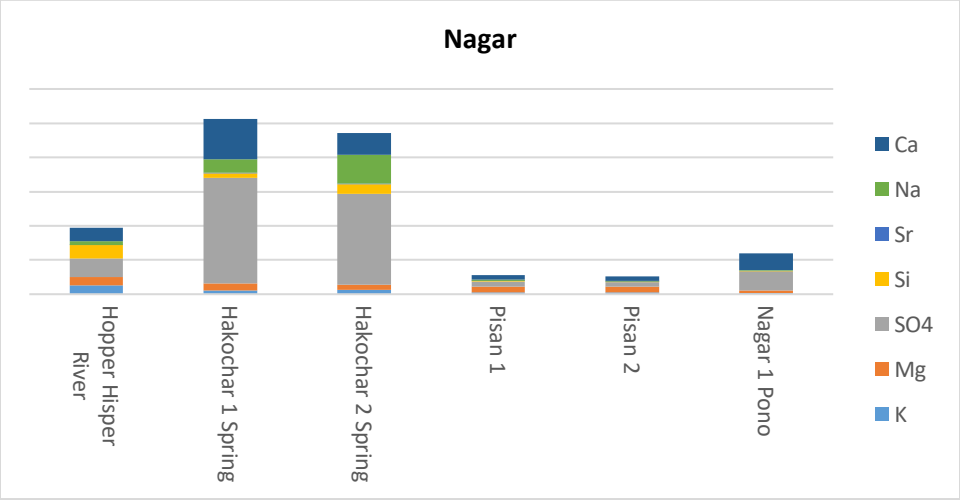

Figure 3: Concentration of Chemicals in water sources of Nagar (not listed in NDWQS)

Table 6: Concentration of Heavy Metals (mg/l) in drinking water sources of Nagar

Sample Location	Source	Concentration of Heavy Metals (mg/l)									
		Ba	As	B	Zn	Hg	Mn	Al	Cr	Ni	Cu
Hopper Hisper River	River	0.72	0.0068	0.02	1.02	ND	1.13	99.92	0.2	0.15	0.09
Hakochar 1 Spring	Spring	ND	0.0027	0.82	ND	0.004	ND	ND	ND	ND	ND
Hakochar 2 Spring	Spring	ND	0.0063	2.33	ND	ND	ND	ND	ND	ND	ND
Pisan 1	Spring	ND	0.002	ND	0.04	ND	ND	ND	ND	ND	ND
Pisan 2	Spring	ND	0.0012	ND	ND	ND	ND	ND	ND	ND	ND
Nagar-1 Pono	Spring	0.01	0.0072	ND	ND	ND	ND	ND	ND	ND	ND

(Ba: Barium As: Arsenic Zn: Zinc Hg: Mercury B: Boron Mn: Manganese Al: Aluminum Cr: Chromium Ni: Nickel Cu: Copper)

Detailed Chemical Analysis of Selected Drinking Water Sources in Astore

The samples collected from Astore district were found satisfactory for occasional drinking since the concentrations of heavy metals present are below the permissible limits of NDWQS and WHO guidelines. However, continuous consumption from these sources is not recommended.

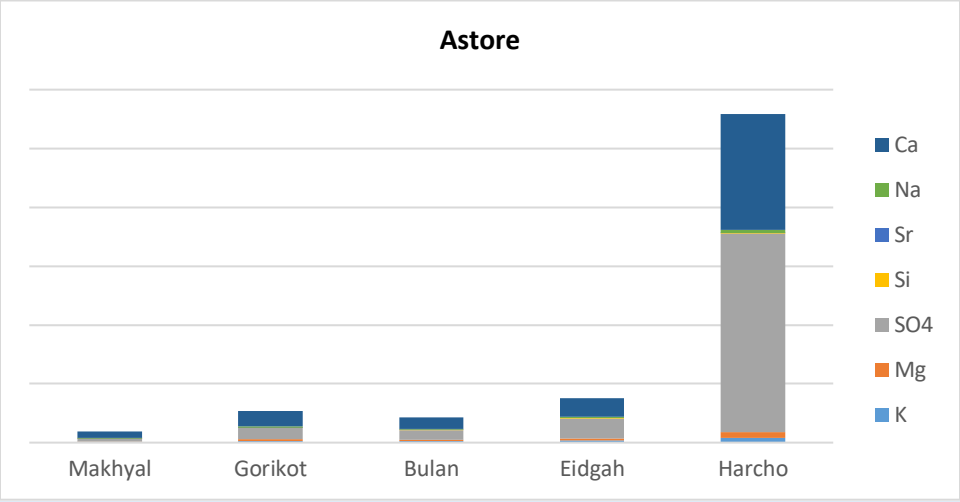

Figure 4: Concentration of Chemicals in water sources of Astore (not listed in NDWQS)

Table 7: Concentration of Heavy Metals (mg/l) in drinking water sources of Astore

Sample Location	Source	Concentration of Heavy Metals (mg/l)			
		Barium	Arsenic	Mercury	Antimony
Makhyal	River	ND	ND	ND	0.002
Gorikot	Spring	0.01	ND	ND	ND
Bulan	Spring	0.01	0.00153	ND	0.002
Eidgah	Spring	0.01	0.00144	0.01	0.009
Harcho	Spring	0.01	ND	ND	0.007

Detailed Chemical Analysis of Selected Drinking Water Sources in Gilgit

Gilgit five sources (Jalalabad T1, Barmus WSC outlet, Jutial WSC outlet and Jutial WSC Inlet) were found free from heavy metals, whereas eleven samples (Guro Juglot, Amphary II, Nagaral, Gilgit River RTC, Gilgit River Basin, Gilgit River City Hospital, Chamoghar, Datuchi, Sinakir, Farfo, Barmus WSC Inlet) were found satisfactory. Sample collected from Bulchi was contaminated with Manganese (Mn) beyond the permissible limits and the sample collected from Amphary I was contaminated with Mercury (Hg), therefore these water sources are unfit for drinking.

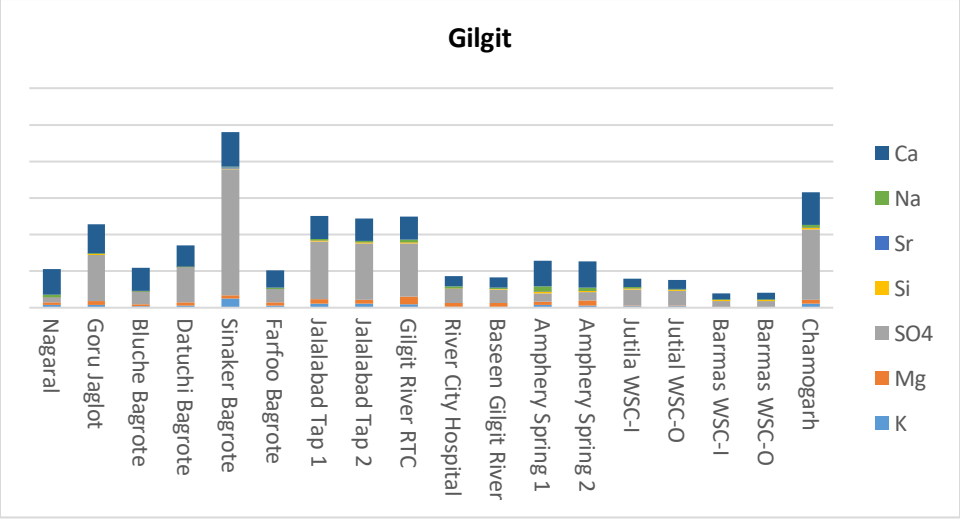

Figure 5: Concentration of Chemicals in water sources of Gilgit (not listed in NDWQS)

Table 8: Concentration of Heavy Metals (mg/l) in drinking water sources of Gilgit

Sample Location	Source	Concentration of Heavy Metals (mg/l)						
		Ba	As	B	Zn	Hg	Mn	Se
Nagaral	Well	ND	ND	ND	ND	ND	ND	ND
Guro Juglot	Spring	0.04	0.00261	0.04	ND	ND	ND	ND
Bluche Bagrote	Spring	ND	ND	ND	0.03	ND	0.66	ND

Sample Location	Source	Concentration of Heavy Metals (mg/l)						
		Ba	As	B	Zn	Hg	Mn	Se
Datuchi Bagrote	Spring	ND	ND	ND	0.03	ND	ND	ND
Sinaker Bagrote	Spring	ND	ND	ND	0.04	ND	ND	ND
Farfoo Bagrote	Spring	ND	0.00229	ND	0.03	ND	ND	0.00101
Jalalabad T 1	Stream	ND	ND	ND	0.01	ND	ND	ND
Jalalabad T 2	Stream	ND	ND	ND	0.02	ND	ND	ND
Gilgit River RTC	River	ND	0.001	ND	ND	ND	ND	ND
City Hospital	River	ND	0.00258	ND	ND	ND	ND	ND
Baseen Glt River	River	ND	0.002	ND	ND	ND	ND	ND
Amphary 1	Spring	ND	ND	ND	ND	0.002	ND	ND
Amphary 2	Spring	ND	ND	ND	ND	ND	ND	ND
Jutial WSC (I)	Stream	ND	ND	ND	ND	ND	ND	ND
Jutial WSC (O)	Stream	ND	ND	ND	ND	ND	ND	ND
Barmus WSC (I)	Stream	ND	0.0011	ND	ND	ND	ND	ND
Barmus WSC (O)	Stream	ND	ND	ND	ND	ND	ND	ND
Chamoghar	Spring	ND	ND	ND	ND	ND	ND	0.00099

(Ba: Barium As: Arsenic Zn: Zinc Hg: Mercury B: Boron Mn: Manganese Se: Selenium)

Detailed Chemical Analysis of Selected Drinking Water Sources in Ghizer

In Ghizer district three samples collected from Gupis, Gutumas and Hyme are safe for human consumption. Whereas, samples collected from Yasin, Taos bala, Nazber, Aminabad, Gindai and Birghal were found to be satisfactory. Sample collected from Barsat was not fit for human consumption due to the presence of Boron (B) and Manganese (Mn) above the permissible concentrations of NDWQS and WHO guidelines.

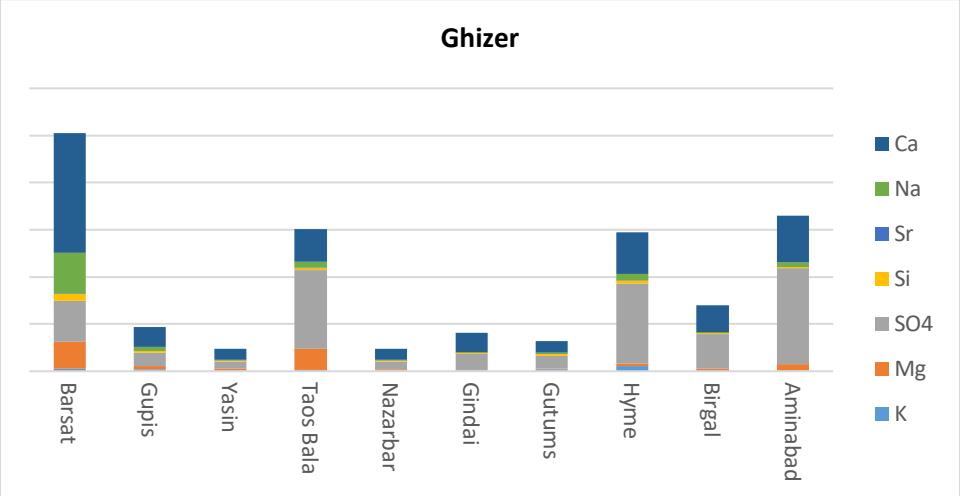

Figure 6: Concentration of Chemicals in water sources of Ghizer (not listed in NDWQS)

Table 9: Concentration of Heavy Metals (mg/l) in drinking water sources of Ghizer

Sample Location	Source	Concentration of Heavy Metals (mg/l)				
		Barium	Arsenic	Zinc	Mercury	Manganese
Barsat	Spring	0.02	0.012	0.01	0.00074	0.86
Gupis	Spring	ND	ND	ND	ND	ND
Yasin	Spring	0.01	ND	0.04	ND	ND
Taos Bala	Spring	0.01	ND	ND	ND	ND
Nazber	Stream	0.01	ND	0.12	ND	ND
Gindai	Spring	ND	0.003	ND	ND	ND
Gutums	Spring	ND	ND	ND	ND	ND
Hyme	Spring	ND	ND	ND	ND	ND
Birgal	Spring	ND	ND	ND	ND	ND
Aminabad	Spring	0.01	ND	ND	ND	ND

Detailed Chemical Analysis of Selected Drinking Water Sources in Diamer

In Gunar Farm nullah the concentration of Chromium (Cr) was above NDWQS and WHO guidelines, which makes the source unfit for human consumption, whereas

in Bunardas and Gas Pain, the concentration is below the standard limits. Chilas Nullah water was found safe as no heavy metal was detected.

Table 10: Concentration of Heavy Metals (mg/l) in drinking water sources of Diamer

Sample Location	Source	Concentration of Heavy Metals (mg/l)		
		Barium	Arsenic	Chromium
Bunar Das	Stream	0.01	0.023	ND
Gas Pain	Stream	0.03	ND	ND
Chilas Nullah	Stream	ND	ND	ND
Gonar Farm	Stream	0.01	0.005	0.062

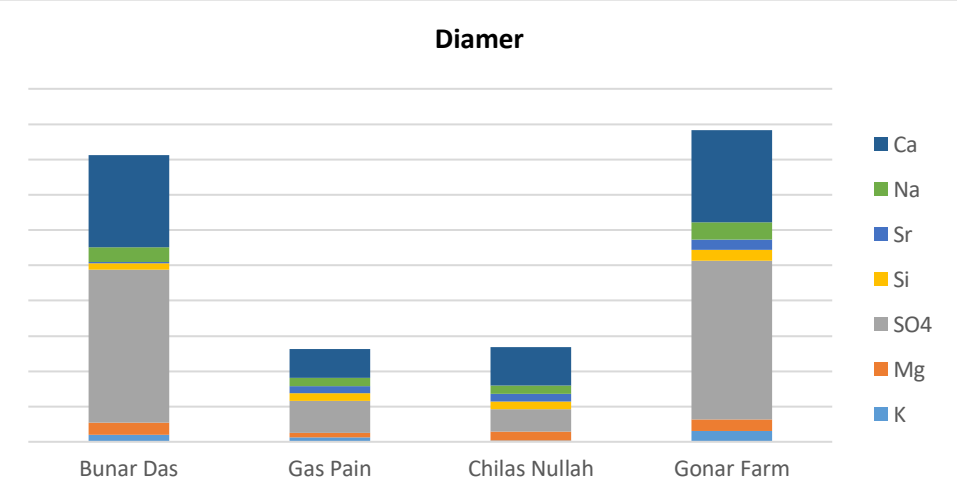

Figure 7: Concentration of Chemicals in water sources of Diamer (not listed in NDWQS)

Table 11: Summary of metals and sources exceeding permissible limits

District	Source of Drinking Water	Metals found above NSDWQ and WHO Guidelines
Skardu	Gamba, Chong Satpara	Mercury
	Dambudas, Chong Satpara	Arsenic
Hunza	Main Ultar Nullah	Barium, Manganese, Aluminum, Chromium and Nickel
	Altit Nullah	Mercury
Nagar	Hopper Hispar River	Manganese, Chromium, Nickel and Barium
	Hakochar 1	Mercury and Boron

District	*Source of Drinking Water*	*Metals found above NSDWQ and WHO Guidelines*
	Hakochar 2	Boron
Gilgit	Amphari 1	Mercury
	Bulchi	Manganese
Ghizer	Barsat	Boron and Manganese
Diamer	Gunar Farm	Chromium

Chemicals Not Listed in National Drinking Water Quality Standards (NDWQS) and WHO Guidelines

Calcium, Potassium, Sodium, Silicon, Strontium and SO_4 have not been defined in National Drinking Water Quality Standards. Certain amount of these metals is essential for normal functioning of human body but exposure to high concentrations and/or longer exposure may lead to toxicity. Mean and minimum concentration of Potassium (K) was 19.83 and 0.25mg/l respectively found in Birgal Ghizer while 81.9mg/l was the highest value recorded at main Ulter Nallah Hunza. Highest value of Sodium (167.33 mg/l) was recorded at Hakochar Spring Nagar and lowest was at Ultar Nullah (0.26 mg/l), 10.42 mg/l was derived as the mean value of Sodium from all sources.

Highest Magnesium concentration (57mg/l) was found in Barsat Ghizer and a minimum (0.92mg/l) in Makhyal Astore. The mean concentration of Silicon (Si) and Strontium (Sr) were 7.3 and 0.5 mg/l one to one. In main Ultar Nallah Hunza, concentration of Silicon was highest that is 143 mg/l. Strontium concentration of 6.07mg/l was recorded at Gonar Farm Chilas as the highest. During spring Hakochar-1 (Nagar-1) the concentration of sulphate was recorded highest as 618.8mg/l, and at Makhyal Astore a minimum concentration of 4.68 mg/l was observed, the mean value of sulphates derived from all sources is 7.3mg/l.

Conclusion

This report concludes that most of the drinking water sources in GB are contaminated with heavy metals, which are attributed to the natural geogenic processes taking place in the strata of this region, these metals are potential environmental contaminants and hazardous to human health, thus there is a dire need to reduce the risk of exposure. It is opined that presence of these chemicals in springs and surface water sources are the main cause of the health issues in the people of GB.

Water supply is a specialized subject of Public Health Engineering being dealt in the region through conventional methods and practices. A water supply system in GB is meant to take water from the source and store it in a tank for the subsequent supply to the command area without any treatment, keeping in view the water quality and its demand for making it safe. The treatment system to remove chemical contamination from drinking water is highly technical and expensive. It is better option to avoid the source contaminated with chemicals.

Keeping in view the above it is highly recommended that future planning of water supply systems shall take into account the nature and concentration of the pollutants in the water source and provision of appropriate treatment systems, if feasible.

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Annexure 1: Source-wise Detailed Results

Table 12: Legends

Heavy Metals in Drinking Water Sources	×	✓	±
	Exceeding limits of NDWQS and WHO guidelines	Absence of metals	Presence of metals within limits
Overall Quality	×	✓	±
	Not fit for drinking	Fit for drinking	Not recommended for continuous consumption

Table 13: Detailed results of water sources in District Skardu

Water Source	Ba	As	Zn	Hg	B	Sb	Mn	Se	Al	Cr	Ni	Cu	Overall Quality
Gamba	±	±	±	×	✓	✓	✓	✓	✓	✓	✓	✓	×
Dambudas	±	×	±	±	✓	✓	✓	✓	✓	✓	✓	✓	×
Astak	±	✓	✓	✓	±	✓	✓	✓	✓	✓	✓	✓	±
Sermik	±	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	±
Hussainabad	±	✓	✓	±	✓	✓	✓	✓	✓	✓	✓	✓	±
Tungus	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
GoI	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Chong Satpara	✓	±	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	×
Sildi Shigar	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 14: Detailed results of water sources in District Hunza

Water Source	Ba	As	Zn	Hg	B	Sb	Mn	Se	Al	Cr	Ni	Cu	Overall Quality
Main Ultar Nullah	×	✓	±	✓	✓	✓	×	✓	×	×	×	×	×
Ultar Nullah Spring Intake	±	×	✓	✓	±	✓	✓	✓	✓	✓	✓	✓	×

Water Source	Ba	As	Zn	Hg	B	Sb	Mn	Se	Al	Cr	Ni	Cu	Overall Quality
Ultar Nullah near Baltit Fort	±	✓	✓	✓	✓	✓	±	✓	±	✓	✓	✓	±
Nasirabad T3	±	±	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	±
Nasirabad T4	±	±	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	±
Nasirabad T6	±	±	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	±
Shishkat Nullah Gojal	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Shishkat Spring Gojal	✓	±	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	±
Hassanabad	✓	±	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	±
Nasirabad Source	✓	±	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	±
Nasirabad T2	✓	±	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	±
Nasirabad T5	✓	±	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	±
Altit Nullah	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	×

Table 15: Detailed results of water sources in District Nagar

Water Sources	Ba	As	Zn	Hg	B	Sb	Mn	Se	Al	Cr	Ni	Cu	Overall Quality
Hopper Hispar River	±	±	±	✓	±	✓	×	✓	✓	×	×	±	×
Pissan1 (Nagar 1)	±	±	±	✓	✓	✓	✓	✓	✓	✓	✓	✓	±
Pissan2 (Nagar 1)	±	±	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	±
Hakochar 1 Spring	±	±	✓	×	×	✓	✓	✓	✓	✓	✓	✓	×
Hakochar 2 Spring	±	±	✓	✓	×	±	✓	✓	✓	✓	✓	✓	×
Nagar 1 Pono	±	±	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	±

Table 16: Detailed results of water sources in District Astore

Water Sources	Ba	As	Zn	Hg	B	Sb	Mn	Se	Al	Cr	Ni	Cu	Overall Quality
Makiyal	±	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	±
Gorikot	±	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	±
Bolan	±	±	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	±
Eidgah	±	✓	±	✓	✓	±	✓	✓	✓	✓	✓	✓	±

Water Sources	Ba	As	Zn	Hg	B	Sb	Mn	Se	Al	Cr	Ni	Cu	Overall Quality
Harcho	±	✓	✓	✓	✓	±	✓	✓	✓	✓	✓	✓	±

Table 17: Detailed results of water sources in District Gilgit

Water Sources	Ba	As	Zn	Hg	B	Sb	Mn	Se	Al	Cr	Ni	Cu	Overall Quality
Guro Juglot	±	±	✓	✓	±	✓	✓	✓	✓	✓	✓	✓	±
Amphary I	±	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	×
Amphary II	±	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	±
Nagaral	✓	✓	±	✓	✓	✓	✓	✓	✓	✓	✓	✓	±
Gilgit River RTC	±	±	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	±
Gilgit River Basin	±	±	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	±
River City Hospital	±	±	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	±
Chamoghar	✓	✓	✓	✓	✓	✓	✓	±	✓	✓	✓	✓	±
Jalalabad T1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Jalalabad T2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Bulche Bagrote	±	✓	±	✓	✓	±	×	✓	✓	✓	✓	✓	×
Datuchi Bagrote	±	✓	±	✓	✓	✓	✓	✓	✓	✓	✓	✓	±
Sinakir Bagrote	±	✓	±	✓	✓	✓	✓	✓	✓	✓	✓	✓	±
Farfoo Bagrote	±	±	±	✓	✓	✓	✓	✓	✓	✓	✓	✓	±
Barmus WSC (O)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Barmus WSC (I)	✓	±	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	±
Jutial WSC (O)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Jutial WSC (I)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 18: Detailed results of water sources in District Ghizer

Water Sources	Ba	As	Zn	Hg	B	Sb	Mn	Se	Al	Cr	Ni	Cu	Overall Quality
Barsat	±	±	±	✓	×	✓	×	✓	✓	✓	✓	✓	×
Yasin	±	✓	±	✓	✓	✓	✓	✓	✓	✓	✓	✓	±
Taosbala	±	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	±
Nazber	±	✓	±	✓	✓	✓	✓	✓	✓	✓	✓	✓	±
Aminabad	±	±	✓	✓	✓	✓	✓	±	✓	✓	✓	✓	±
Gupis	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Gindai	✓	±	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	±

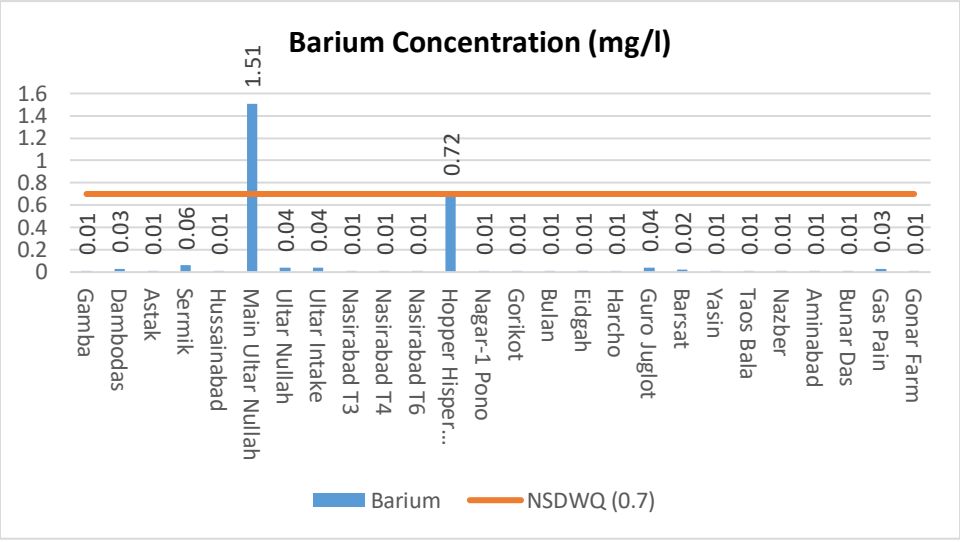
Water Sources	Ba	As	Zn	Hg	B	Sb	Mn	Se	Al	Cr	Ni	Cu	Overall Quality
Chutumas	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Hymi	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Birghal	✓	✓	✓	±	✓	✓	✓	✓	✓	✓	✓	✓	±

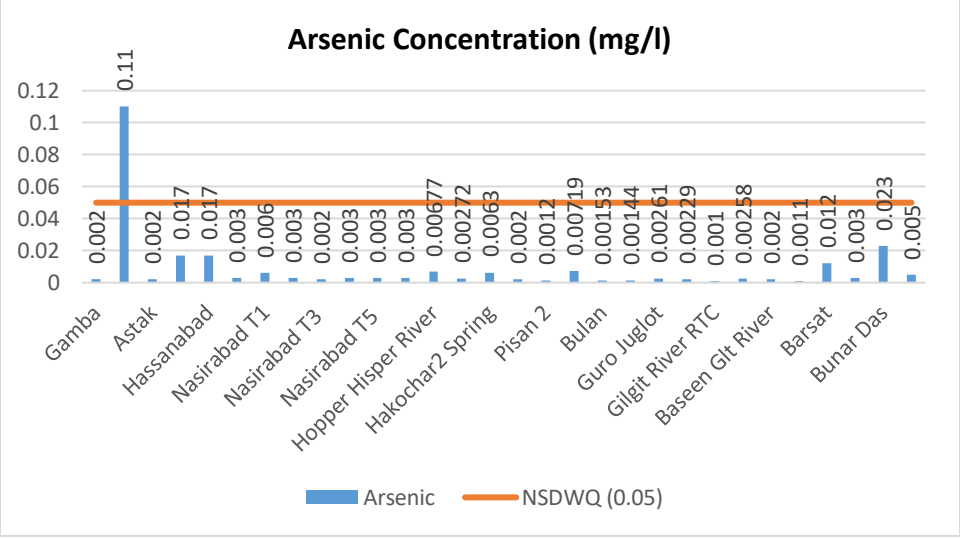
Table 19: Detailed results of water sources in District Diamer

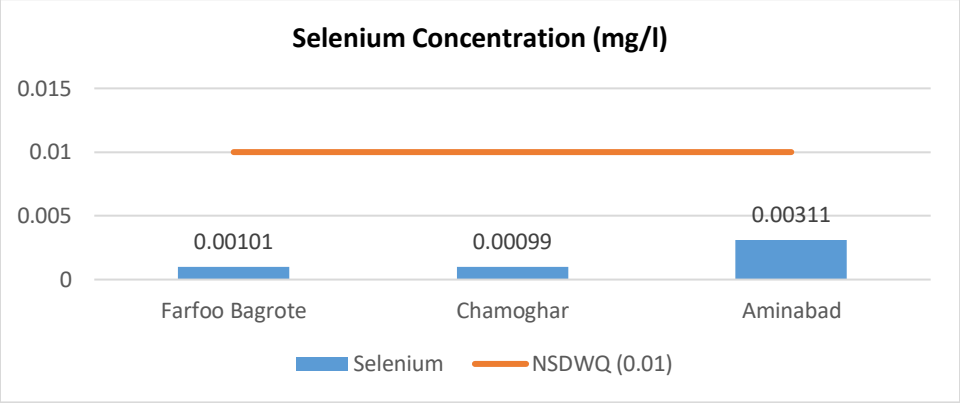
Water Sources	Ba	As	Zn	Hg	B	Sb	Mn	Se	Al	Cr	Ni	Cu	Overall Quality
Bunardas	±	±	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	±
Gaspin	±	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	±
Chilas Nullah	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Gunar farm	±	±	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	×

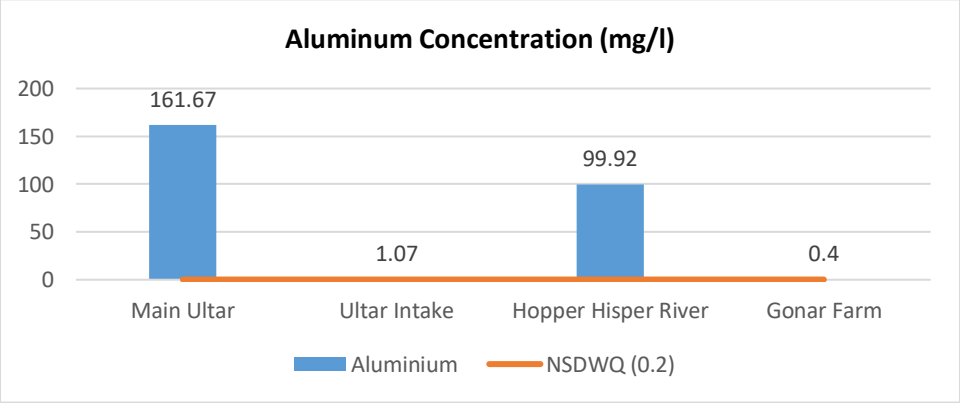
Ba: Barium
As: Arsenic
Zn: Zinc
Hg: Mercury
B: Boron
Sb: Antimony
Mn: Manganese
Se: Selenium
Al: Aluminum
Cr: Chromium
Ni: Nickel
Cu: Copper

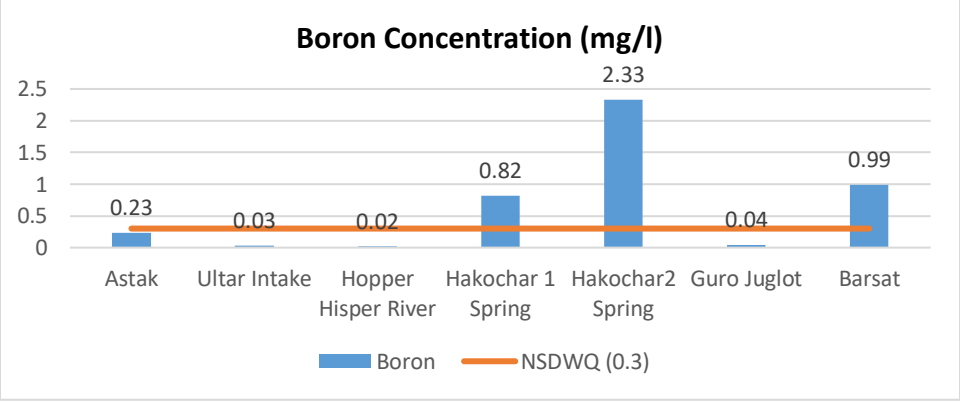
Annexure 2: Concentration of Heavy Metals

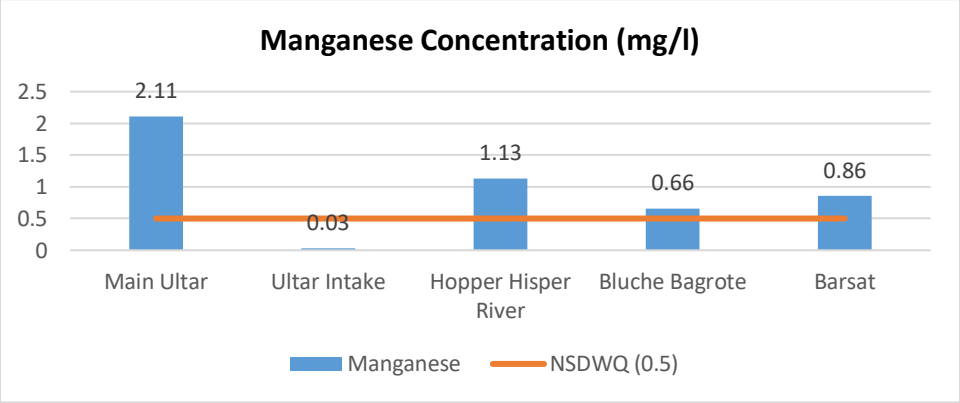


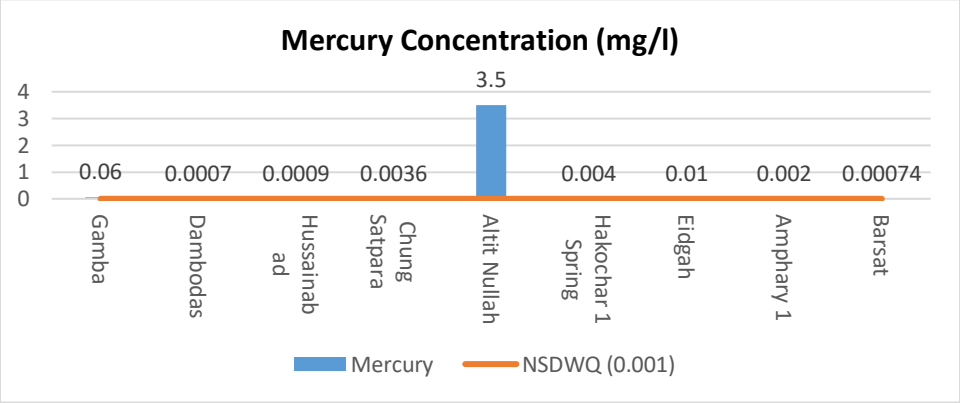



Selenium Concentration (mg/l)
0.015
0.01
0.005
0
0.00101
0.00099
0.00311
Farfoo Bagrote
Chamoghar
Aminabad
Selenium
NSDWQ (0.01)


Aluminum Concentration (mg/l)
200
150
100
50
0
161.67
1.07
99.92
0.4
Main Ultar
Ultar Intake
Hopper Hisper River
Gonar Farm
Aluminium
NSDWQ (0.2)


Boron Concentration (mg/l)
2.5
2
1.5
1
0.5
0
0.23
0.03
0.02
0.82
2.33
0.04
0.99
Astak
Ultar Intake
Hopper Hisper River
Hakochar 1 Spring
Hakochar2 Spring
Guro Juglot
Barsat
Boron
NSDWQ (0.3)


Manganese Concentration (mg/l)
2.5
2
1.5
1
0.5
0
2.11
0.03
1.13
0.66
0.86
Main Ultar
Ultar Intake
Hopper Hisper River
Bluche Bagrote
Barsat
Manganese
NSDWQ (0.5)


Mercury Concentration (mg/l)
4
3
2
1
0
0.06
0.0007
0.0009
0.0036
3.5
0.004
0.01
0.002
0.00074
Gamba
Dambodas
Hussainabad
Chung Satpara
Altit Nullah
Hakochar 1 Spring
Eidgah
Amphary 1
Barsat
Mercury
NSDWQ (0.001)

Annexure 3: Concentration of Chemicals not Listed by WHO and NDWQS

Table 20: Concentration of Chemicals non-NDWQS in District Skardu

Water Source	K	Mg	SO_4	Si	Sr	Na	Ca
Gamba	4.57	11.13	36.24	0.65	0.24	3.7	76.52
Dambodas	7.83	8.53	62.15	0.49	0.14	2.64	183.89
Astak	6.95	27.24	186.91	1.24	0.31	29.69	50.95
Sermik	5.7	7.24	8.15	0.59	0.42	6.77	50.34
Gol	4.04	3.4	23.15	0.48	0.07	4.26	30.33
Hussainabad	3.69	3.67	8.12	0.4	0.08	1.83	29.55
Chung Satpara	2.21	3.06	12.55	0.26	0.08	1.19	20.08
Tungos Spring Shigar	8.81	6.48	64.16	1.56	0.13	1.61	35.46
Sildi Spring Shigar	5.97	5.52	23.07	3.58	0.15	4.1	35.04

Table 21: Concentration of Chemicals non-NDWQS in District Hunza

Water Source	K	Mg	SO_4	Si	Sr	Na	Ca
Nasirabad	6.58	6.6	103.44	3.41	0.2	3.17	68.22
Hassanabad	17.87	10.07	93.03	2.7	0.15	8.08	62.41
Main Ulter Nala	81.98	52.86	73.06	143.11	0.81	44.02	82.87
Ultar Below Intake	16.52	16.36	129.38	3.78	0.24	5.44	115.68
Ultar Intake	7.82	2.28	25.85	3.11	0.05	0.26	18.91
Nasirabad Source Spring	4.93	5.84	91.44	4.25	0.15	2.89	51.22
Nasirabad T2	4.94	5.7	96.51	4.33	0.15	2.97	33.26
Nasirabad T3	4.92	5.63	100.03	4.34	0.15	2.99	54.05
Nasirabad T4	4.32	4.97	93.79	3.9	0.13	2.66	49.32
Nasirabad T5	4.35	5.04	108.46	4.04	0.14	2.73	52.37
Nasirabad T6	5.19	5.88	92.92	3.85	0.16	3.19	55.67

Water Source	K	Mg	SO_4	Si	Sr	Na	Ca
Shishkat Nallah	7.85	3.88	35.06	1.77	0.1	2.16	24.83
Shishkat Spring	6.78	4.1	84.93	4.39	0.1	9.4	48.06

Table 22: Concentration of Chemicals non-NDWQS in District Nagar

Water Source	K	Mg	SO_4	Si	Sr	Na	Ca
Hopper Hisper River	50.8	48.26	111.5	76.51	0.33	20.97	81.13
Hakochar 1 Spring	20.42	41.49	618.83	27.39	1.29	79.54	234.25
Hakochar 2 Spring	26.34	28.37	532.1	57.49	1.53	167.53	128.62
Pisan 1	9.31	33.49	32.6	2.93	0.14	7.93	25.42
Pisan 2	10.79	31.69	28.75	2.33	0.14	4.6	25.1
Nagar 1 Pono	8.65	11.51	111.92	3.85	0.17	5.06	96.76

Table 23: Concentration of Chemicals non-NDWQS in District Astore

Water Source	K	Mg	SO_4	Si	Sr	Na	Ca
Makhyal	0.91	0.92	4.68	0.35	0.02	1.51	10.06
Gorikot	2.66	2.72	20.01	0.44	0.12	1.66	25.97
Bulan	2.37	2.11	16.92	0.36	0.07	1.31	19.24
Eidgah	3.9	3.05	34.13	0.39	0.08	1.88	31.69
Harcho	8.1	9.92	336.96	0.8	0.46	4.88	197.78

Table 24: Concentration of Chemicals non-NDWQS in District Gilgit

Water Source	K	Mg	SO_4	Si	Sr	Na	Ca
Nagaral	7.66	6.57	13.65	0.56	0.17	6.13	71.12
Goru Jaglot	7.52	10.06	126.84	2.76	0.15	2.27	77.75
Bluche Bagrote	3.41	5.31	36.04	0.22	0.09	0.66	63.12
Datuchi Bagrote	6.12	8.09	95.96	0.33	0.37	1.93	56.9
Sinaker Bagrote	24.54	9.5	345.08	0.36	4.27	1.66	94.36
Farfoo Bagrote	6.46	7.96	36.87	0.45	0.2	2.15	47.32
Jalalabad Tap 1	10.58	12.4	157.46	3.76	0.22	3.41	63.55
Jalalabad Tap 2	10.28	12.08	152.52	3.81	0.21	3.28	61.11
Gilgit River RTC	10.08	19.75	144.98	3.4	0.53	7.46	62.46
River City Hospital	3.23	9.72	38.06	2.69	0.19	4.34	28.85

Water Source	K	Mg	SO_4	Si	Sr	Na	Ca
Baseen Gilgit River	2.79	9.79	36.4	2.56	0.18	3.68	26.98
Amphery Spring 1	6.78	10.02	22.34	5.34	0.17	13.09	70
Amphery Spring 2	5.97	14.2	21.81	4.34	0.15	8.58	71.69
Jutila WSC-I	4.64	1.99	42.52	4.21	0.04	2.56	22.61
Jutial WSC-O	4.45	1.92	39.17	3.95	0.04	2.5	22.94
Barmas WSC-I	1.87	1.02	16.07	2.38	0.04	1.47	16.89
Barmas WSC-O	1.83	1.02	16.07	2.34	0.04	1.45	18.2
Chamogarh	10.41	10.98	193.2	4.41	0.23	7.65	88.55

Table 25: Concentration of Chemicals non-NDWQS in District Ghizer

Water Source	K	Mg	SO_4	Si	Sr	Na	Ca
Barsat	5.77	57.44	86.68	14.68	1.67	85.39	253.25
Gupis	4.13	7.02	28.37	3.69	0.17	8.2	41.6
Yasin	1.14	3.78	16.05	2.19	0.07	1.87	22.75
Taos Bala	2.24	44.83	166.87	5.31	0.8	11.76	69.22
Nazarbar	1.08	3.61	16.15	2.23	0.07	1.82	22.85
Gindai	1.63	1.74	33.9	2.07	0.06	1.71	40.51
Gutums	3.83	2.08	26.33	4.67	0.05	2.98	24.25
Hyme	10.96	5.96	169.45	6.73	0.25	12.74	89.18
Birgal	0.25	4.66	74.38	1.8	0.2	2.16	56.59
Aminabad	1.53	13.77	203.26	2.9	0.59	8.55	99.45

Table 26: Concentration of Chemicals non-NDWQS in District Diamer

Water Source	K	Mg	SO_4	Si	Sr	Na	Ca
Bunar Das	4.08	6.61	86.71	3.9	0.44	8.45	52.35
Gas Pain	2.39	2.72	18.14	4.16	4.16	4.85	16.26
Chilas Nullah	0.8	4.89	12.8	4.3	4.3	4.64	22
Gonar Farm	6.32	6.32	89.94	6.07	6.07	9.66	52.12

K: Potassium Mg: Magnesium SO_4: Sulphates Si: Silicon
Sr: Strontium Na: Sodium Ca: Calcium

Gilgit-Baltistan Environmental Protection Agency (GB-EPA)

Gilgit-Baltistan Environmental Protection Agency
Shahrah-e-Quaid-e-Azam, Khomer, Gilgit
Phone No. 05811-920676, 920679 Fax No. 05811-922016
http://www.gbepa.gog.pk/