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WATER QUALITY ASSESSMENT OF PASSU VALLEY IN HUNZA NAGAR, GILGIT BALTISTAN, PAKISTAN

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ABSTRACT

The current study was performed to evaluate the physico-chemical, metals, and microbial characteristics of the surface water available in Passu valley located along the eastern bank of Hunza River of district Hunza Nagar, Gilgit Baltistan, Pakistan. A total of 24 water samples were collected and analyzed. The results of the study comprehend that the physico-chemical characteristics of the water samples are satisfactory. However, heavy metals like arsenic, lead, iron, and zinc, are present at fairly higher concentrations than recommended by the WHO, and thus, a concern for public health quality of water. The results also showed that all of the water samples collected from springs and tap water sources in Passu Valley are highly contaminated with microbes and are unsafe for human consumption. This is the region where the major human settlements are located and agricultural activities, tourism attractions, domestic discharges, and erosion are the fundamental sources of water pollution. Residents have very little choice but to drink the contaminated water because there are no other water sources available, and they rarely inquire about the water's purity. The sources of contamination should be investigated further in order to lessen the amount of pollution in the Passu Valley's surface water, which could help to promote sustainable ecotourism.

Key-words: water quality, physic-chemical, metal, microbial analysis, Passu valley.

INTRODUCTION

An essential tool for preserving public health and water resources is water quality-monitoring and assessment (Yasin *et al.,* 2020). However, the quality of drinking water in underdeveloped countries is generally poor, especially in rural areas, and is a primary cause of numerous waterborne infections (Li and Ng, 2019). Consequently, it is crucial to evaluate and keep track of the water quality of the available resources, which are primarily used for drinking (Şener*et al.,* 2017). The sixth sustainable development goal (SDGs) (out of 17 goals) of the United Nations (UN) strongly underlines the need of having access to clean water and sanitary facilities. Unfortunately, Pakistan's public health drinking water quality is still not satisfactory in many remote areas (Azizullah *et al.*, 2011). The quality of Pakistan's drinking water has been geospatially assessed in several locations, including Balochistan (Ahmad *et al.,* 2020), Khyber Pakhtunkhwa (Javedet al., 2019), Punjab (Bashir *et al.,* 2020), Sindh (Bhatti *et al.,* 2020). Similar assessments have also been made in Gilgit Baltistan's (GB) in a number of its cities and valleys (Ali *et al.,* 2013) and in springs (Ahsan*et al.,* 2021; Farhat *et al.,* 2021).

The most common sources of drinking water in Pakistan's northern regions, formerly known as Gilgit Baltistan, are glacio-fluvial streams and lakes. Although it is a serious public health concern, the deteriorating condition of these surface reservoirs brought on by human activity is more likely to lead to the contamination of drinking water resources (Ali *et al.,* 2013). Moreover, poor sanitation practices, a lack of sewerage treatment services, and lack of awareness have a significant negative impact on public health in Gilgit Baltistan. Due to these circumstances, the indigenous population experience an alarming trend of gastrointestinal diseases (Nafees *et al.,* 2014).

The purpose of this study was to look into the drinking water quality evaluation of Passu Valley using laboratory analysis, statistical methodologies, and the spatial distribution of the main pollution indicators, such as physico-chemical, metals, and microbiological factors. The guidelines for water quality parameters are also provided in terms of WHO Guidelines for Drinking Water (WHO, 2011). This study should enable local water management agencies to make sound decisions and maintain rigorous control the distribution of pollutants in the valley. It will also assist in identifying the main sources of pollution in the river and surface water streams.

MATERIALS AND METHODS

Study Area

The Passu Valley is located along the eastern bank of the Hunza River and shares boundaries with the Passu Glacier and Passu Lake. Administratively, the valley is located in Gojal tehsil (sub-district) of Hunza Nagar district, Gilgit Baltistan. The valley attracts tourists due to the presence of Passu Cones and Sar mountains.

The population of Passu Valley is approximately 1168 comprising a total of 143 households (Dhakal *et al.*, 2021). Glaciers melt from the Passu, Batura, Zarabad, and Khuramabad glaciers, as well as others, are diverted through irrigation canals in Passu that have intakes near the glaciers' terminus. The irrigation canals in the Passu village irrigate a total area of 4 km^2. The Passu village receives irrigation water from the Passu Glacier through the Passu Main Nalah, which is recognized as the main canal.

The vast majority of people relied on glacier melt and streams, while a relatively small percentage of people employed electric motors to draw water from rivers for irrigation. Farmers in the village use flood irrigation to water fodder crops, orchards, and firewood plantations, as well as bed furrow or ridge furrow to irrigate vegetables and cereal crops. Karakoram Highway connects the valley with other areas of Hunza Nagar.

Water Sampling

A total of 24 water samples from the Passu Valley were deterministically collected in 2022 using a random sampling strategy (Fig. 1,2). According to site accessibility, pooled data is obtained from spring and tap water sources that are regularly used by human settlements in the valley. Before being transported to the laboratory of Institute of Environmental Studies at the University of Karachi for laboratory analysis, the samples were collected and kept in sanitized glass bottles in an icebox.

Physico-Chemical Analysis

On-site measurements were made of the pH, turbidity, salinity, and total dissolved solids (TDS). A HACH sensation 156 multi-parameter dissolved oxygen meter was used to measure pH and salinity, and EUTECH meter (Model No. TN-100) was used to measure turbidity in the water samples. For TDS and chloride, gravimetric and argentometric estimation techniques were used (APHA, 2005). The gravimetric method was used to measure sulphate, and the EDTA titrimetric method was used to measure hardness. The brucine-reagent and ascorbic acid methods were used to measure nitrate and total phosphate, respectively. The above-mentioned parameters were analyzed using Standard Methods for the Examination of Water and Wastewater (APHA, 2005).

Metal Analysis

Arsenic (As), copper (Cu), lead (Pb), iron (Fe), zinc (Zn), calcium (Ca), and magnesium (Mg) were estimated using the proper Merck NOVA 60-Germany kits for metal analysis (APHA 2005).

Microbiological Analysis

The microbial parameters were examined in the water samples including total coliform count (TCC), total faecal coliforms (TFC), and total fecal streptococci (TFS). Single and double-strength lactose broth (Merck, Germany) was used for TCC while EC medium (Merck, Germany) was used for the determination of TFC. TFS was estimated by using sodium azide broth. The most probable number (MPN) technique was employed to determine the bacterial load in the water samples (APHA, 2005).

Spatial distribution by inverse distance weight (IDW)

The values of unknown (unsampled) points can be determined using spatial distribution methods for interpolation based on the weighted measures and proximity-centered assumptions that closer points are more similar than the points located relatively far away. Kriging and inverse distance weight are the two most used geo-statistical interpolation techniques (IDW). Kriging, which is further categorized into the categories of simple, ordinary, and universal kriging, involves applying weights to known or observed values based on the spatial orientation of the measured places (Elumalai*et al.*, 2017). IDW, unlike kriging, simply depends on the closeness of the known (sampled) points since it uses the idea that closer samples points have a bigger impact on the un-sampled location (Haldar*et al.*, 2020; Nistor *et al.*, 2020). The study employed the IDW method based on the methodology explained in a previous study (Fatima *et al.*, 2022a).

RESULTS AND DISCUSSION

Descriptive Statistics

The results of descriptive statistics were obtained using OriginPro 2022 (OriginLab, 2022) to compute the mean, minimum, maximum and standard errors (Table 1).

Physico-chemical characteristics

pH

The water samples taken from the Passu Valleys for the determination of physico-chemical characteristics showed that all results fell within the established WHO criteria. The water samples' average pH ranged from 7.3 to 7.8 (7.55±0.12). The Basho, Chu Tran, and Shigar valleys in Gilgit Baltistan were assessed for water quality, and their mean pH values were reported to be 7.22 (Fatima *et al.*, 2022c), 7.17 (Fatima *et al.*, 2022a), and 7.135 (Fatima *et al.*, 2022b), respectively. However, the pH recorded along Sultanabad Stream (7.4), which is slightly alkaline, is compatible with the results of the current study (Begum *et al.*, 2014).

Turbidity

Following the WHO recommended limits (5 NTU), turbidity in water samples obtained from Passu Valley was found to be between 0.18 and 0.91 NTU (0.37±0.16 NTU). The turbidity values are lower than those in Gilgit Baltistan's Basho Valley (0.480.15) (Fatima *et al.*, 2022c) and Chu Tran Valley (0.390.03 NTU) (Fatima *et al.*, 2022a), but they are equivalent to earlier investigations of the adjacent areas (Shedayi *et al.*, 2015; Fatima *et al.*, 2022b).

Salinity

Passu Valley water samples had a salinity that ranged from 0.16 to 0.67‰, with a mean value of 0.36‰ and a standard deviation of 0.14. The current salinity values are greater than the 0.015-0.025 recorded by one of the study to analyze drinking water quality status in the Gilgit city of GB region (Shedayi *et al.*, 2015), although they are still within the WHO-recommended limits (1.2‰).

Total dissolved solids (TDS)

TDS levels in Passu Valley's water samples ranged from 340.12 to 463.28 mg/L (384.39±28.62 mg/L), which is greater than Nagar Valley of District Hunza during 2013 (175.7-233.67 mg/L) (Ali *et al.*, 2013)but significantly lower than Chu Tran Valley of District Skardu (44076.75 mg/L) (Fatima et al., 2022a) In water samples from the GB region, other studies have found mean values of 280.4 mg/L (Fatima *et al.*, 2022c), 104.8 mg/L (Islam et al., 2021), and 284.4 mg/L (Begum et al., 2014), all of which are lower than the mean value observed in the current study. All of these water sample results, however, fall well under the TDS threshold limit (1000 mg/L) set by the WHO.

Chloride

Chloride levels in the Passu Valley water samples ranged from 78 to 132 mg/L, with a mean value of 99.25±12.76 mg/L. The findings show that the chloride levels in the water samples are significantly below the WHO-permitted limit (250 mg/L). However, according to other research, Gilgit Baltistan's Basho Valley (Fatima *et al.*,2022c) and Chu Tran Valley (Fatima *et al.*, 2022a) had chloride levels between 58 and 106 mg/L and 87 to 139 mg/L, respectively.

Hardness as $CaCO_3$

The total hardness ranged from 115 to 165 mg/L with a mean concentration of 132.50±15.09 mg/L, which is under the WHO-permitted limit of 500 mg/L. Studies carried out in other Gilgit Baltistan valleys also noted the presence of hardness in water samples, with values of 4.66±16.66 mg/L in Nagar Valley (Ali *et al.*, 2013), 160±190 mg/L in Danyore Valley (Shedayi *et al.*, 2015), 130.54±76.75 mg/L in Chu Tran Valley (Fatima et al., 2022a), 102.9±10.44 mg/L in Basho Valley (Fatima *et al.*, 2022b).

Table 1.Descriptive Statistics of 24 water samples from Passu Valley.

Parameters	**Unit**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Median**	**WHO Guideline 2011**
Physico-chemical							
pH	-	7.55	0.12	7.3	7.8	7.5	6.5-8.5
Turbidity	NTU	0.37	0.16	0.18	0.91	0.36	<5
Salinity	‰	0.36	0.14	0.16	0.67	0.32	1.2
Total Dissolved Solids (TDS)	mg/L	384.39	28.62	340.12	463.28	382.795	<1000
Chloride		99.25	12.76	78	132	95.5	<250
Hardness		132.50	15.09	115	165	132	<500
Sulphate ($SO4^{-}$)		64.25	9.70	50	88	63	250
Nitrate ($NO3^{-}$)		0.13	0.05	0.046	0.24	0.1115	12
Metals							
Arsenic (As)	mg/L	0.04*	0.03	0	0.113	0.034	0.01
Copper (Cu)		1.17	0.23	0.58	1.78	1.225	0.2
Lead (Pb)		0.35*	0.16	0.066	0.67	0.345	<0.01
Iron (Fe)		1.18*	0.22	0.84	1.52	1.26	0.3
Zinc (Zn)		1.09*	0.28	0.71	1.56	1.115	0.5
Calcium (Ca)		44.08	3.22	39.06	49.05	43.05	150
Magnesium (Mg)		9.00	0.95	7.25	10.43	8.935	100
Microbial							
Total Coliform Count (TCC)	MPN /100 mL	750.63	863.65	3	2400	240	0
Total Faecal Coliform (TFC)		272.04	543.67	3	2400	78.5	0
Total Faecal Streptococci (TFS)		6.54	3.35	3	11	7	0

*Mean values are above WHO Guidelines (WHO 2011)

Sulphate

Sulphate (SO_4^-) levels ranged from 50 to 88 mg/L in the Passu Valley water samples, with a mean value of 64.25±9.70 mg/L. The sulphate concentration in the water samples indicated that the levels are well within the WHO-recommended limits for sulphate in drinking water (250 mg/L). The surrounding Gilgit Baltistan localities have a similar concentration of sulphate 89.5 ± 9.86 mg/L in Basho Valley (Fatima *et al.*, 2022c) and 130.54 ± 12.88 mg/L in Chu Tran Valley (Fatima *et al.*, 2022a).

Nitrate

The findings indicate that nitrate (NO_3) levels in the water samples from Passu Valley range from 0.046 to 0.24 mg/L, with an average of 0.13 ± 0.05 mg/L. However, a study found that Sultanabad stream in Gilgit Baltistan has a somewhat greater value of nitrate (8.8 mg/L) (Begum *et al.*, 2014). According to a study, Basho Valley had a nitrate concentration of 0.25 ± 0.08 mg/L (Fatima *et al.*, 2022c), while Chu Tran Valley had a nitrate concentration of 0.23 0.14 mg/L (Fatima *et al.*, 2022a), and Shigar Valley had a nitrate concentration of 0.188 ± 0.024 mg/L (Fatima *et al.*, 2022b). The results of the current study are relatively lower than those of other valleys in Skardu.

Heavy Metals in water samples

Passu Valley water samples showed a pattern of mean metal concentrations that went as follows: Ca> Mg > Fe > Cu > Zn >Pb> As. Only copper, calcium, and magnesium were found in amounts that were under the WHO recommendations range (Table 1). Results, however, showed that heavy metals like arsenic, lead, iron, and zinc, are present at far higher concentrations than recommended by the WHO. The constant ingestion of these heavy metals through drinking water poses a risk to the general public's health (Fatima *et al.*, 2022a).

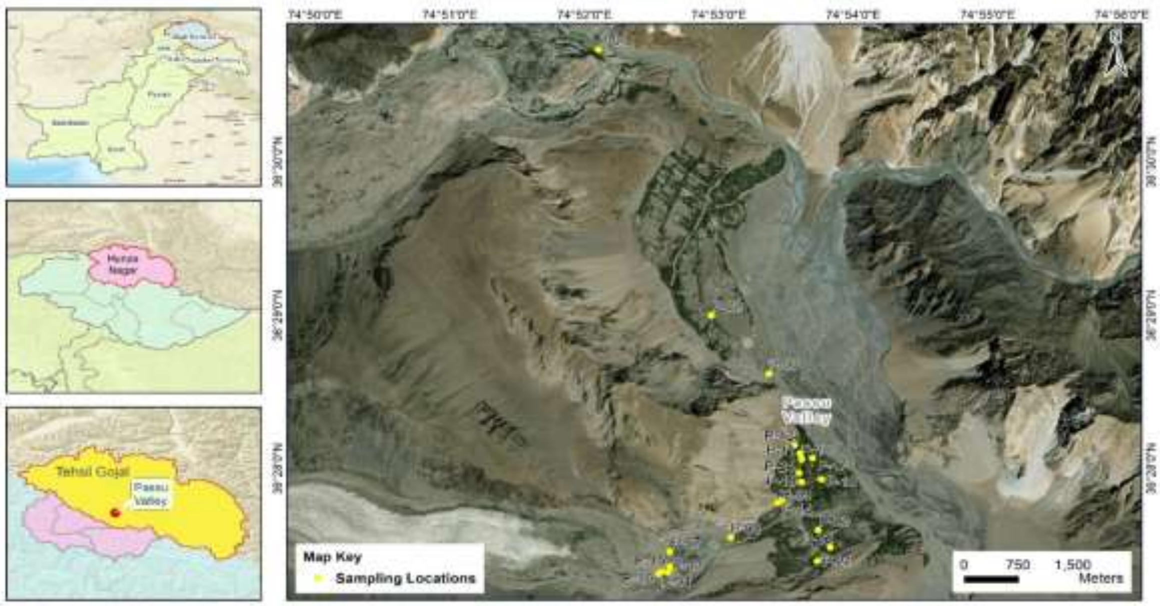

Fig. 1. Study area and sampling location map of Passu Valley.

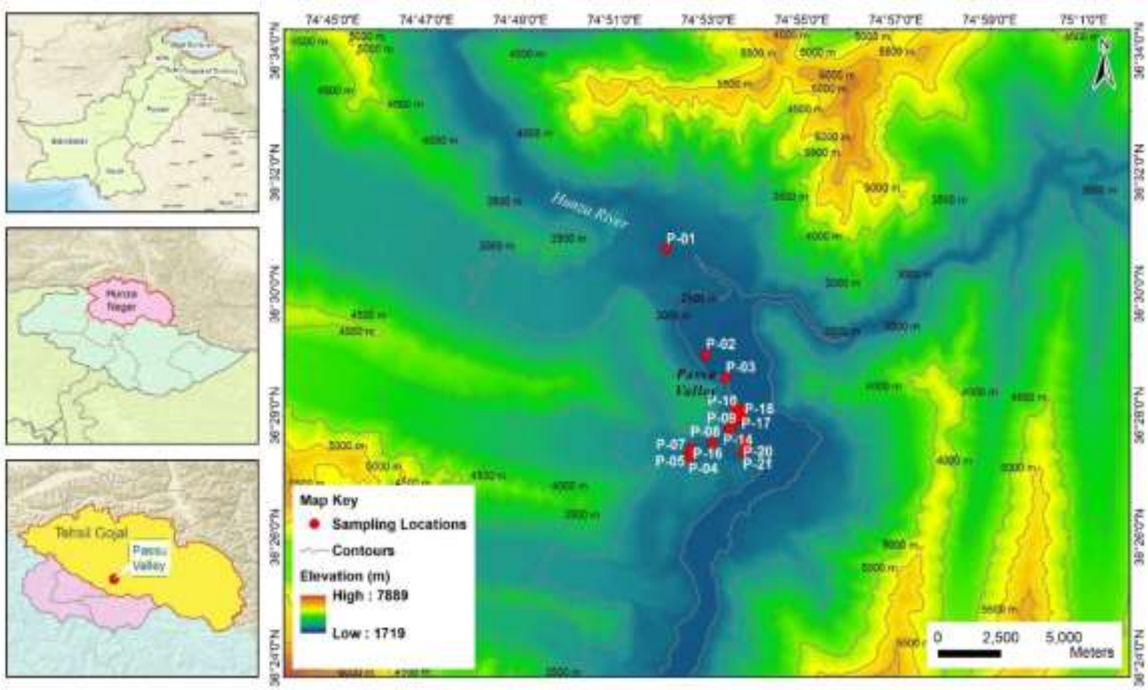

Fig. 2. Topography and sampling location map of Passu Valley.

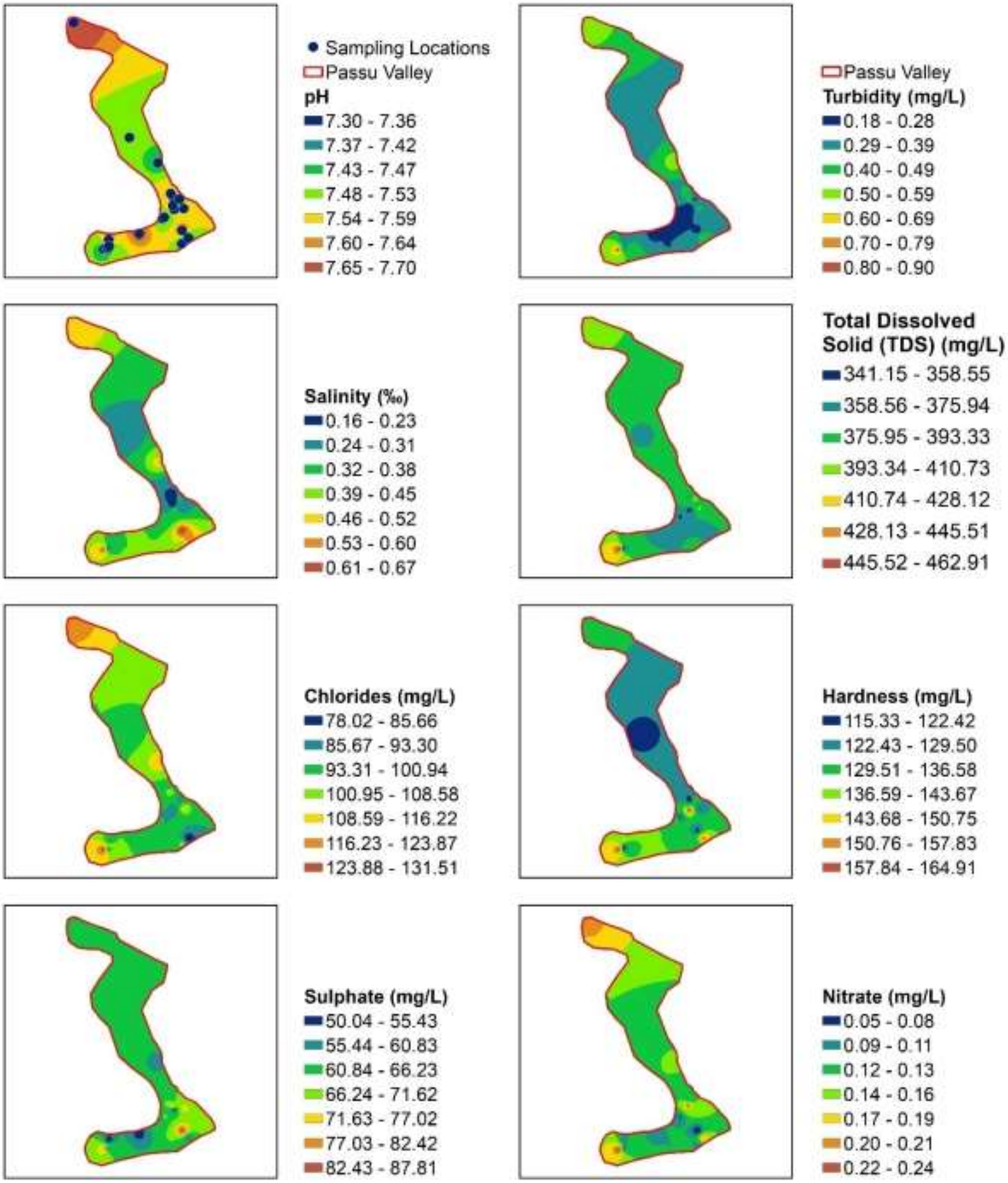

Fig. 3.Geospatial distribution of physico-chemical water quality in Passu Valley.

Microbial water quality

The results showed that all of the water samples collected from springs and tap water sources in Passu Valley are highly contaminated with microbial sources (>3 MPN/100 mL), which is unsafe for human consumption. These bacteriological parameters (TCC, TFC, and TFS) are mostly brought about by the direct and indirect faecal contamination of the valley's surface water by residential sources. With no facilities for water or wastewater treatment, it is obvious that the Passu Valley has the least developed surface water and sewage infrastructure. The potential for bacterial pollution in the valley settlements creates a significant danger for water-borne illnesses. The fact that water resources are not being preserved in any way is also obvious.

Geospatial distribution

The Geospatial distribution of physico-chemical parameters is illustrated in Fig. 3. The spatial distribution shows that the water quality of the central parts of the valley is less contaminated as compared to the upper and lower areas. However, the presence of contaminants along the lower areas confirms that human activities including domestic and agricultural runoff are major sources of surface water contamination along Passu Valley.

CONCLUSION

The study discussed the Passu Valley's water quality from three approaches: 1) the water quality is satisfactory based on physico-chemical characteristics, 2) heavy metals are present in high concentrations, making the water quality unsuitable for drinking purposes, and 3) based on bacteriological load, the drinking water available in the area is highly unsuitable and may pose a health risk to the general public. The research recommended rigorous and frequent water quality monitoring to identify causes of contamination and protect local public health. Water treatment should also be developed to guarantee that people have access to clean, drinkable water. The availability of potable water is inevitable as the valley has enormous potential for eco-tourism. This has also been evident due to the construction of China Pakistan Economic Corridor (CPEC). Hotel business is now overwhelmed due to the massive influx of the tourist both from the country and abroad. In general, like other parts of Hunzadistrict, the people are healthy in the Passu valley however, the residents are now complaining and suffering from water borne ailments. Such ailments are more common in children and elderly people.

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