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Drinking Water Quality Assessment in Some Selected Villages of Nagar Valley Gilgit-Baltistan, Pakistan

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Abstract: Water and life are two sides of the same coin, since water sustains all life processes. The quality of water is of vital concern for mankind since it is directly linked with human health and environmental protection. Due to its outstanding significance to the consumer its parameters must follow the permissible limits set by international water regulating agencies. The present study was therefore undertaken to assess the quality of drinking water in some villages of Nagar valley. Some physical, biological and chemical parameters were examined from tap, channel and tank water. Among the tested characteristics, temperature values fluctuated between 12.10–13.50 °C, electric conductivity values ranged from 199.10-588.00µs/cm, turbidity values differed from 0.20–0.38 NTU, pH values varied between 7.00-7.93, total alkalinity values ranged between 57.00–102.33 mg/l, total dissolved solids ranged from 118–357 mg/l, calcium hardness contents fluctuated between 4.66–16.66 mg/l,cynuric acid level varied between 35.33–52 mg/l. Similarly, total coliform count ranged from 47.25–54.00 cfu/ml while the investigated samples were free from faecal contamination. All the inspected characteristics were within the approved standards set by WHO and EPA.

Keywords: Drinking water quality, physico-chemical characteristics, contaminants, WHO, EPA, Gilgit-Baltistan.

INTRODUCTION

Water is one of the best gifts to all living creature, given by the nature. It is compulsory for the growth and maintenance of human body and also for many biological activities[1]. It plays a vital role for the survival of all forms of life on earth and works as a universal solvent[2, 3].

Pure water is an essential resource for life. Man uses it for different purposes like drinking, washing, in agriculture, food processing and in other applications[4]. Good quality of drinking water is essentially needed for all the people throughout the world[5]. The best quality potable water free from hazardous materials and contaminants must be available for the public to avoid disease incidence and it is also used as a powerful environmental tool, required to determine the health of public. Good quality drinking water means keeping away public from dangerous water related diseases[6, 7]. Superior quality of water not only enhances human productivity but also add bonus days to the human life[8].

Good quality of drinking water is one of the biggest problems in developing countries[9]. According to GWSSAR, 1.1 billion population use poor quality of drinking water from different sources including lakes, rivers, hand pumps, wells and from others. 20% of Asia, 42% of sub Saharan Africa and 2.2 billion people of the world need safe drinking water[10]. Due to absence of safe drinking water and the presence of microbial contamination, health problems occur in almost all the population in developing countries[11]. In Pakistan, up to 66% of drinking water is obtained through pipes and hand pumps[12]. It is of great interest that about 30% of waterborne diseases and 40% of people loses their lives due to unavailability of clean and safe water[13].

Pure water for human use is not always available naturally due to occurrence of suspended or dissolved impurities[14]. Among the environmental pollutants, heavy metals are considered as more problematic. Heavy metals in air, marine, ground water and industrial water are most noxious pollutants threatening safety of human life[15]. Heavy metals are introduced into environment though anthropogenic as well as natural phenomenon. In water systems, metal contamination is possible from direct atmospheric deposition, weathering or either the release of agricultural, communal, residential or manufacturing runoff[16].

Due to regular emission of waste products into aquatic system the contamination of heavy metals concentration rises up by deposition. Heavy metals migrate to food chain where they can show adverse effects on human and aquatic life[17]. WHO has published that up to 17 types of bacteria can be found in tap water which can cause water borne diseases that affect human health[18]. The most dangerous disease related to water is diarrhea, which causes majority of deaths in infants and children in Pakistan, and every fifth person is suffered from diseases caused by contaminated water[19]. According to reports more than three million Pakistanis are suffered from diseases caused by poor quality of water each year and out of which 0.1 million lost their lives[20]. These situations necessitate the need of assessment of water quality to assure the protection of environment and precious human lives. Thus the present study was designed to investigate the water quality of some villages of Nagar valley, District Hunza-Nagar to compare the data with world standards.

MATERIAL AND METHOD

Study area: The villages selected from Nagar valley i.e. Ghulmet, Thole and Nilt are located at 74.501038 longitudes and 36.233197 latitude, 74.448509 longitudes and 36.236243 latitude, 74.436493 longitudes and 36.223227 latitude respectively. It is a rural area composed of 6,000 residents. A 7788 meters high peak Rakaposhi glaciers are the only main source of water for the community **(Fig. 1).**

Sampling procedure: Water samples were collected in pre sterilized plastic bottles of 500 ml capacity in triplicate from three main sources of drinking water i.e. channel, tank and tap water. The samples were transferred to the Department of Agriculture and Food Technology for physic-chemical and microbial study.

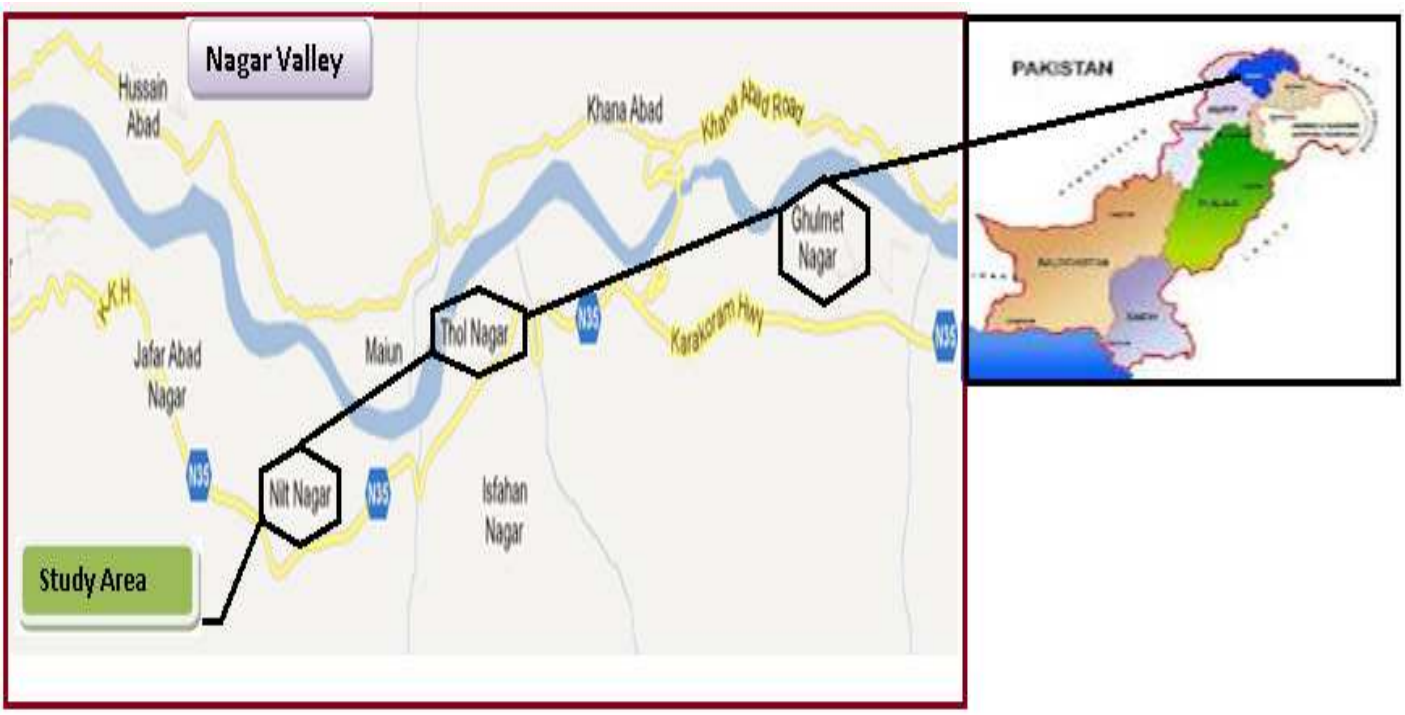

Fig. 1: Map of study area of Nagar valley, Gilgit-Baltistan, Pakistan.

Parameters tested: Various water quality characteristics were measured using standard testing procedures outlined by standard method of AOAC[21] and EPA[22, 23]. Physical parameters like temperature of all the samples were measured by using conductivity meter, turbidity was determined using turbidity transparency tubes and electric conductivity (EC) was measured by using a conductivity meter. For microbial analysis total viable count method was used to test total coliform bacteria[24], while membrane filtration technique was used to test total faecal coliform bacteria (EPA Method 1103.1). Chemical parameters like pH were analyzed using digital pH meter and total dissolved solids (TDS) were assessed by conductivity meter. Total alkalinity, calcium hardness and cynuric acid were determined by using a Lovibond Mini Kit. All the solutions were prepared by using distilled water in triplicate. The results were statistically analyzed using one way ANOVA and differences were compared with least significant difference (LSD) test [25] using statix-8 statistical software.

RESULTS AND DISCUSSION

The present study was carried out to assess the quality of drinking water from three villages of Nagar valley for some physico-chemical and biological parameters. These characteristics were temperature, turbidity, EC, total coliform count, total faecal coliform, pH, TDS, total alkalinity, calcium hardness and cynuric acid content **(Table 1 and 2).**

Table-1:- Physical and biological parameters of drinking water tested from three villages of Nagar

Area	Source	Parameters				
		Temp. (°C)	**Turb. (NTU)**	**EC (µs/cm)**	**TCC (cfu/ml)**	**TFC (cfu/ml)**
Ghulmet	Tap	12.63bc	0.25de	312.33e	49.33bc	0
	Channel	12.99ab	0.20e	199.10h	49.33bc	0
	Tank	12.10c	0.20e	318.33d	48.66bc	0
Thole	Tap	13.13ab	0.35ab	389.67c	53.00ab	0
	Channel	13.50a	0.35ab	582.33b	54.00a	0
	Tank	13.16ab	0.31bc	588.00a	50.33abc	0
Nilt	Tap	12.76b	0.29cd	292.33f	48.50bc	0
	Channel	12.86ab	0.33abc	275.33g	48.00c	0
	Tank	12.90ab	0.38a	293.33f	47.25c	0
WHO Limits	-----	-----	5	1400	100	0

- Temp= temperature, Turb= turbidity, EC= electric conductivity, TCC=total coliform count, TFC= total faecal coliform count
- All the values are means of three replications.
- Means followed by the same alphabets are not significantly different at alpha = 0.05

Temperature is biologically an important factor which plays a vital role in proper functioning of all living things. Microbial load in water will be lower if temperature[26] remains below 15°C.

Examination of Ghulmet tap water, channel water and tank water for temperature resulted 12.63 °C, 12.99 °C and 12.10 °C. Thole tank water, channel water and tank water tests for temperature observed 13.13 °C, 13.50 °C and 13.16°C. Nilt tap water, channel water and tank water assessment for temperature found 12.76 °C, 12.86 °C and 12.90 °C. Temperature examination revealed a little fluctuation in results between 12.10-13.50 °C. Highest value was determined in Thole channel water while lowest was found in Nilt tank water (**Table-1**). Variation in temperature might be due to the rate of chemical reactions and the nature of biological processes taking place in aquatic system[27]. EPA and WHO has provided no guideline and standards for temperature of drinking water, however, it has been suggested that the temperature of drinking water must be less than 15°C because warm water holds less oxygen content.

Table-2: Chemical parameters of drinking water tested from three villages of Nagar

Area	Source	Parameters				
		pH	TDS (mg/L)	TA (mg/L)	C. Hard. (mg/L)	C. Acid (mg/L)
Ghulmet	Tap	7.80ab	187.37e	61.66f	7.33cd	41.03c
	Channel	7.93a	118.40h	57.00g	4.66d	40.66c
	Tank	7.86ab	192.13d	61.33f	6.33cd	38.00cd
Thole	Tap	7.23c	233.67c	92.33b	13.00b	52.00a
	Channel	7.13cd	352.00b	99.66a	15.33ab	48.66ab
	Tank	7.00d	357.67a	102.33a	16.66 a	48.00b
Nilt	Tap	7.86ab	175.70f	71.33e	6.00cd	40.33c
	Channel	7.73b	166.40g	80.33c	8.66c	36.00d
	Tank	7.83ab	176.23f	76.33d	6.33cd	35.33d
WHO Limits	-----	6.5 - 8.5	1000	600	100	100

- TDS= total dissolved solids, TA= total alkalinity, C. Hard.= calcium hardness, C. Acid= cynuric acid

Turbidity is the measurement of relative clarity of water. Turbidity in water is due to the presence of suspended substances like clay, silt and microscopic organisms and it can also be a source of nutrients for micro organisms[6]. Turbidity values examined from Ghulmet tap water, channel water and tank water revealed 0.25 NTUs, 0.20 NTUs and 0.20 NTUs respectively. Thole tap water channel water and tank water turbidity tests found 0.35 NTUs, 0.31 NTUs and 0.31 NTUs. Evaluation of turbidity from Nilt tap water, channel water and tank water revealed 0.29, 0.33 and 0.38 NTUs respectively. A little fluctuation in the findings of tested samples was observed that varied between 0.20-0.38 NTUs. Maximum turbidity value was found in Nilt tank water, while the lowest values were found in Ghulmet tap and tank water (**Table-1**). According to WHO and EPA turbidity must not exceed 5 NTUs and water having turbidity less than 1.00 NTUs is excellent for domestic consumption. High turbidity cause problems during purification (flocculation and filtration) and increases the treatment expenses. It also diffuses light and hence lowers the rate of photosynthesis and may cause plants death[28]. Turbidity results of all the samples in the present study were in confirmation with the recommended levels that shows the suitability of tested water samples for drinking purpose.

Electrical conductivity (EC) is the calculation of water tendency to pass electric current through it. It indicates the total amount of dissolved salts. EC values for drinking water depends on the concentration of dissolved salts and ionic particles through which electric current passes, it will be higher with more electrolytes in water[18]. EC values determined for Ghulmet tap water, channel water and tank water were 312.33 µs/cm, 199.10 µs/cm and 318.33 µs/cm respectively. Thole tap water, channel water and tank water examination for EC revealed 389.67 µs/cm, 82.33 µs/cm and 588.00 µs/cm. Determination of EC values in Nilt tap water, channel water and tank water were 292.33 µs/cm, 275.33 µs/cm and 293.33 µs/cm. EC values examined for different samples fluctuated between 199.10-588.00µs/cm. Maximum value for EC was found in Thole tank water, while the lowest value was observed in Ghulmet channel water (**Table-1**). Thole tank water has highest value of EC, which might be due to presence of high concentrations of

dissolved salts and ionic particles then others tested samples of different localities. According to WHO and EPA, electrical conductivity of drinking water must not exceed 1400 µs/cm. Thus the EC values analyzed for the samples under investigation were within the prescribed standards of WHO and EPA.

Total coliform examination provides indication of the hygienic condition of water used for drinking and other purposes. Total coliforms include bacteria which are found in the soil, water and animal or human waste. The total coliform bacteria occurrence is much higher when the water temperature is above 15 °C[29]. Total coliform colonies detected from Ghulmet tap water, channel water and tank water were 49.33 cfu/ml, 49.33 cfu/ml and 48.66 cfu/ml. Results for total coliform bacteria from Thole tank water, channel water and tank water were found as 54.00 cfu/ml, 53.00 cfu/ml and 50.33 cfu/ml respectively. Nilt tap water, channel water and tank water showed 48.50 cfu/ml, 48.00 cfu/ml and 47.25 cfu/ml respectively. According to WHO and EPA, the number of total coliform bacteria must not exceed 500 bacteria per ml. The present results for total coliform bacteria assessed from different sources and locations varied between 47.25-54.00 cfu/ml. Highest no of coliform colonies were calculated in Thole tank water, while the lowest number of colonies were calculated in Ghulmet channel water (**Table-1**). Microbial contamination of drinking water is caused by the human activities and livestock[30]. The results for all investigated samples were meeting the international standards set by WHO and EPA.

Presence of faecal coliform in aquatic environments may indicate that the water has been contaminated with the faecal material of humans or other animals. Faecal coliform bacteria can enter rivers and other water sources through direct discharge of waste from mammals, human sewage, birds, storm runoff and agricultural waters. Large quantities indicate a higher risk of pathogens, which cause ear infections, dysentery, typhoid fever, viral and bacterial gastroenteritis[31] and hepatitis A. All the investigated samples from different sources and locations were free from faecal coliform bacteria (**Table-1**).

pH is the intensity of acid or alkaline conditions of a solution; naturally all waters are slightly alkaline which results in the presence of carbonates[18]. pH values from Ghulmet tap water, channel water and tank water found 7.80, 7.93 and 7.86 respectively. Examination of pH values from Thole tap water, channel water and tank water revealed 7.23, 7.13 and 7.00. While pH values from Nilt tap water, channel water and tank water observed 7.86, 7.73 and 7.83. pH results of examined samples fluctuated between 7.00-7.93. Highest pH value was determined in Ghulmet channel water and lowest value was found in Thole tank water sample (**Table-2**). Water having pH at around 8.0 is helpful for successful chlorination while supply pipes are also safe from corrosion. Similarly, low pH values can leach metal ions like Fe, Zn, Pb, Mn and other elements, which damage water supply installations[32]. Prescribed limits for pH values set by WHO and EPA ranges from 6.5-8.5 and the obtained results were under the prescribed limits.

TDS is the calculation of inorganic salts and minute amounts of organic substances present in a water solution. The key compounds are usually calcium, magnesium, sodium, and potassium cations and carbonate, hydrogen carbonate, chloride, sulphate, and nitrate anions[18]. Outcomes of Ghulmet tap water, channel water and tank water for total dissolved solids ranged 187.37 mg/L, 118.40 mg/L and 192.13 mg/L respectively. Thole tap water, channel water and tank water showed TDS contents about 233.67 mg/L, 352.00 mg/L and 357.67 mg/L. The evaluated results for TDS in Nilt tap water, channel water and tank water found around 175.70 mg/L, 166.40 mg/L and 172.23 mg/L. The overall results obtained for TDS content of water samples varied between 118-357 mg/L. Highest TDS levels were determined in Thole tank water, while the minimum values were found in Ghulmet tap water (**Table-2**). Water which has TDS levels less than 600 mg/l is regarded as good, while water having TDS more than 1000 mg/L is unacceptable for human consumption[18]. High TDS values are unacceptable because it imparts bitter taste to drinking water and cause scaling of supply pipes. Elevated TDS content also indicates contaminants like iron, manganese, arsenic, sulphates and other elements. Furthermore, increased concentration may also affect individuals who are suffering from kidney and heart problems and also has constipation effects[33]. TDS values of Thole tank water were higher as compared to other samples which might be due to the

presence of higher amount of calcium, magnesium, and other cations and anions. However all the parameters tested were following the permitted standards of WHO and EPA.

The capability of water to neutralize a strong acid is called alkalinity; hence alkalinity of water is due to existence of bicarbonates, carbonate and hydroxide compounds of calcium, sodium and potassium[2]. The results pertaining to total alkalinity in Ghulmet tap water, channel water and tank water were found in the range of 61.66 mg/L, 57.00 mg/L and 61.33 mg/L respectively. The findings for total alkalinity in Thole tap water, channel water and tank water were found as 92.33 mg/L, 99.66 mg/L and 102.33 mg/L, while for the three sources of Ghulmet locality revealed 71.33 mg/L, 80.33 mg/L and 76.33 mg/L. Overall results for total alkalinity varied between 57.00–102 mg/L. Highest value was obtained for Thole tank water and the lowest was calculated from Ghulmet channel water (**Table-2**). This fluctuation might be due to presence of different concentrations of calcium, sodium and potassium and other compounds which may have accompanied the water from the catchment area and the ways through which water passes. According to the WHO and EPA standards, total alkalinity of drinking water must not exceed 600 mg/L. Water having alkalinity less then 100mg/L is best for domestic use[34] and the findings of all the samples were within the approved standards.

Calcium content enters into the water by the leaching process of rocks and its high content may cause hardness of water[29]. Examined values for Ca hardness of samples from Ghulmet tap water, channel water and tank water found 7.33 mg/L, 4.66 mg/L and 6.33 mg/L. Ca hardness from Thole tap water, channel water and tank water ranged 13.00 mg/L, 15.33 mg/L and 16.66 mg/L, while finding for Nilt tap water, channel water and tank water were determined as 6.00 mg/L, 8.66 mg/L and 6.33 mg/L respectively. Results of investigated samples of drinking water for calcium hardness from the different sources of three localities varied between 4.66–16.66 mg/L. Higher level of Ca hardness was found in Thole tank water, while the lowest was determined from Ghulmet channel water (**Table-2**). Ca hardness level in Thole tank water was higher than other samples, which might be due to high content of calcium in the rocks of the catchment area of the locality. According to WHO and EPA, Ca hardness must not exceed 100 mg/L and the values found for the present study fall under these limits.

Cynuric acid is a conditioner or stabilizer which is added to water to slow down the disintegration of chlorine from the sun rays. By using proper level of cynuric acid, up to 80% of normal chlorine can be saved from break down during bright sunny days[6]. The determined levels of cynuric acid of drinking water from Ghulmet tap water, channel water and tank water ranged from 41.33 mg/L, 40.66 mg/L and 38.00 mg/L respectively. Similarly, the findings for cynuric acid from Thole tap water, channel water and tank water were found as 52.00 mg/L, 48.66 mg/L and 40.33 mg/L, while the results for Nilt tap water, channel water and tank water ranged from 40.33 mg/L, 36.00 mg/L and 35.33 mg/L respectively. WHO and EPA have recommended 100 mg/L of cynuric acid contents that must not exceed in drinking water. The analyzed results for cynuric acid of different samples showed fluctuation between 35.33-52 mg/L. Highest level of cynuric acid was found in Thole tap water, while the lowest was found in Nilt tank water (**Table-2**). The levels of cynuric acid in the investigated samples were under the prescribed standards of WHO and EPA.

CONCLUSION

The results pertaining to water quality from different villages of Nagar valley revealed that all the tested parameters i.e. temperature, pH, turbidity, electrical conductivity, total dissolved solids, total coliform bacteria, total faecal bacteria, calcium hardness, cynuric acid and total alkalinity were meeting the prescribed standards of WHO and EPA. However, careful attention towards contamination of water sources is recommended so that future risk in terms of environmental pollution and human health concerns could be minimized or controlled. Similar studies are also recommended in all human settlements (villages

and towns) so that reliable data could be available for health care departments, planners, community welfare organizations and researchers.

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