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An Assessment of Physio-chemical and Microbiological Parameters of water from Hunza and Gilgit River Gilgit-Baltistan Pakistan

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Abstract: This study focused upon the determination of physio-chemical and biological assessment of two major rivers Gilgit and Hunza, Gilgit-Baltistan, Pakistan. The data was collected during the mid of October 2014.Fourteen different samples were collected at different stations of both rivers. On the basis of sample collection, the whole of these two rivers were divided into seven different stratums. Seven samples were collected from river Hunza and the remaining seven samples were taken from Gilgit River. The physio-chemical and biological parameters which were taken to analyze water quality were pH, Total Dissolved Solid, Temperature, Turbidity, Electrical Conductivity, Salinity, Color, Odor and E-Coli bacteria. Some parameters were analyzed and assessed on the spot such as Temperature, Turbidity, Electrical Conductivity, Salinity and Total Dissolved Solid with the help of multivariate parameters. Few chemical and microbial parameters like turbidity, pH and E-Coli were tested in Gilgit-Baltistan Environmental Protection Agency laboratory. The data showed variation of the investigated parameters in Hunza River water samples as pH 8.200-8.500, TDS 14.300-32.701 ,Turbidity 107.90-173.00,pH8.2-8.5 Electrical Conductivity 28.100-34.900, Hardness 0.8300-1.9100,EColi 0.000 and temperature level from 8.200-16.100.In Gilgit River the range of these parameters were pH 8.300-8.500, TDS 14.900-15.800, Turbidity 5.87-7.900, Electrical Conductivity 21.500-23.300, Hardness 0.8700-0.9200, E. Coli

0.000-3.000 and temperature level from 14.100-16.100.The major causes of contamination of water in both rivers were identified as due to household wastes and garbage.

Key Words: Water Quality, Total Dissolved Solids, Turbidity, Electrical Conductivity, Environmental Protection Agency, World Health Organization.

INTRODUCTION

Rivers play a major role in controlling the global water cycle and in the hydrologic cycle. They are most active agents of transport[1]. People along the river use water for many purposes. However, the surface water quality is deteriorating due to anthropogenic activities, industrialization, farming activities, transportation, urbanization, animal and human excretions and domestic wastes[2]. According to[3-4]Srivastava *et al*., 2011; Gupta *et al*., 2011variation in the quality and quantity of river water due to natural and anthropogenic activities is widely studied in the case of several world rivers. According to [5]Rani *et al*[5]riverine system consist of both main course and tributaries, carrying the one way flow of sediment with load of dissolved matter and particulate phases coming from natural and anthropogenic sources. Rivers are waterways of strategic importance across the world, providing main water resources for domestic, industrial and agricultural purposes[6].Rivers also serves for domestic, industrial and agricultural disposal, transportation, getting food resources and for recreational activities[7]. According to[8-9]Lawson, 2011; Adeyemo *et al*., 2008, the water quality of rivers, streams and lakes changes with the seasons and this has deep influence on the population density of aquatic plants and animals. According to Yadav *et al*[10].the Physicochemical parameters of water quality in river Ghangha at Ghazipur India were changed with reference to time .They were studied the parameter like temperature that was increasing, depletion in dissolved oxygen, and other parameters were potassium, phosphate, sodium and nitrate etc.Andrew[11], analyzed different parameter of the water in Ogun river in Nigeria and stated that some were in normal position like Mg,Ca,Ph and acidity.There were few parameters which were out of desireable level such as Nitrate,Total solid,Total suspended solid,Total dissolved solid,Sodium,Potassium and copper.It is a common practice for people living along the river catchments to discharge their domestic wastes as well as human excreta into rivers. Wild and domestic animals using same drinking water can also contaminate the water through direct defecation and urination. The quality of water may be described according to their Physio-chemical and microbiological characteristics[12-13].Important physical and chemical parameters that affect the natural water quality are temperature, pH, turbidity, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, alkalinity, nutrients, etc[14].Rivers included in most different studies are the Goksu river, Turkey[15],Nansha river, Beijing central region China[16] (Jia *et al*.,2011), Chenab river, Pakistan[17] In Pakistan water quality of rivers reported are river Kabul[18],Indus[19],Neelam[20] and Lei[21]. Results from these and other studies of water of different origins[22-23-24] discovered that anthropogenic activities significantly degraded water quality in the downstream sections of the major rivers consequent to cumulative effects of upstream development and inadequate wastewater treatment facilities at the banks of small tributaries. The current study focused upon the determination of Physio-chemical and microbiological assessment of the two main rivers (Gilgit and Hunza), Gilgit-Baltistan, Pakistan.

MATERIAL AND METHODS

Fourteen samples were collected, seven each from Gilgit and Hunza river. For the sample collection both river were divided into seven strata on the basis of average one km distance and then within different stratum, simple random sampling technique was used. The samples were labeled with time, date and location and transported to Gilgit-Baltistan Environmental Protection agency laboratory. The taste and colour was checked on the spot. Temperature was measured by using thermometer, pH was measured with digital pH meter, turbidity was measured with turbidity meter, Salinity, electrical conductivity and total dissolved solids were measured with conductivity meter, hardness was detected with applying the formula (Hardness=TDS/17.1GPL). By putting value of TDS hardness was obtained. For microbiological analysis Waqtech water testing kit was used which employ the membrane filtration technique, and membrane Lauryl Sulphate Broth as medium. A 100 ml volume of water was sucked through the membrane, fitted in the sterile membrane unit with the help of vacuum pump. The membrane was then placed on the absorbent pad saturated with membrane Lauryl sulphate broth in sterile aluminum Petri dish. The plates were then incubated for 18 hours at 40-44 ^{0}C. After incubation period all yellow colonies on the membrane were counted and reported in per 100 ml of water. All the results were statistically analyzed using one way ANOVA and differences were compared with using statix-8 statistical software.

RESULTS

Results of Hunza River:

Electrical Conductivity (µS): The status of Conductivity in the Hunza River is presented in table 2. The maximum value was recorded 34.900ppm from sample 5 (junction between Chikas and Hunza River) and minimum 28.100ppm have seen from sample 4(lower station of Nomal area) (table1) while the mean value was observed 30.371ppm with 2.2706 standard deviation (Table 2).

E coli (mg/l): Result of overall status of E coli is documented in table2. The maximum value was 0.0000mg/l found from the samples at Hunza River and minimum value was 0.0000mg/l recorded while mean value was recorded 0.0000mg/l with 0.0000 standard deviation (Table 2) where the total sample were seven.

Hardness: Overall feature of Hardness of the Hunza River is shown in table2. The maximum value 1.9100ppm was recorded from samples 2 (Jama'at khana 2 area Sultanabad) (table 1) and minimum value have recorded 0.83ppm from sample 7 (Junction between H.R and G.R) (table 1) .The mean value was recorded 1.3200ppm with0.3335 standard deviation (Table 2). The number of samples were seven from which the result had concluded.

Turbidity (NTU): Status of Turbidity in seven different places of Hunza River was presented in table2. The maximum value 173.00NTU from sample 7 (Junction between H.R and G.R) (table 1) was recorded and minimum value 107.90NTU from sample 1(Gas plant area) (table 1). Mean value was recorded 141.40 with 24.852NTU standard deviation (Table 2).

PH: The overall results of pH is shown in table1.The results showed maximum value 8.5000pH which was recorded from the sample 7 (Junction between H.R and G.R) (table 1) and minimum 8.2000pH respectively was observed from seven samples 3, 4(Grammar public school, lower station of Nomal area) (table 1). Mean value was found 8.3286p with 0.0951pH standard deviation (Table 2).

Salinity: The status of Salinity concentration in Hunza River is shown in table1 .Maximum value was seen 25.700ppm from sample 1(Gas plant area) (table 1) and minimum value 14.100ppm was recorded from the sample 4 (lower station of Nomal area) (table 1) while mean value was observed 19.571ppm with 5.6774 standard deviation (Table 2).

ANOWA Result of Hunza River:

Table 1: Physio-chemical and biological parameters of Hunza River

Variable	N	Mean	SD	Minimum	Maximum
Conductivity		30.371	2.2706	28.100	34.900
E coli	7	0.0000	0.0000	0.0000	0.0000
Hardness	7	1.3200	0.3335	0.8300	1.9100
NTU	7	141.40	24.852	107.90	173.00
pH	7	8.3286	0.0951	8.2000	8.5000
Salinity	7	19.571	5.6774	14.100	25.700
TDS	7	22.614	5.6940	14.300	32.700
Temperature	7	11.671	3.0625	8.2000	16.100
Color	7	objectionable/ non-acceptable			
Odor	7	objectionable/non-acceptable			

Table2: Inventory of water quality parameters at Hunza River

S#	S. Name	Sample Location	Turbidity. <5NTU	pH 6.5-8.5	Conductivity µS	TDS .ppm <500	Salinity ppm, 35ppt /3500 mg/L	Tem0C <37	Color <15TCU	Odor	Hardness GPG Hardness =TDS/17.1 <150ppm	E-Coli 0/100 ml
1	A	Gas plant area Sultanabad	107.9	8.3	30.1	23.6	25.7	8.4	turbid	acceptable	1.38	Nil
2	B	Jama'at Khana Area	109.5	8.3	31.5	32.7	25.3	8.2	turbid	acceptable	1.91	Nil
4	D	Nomal Area	147.9	8.4	28.1	19.2	14.1	11.0	turbid	acceptable	1.12	Nil
5	E	Junction b/w Chikas and HR	160.4	8.3	34.9	24.9	18.0	13.4	turbid	acceptable	1.45	Nil
6	F	Danyore RCC Bridge	153.6	8.3	29.1	20.3	14.3	14.5	turbid	acceptable	1.19	Nil
7	G	Junction between HR and GR	173.0	8.5	28.9	14.3	14.2	16.1	turbid	acceptable	0.83	Nil

Key to Abbreviations: E-C=Electrical Conductivity, E. coli=Escherichia Coli, NTU=Nephelometric Turbidity Unit, TDS=Total Dissolved Solid, TCU=True Color Unit, pH=Potential Hydrogen, mg/l=milligram per liter, ppm= Parts per million

Total Dissolved Solids: The status of total dissolved solid of the Hunza River is shown in table 2. Maximum value 32.700ppm was seen from the sample 2(Jama'at khana 2 area Sultanabad) (table 1) and minimum 14.300 was recorded from the sample 7((Junction between H.R and G.R) (table 1) while mean value was noted 22.614ppm with 5.6940 standard deviation (Table 2).

Temperature (^{0}C): Temperature of temperature from seven different samples of the Hunza River is shown in table1. It showed maximum value 16.100 from the sample 7(Junction between H.R and G.R) (table 1) and minimum value 8.2000 was recorded from the sample 2 (Jama'at khana 2 area Sultanabad) (table 1) while the mean value was recorded 11.671 with 3.0625 standard deviation at Hunza River (Table 2).

Color: The table1 is showing the overall status of the color of seven samples. The maximum value was recorded as turbid and minimum value was also turbid seen from overall seven samples at Hunza River (table1) while mean and standard deviation were also turbid (Table 2).

Odor: Overall status of odor of the Hunza River is presented in table 2. All the value and characteristics about its minimum, maximum, standard deviation and mean has same value that is non-objectionable (Table 1&2).

Results of Gilgit River:

Electrical Conductivity (µS): The status of Conductivity in the Gilgit River is presented in table 4. The maximum value was recorded 23.300µS from the sample N (RCC Bridge Konodas) and minimum 21.500 µS have seen from the sample (Skarkoi) (Table 3) while the mean value was observed 22.200 µS with 0.6481 µS standard deviation (Table 4).

E coli (mg/l): Result of overall status of E coli is documented in table 4. The maximum value was 3.0000mg/l found from sample N (RCC Bridge Konodas) and minimum value was 0.0000mg/l recorded from sample I-O (Khari Area, Waste dumped area near KIU, Double Pull near CM House, Hyderpura Service station, Fatima Jinnah women Degree College, Skarkoi) (Table 3) while mean value was recorded 0.4286 0/100ml with 1.1339 standard deviation (Table 4) where the total sample were seven.

Hardness: Overall feature of Hardness of the Gilgit River is shown in table 4. The maximum value 0.9200 ppm was recorded from the sample N (RCC Bridge Konodas) of Gilgit River and minimum value 0.8700ppm from the sample O (Skarkoi) (Table 3) while the mean value was recorded0.8947 ppm with 0.0185 standard deviation (Table 4). The number of samples were seven from which the result had concluded.

Turbidity (NTU): Table 4 shows status of Turbidity in seven different places of Gilgit River. The maximum value 7.9200NTU was recorded from the sample O (Skarkoi) and minimum value 5.8700NTU was observed from the sample N (RCC Bridge Konodas) (Table 3) from Gilgit River. Mean value was recorded 6.8057 with 6.6690NTU standard deviation (Table 4).

pH: The overall results of pH is shown in table 4.The results showed maximum value 8.5000pH which was recorded from the sample N (RCC Bridge Konodas) and minimum 8.3000pH respectively was observed from the sample L(Hyderpura Service station) (Table 3) at Gilgit River. Mean value was found 8.4000pH with 0.0577pH standard deviation (Table 4).

Salinity: The status of Salinity concentration in the Gilgit River is shown in table4 .Maximum value was seen 13.300ppm from the sample N (RCC Bridge Konodas) and minimum value 10.700ppm was recorded from the sample K(Double Pull near CM House) (Table 3) , Gilgit River while mean value was observed 11.257ppm with 0.9144 standard deviation (Table 4).

Total Dissolved Solid: The status of total dissolved solid of the Gilgit River is shown in table 4. Maximum value 15.800ppm was seen from the sample N (RCC Bridge Konodas) and minimum 14.900 was recorded from the sample O (Skarkoi) (Table 3) while mean value was noted 15.314ppm with 0.3288 standard deviation (Table 4).

Temperature (^{0}C): Temperature of temperature from seven different samples of the Gilgit River is shown in table4. It showed maximum value 16.700 was recorded from the sample L(Hyderpura Service station) and minimum value 14.100 from the sample M(Fatima Jinnah women Degree College) (Table 3) while the mean value was recorded 15.600 with 0.9201 standard deviation at Gilgit River (Table 4).

Table 3: Inventory of water quality parameters at Gilgit River

S #	S:Name	Sample location	NTU	pH	Sμ	TDS <500ppm	Salinityppm	Tem.	Color	Odor	Hardness.GPG <500ppm	E-Coli
8	I	Khari Area	6.69	8.4	21.8	15	10.8	17	Slightly turbid	acceptable	0.88	Nil
9	J	Waste dumped area near KIU	6.52	8.4	22.1	15.4	11.1	16	Slightly turbidity	acceptable	0.9	Nil
10	K	Double Pull near CM House	6.33	8.4	21.6	15.1	10.8	16	Slightly turbid	acceptable	0.88	Nil
11	L	Hyderpura Service station	7.12	8.3	22.4	15.4	11	17	Slightly turbid	acceptable	0.901	Nil
12	M	Fatima Jinnah women Degree College	7.19	8.4	22.3	15.6	11.1	14	Slightly turbid	acceptable	0.912	Nil
13	N	RCC Bridge Konodas	5.87	8.5	22.7	15.8	13.3	15	Slightly turbid	acceptable	0.92	3 colonies
14	O	Skarkoi	7.92	8.4	21.5	14.9	10.7	16	Slightly turbid	acceptable	0.87	Nil

Color: Table 4 shows the overall status of the color of seven samples. The maximum, minimum, standard deviation and mean color value was recorded as slightly turbid from overall seven samples at Gilgit River (Table 3).

Odor: Overall status of odor of Gilgit River is presented in table 4. All the values and characteristic about its minimum maximum, standard deviation and mean has same value that is non-objectionable.

Key to Abbreviations: E-C=Electrical Conductivity, E. coli=Escherichia Coli, NTU=Nephelometric Turbidity Unit, TDS=Total Dissolved Solid, TCU=True Color Unit, pH=Potential Hydrogen, mg/l=milligram per liter, ppm= Parts per million

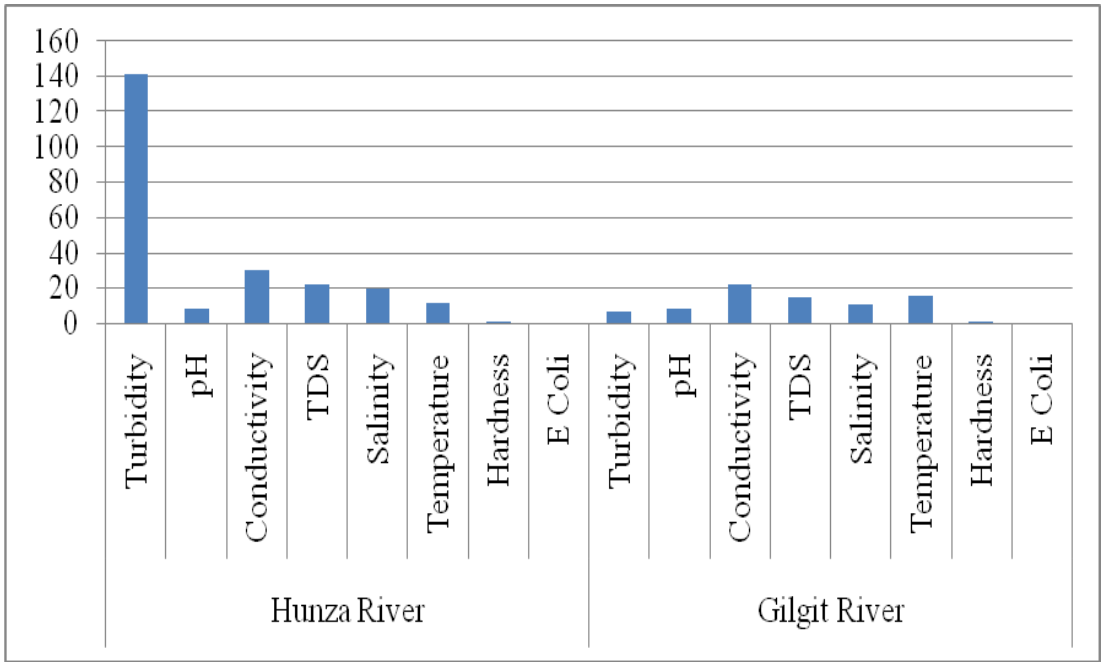
ANOWA Results of Gilgit River:

Table 4: Physio-chemical and biological parameters of Gilgit River

Variable	N	Mean	SD	Minimum	Maximum
Conductivity	7	22.200	0.6481	21.500	23.300
E coli	7	0.4286	1.1339	0.0000	3.0000
Hardness	7	0.8947	0.0185	0.8700	0.9200
NTU	7	6.8057	0.6690	5.8700	7.9200
pH	7	8.4000	0.0577	8.3000	8.5000
Salinity	7	11.257	0.9144	10.700	13.300
TDS	7	15.314	0.3288	14.900	15.800
Temperature	7	15.600	0.9201	14.100	16.700
Color	7	objectionable/ non-acceptable			
Odor	7	objectionable/non-acceptable			

Table 5: Combined ANOWA Results of Both Rivers (Hunza and Gilgit)

Variable	Mean	S.D	Range	Minimum	Maximum
Turbidity	78.72	71.51	167.13	5.87	173.00
pH	8.37	0.09	0.30	8.20	8.50
Conductivity	26.47	4.42	13.40	21.50	34.90
TDS	19.03	5.23	18.40	14.30	32.70
Salinity	15.35	5.61	15.00	10.70	25.70
Temperature	13.84	2.98	8.50	8.20	16.70
Hardness	1.11	0.31	1.08	0.83	1.91



Graphical Mean Result of both Rivers(Hunza and Gilgit).

DISCUSSION

Temperature: examination of both rivers has been mentioned in table 5.The mean temperature is 13.84, standard deviation is 2.98, range is 8.50, minimum value is 8.20 and maximum value of temperature is 16.70°C. (**Table-5**). Variation in temperature might be due to the rate of chemical reactions and the nature of biological processes taking place in both rivers. 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 37°C because warm water holds less oxygen content. In a study conducted by[25]Shedayi *et al.*, 2015at drinking water quality of Nomal, Gilgit-Baltistan, and observed temperature variation of the sampled water from 9 to 25 °C. Of the seven samples one were at higher side. This deviation from limitation may be because of the timing of the sampling.

Turbidity: values examined from both rivers revealed the fluctuation in the findings of tested turbidity character which is from 5.87 NTU-173.00 NTU. The mean value is 78.72 NTU, standard deviation is about 71.52 and range is nearly 167.3 NTU (**Table-5**). 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. Most turbidity result means the maximum value deducted from the result is 173.00 which show that highly human intervention of other activities like mining, erosion of soil or mining etc going in the river. But somehow few results are within in limit that shows the suitability of tested water samples for drinking purpose.

Electrical Conductivity: values determined from both river (Hunza and Gilgit) has presented in table 5. According to the results, mean value is 26.47 µS/cm, standard deviation is about 4.42 µS/cm and range is 13.40µS/cm. Maximum value for EC was found in 34.90 which might be due to presence of high concentrations of dissolved salts and ionic particles the lower value is 21.50 µS/cm (**Table-5**).[26]Yahya *et al.*, 2012, in a study found electrical conductivity values varied between 220.3 to 287 µS/cm and 228.6 to 85.3 µS/cm during post monsoon season. These values were not high compared

with WHO guidelines values of 1000 mg/l. According to WHO and EPA, electrical conductivity of drinking water must not exceed 1000 µS/cm. Thus the EC values analyzed for the samples under investigation were within the prescribed standards of WHO and EPA.

E-Coli bacteria: examination provides indication of the hygienic condition of water used for drinking and other purposes. Total coliform bacteria and faecal coliform Escherichia Coli (E. coli) are two types of faecal indicator bacteria. Several bacteria can be classified as coliform, and are commonly found in soil, on the surface of leaves, in decaying matter, and can grow in water distribution mains[27]In all the tested samples no colonies of E Coli bacteria were found except in one location there were 3 colonies of these bacteria. According to WHO and EPA, the number of E-Coli bacteria must not deducted in 100ml of water. The present results for E Coli bacteria assessed from different sources and locations from both Hunza and Gilgit River, and the maximum result was three E Coli (**Table-5**). Microbial contamination of drinking water is caused by the human activities and livestock. The results for all investigated samples were meeting the international standards set by WHO and EPA except one sample.

PH: values from overall results of both Rivers were such as that the minimum value was 8.37, standard deviation was 0.09 and the range value was about 0.30. Highest pH value was determined in 8.50 and lowest value was found 8 (**Table-5**). These results are also in accordance with a study conducted by [28]Inam & Alam, 2014 where pH values measured at different locations were within the range of WHO standards. However, the range of pH values was from 6.6 and 7.75 with an average of 7 at level one and from 6.7 to 7.68 with an average of 7.04 at level two. 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. 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.

Total Dissolved Solids: is the calculation of inorganic salts and minute amounts of organic substances present in a water solution. An outcome of results collectively from Hunza and Gilgit River was like that the mean value was 19.03, standard deviation was 5.23 and the range was 18.40. Highest TDS level determined was 32.70 while the minimum value found was 14.30 (**Table-5**). [29]Vinod Jena *et al*., 2013found TDS content of the river water in the range of 29.4-52.5 mg/l. appreciable TDS values were observed at all sampling sites indicating the mixing of pollutants in river from anthropogenic activities in and around the river, such as the mixing of sewage, clothes washing and garbage dumping, which are some common activities at the riverbank in this area. 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. Furthermore, increased concentration may also affect individuals who are suffering from kidney and heart problems and also has constipation effects. However all the parameters tested were following the permitted standards of WHO and EPA.

Water: That contain a significant concentration of dissolved minerals like calcium, magnesium, strontium, iron and manganese, are called "hard" because it takes a large amount of soap to produce a lather or foam with these waters. When hard waters are heated in water heaters they leave a mineral deposit called "scale." Total hardness is expressed as mg/L of calcium carbonate because calcium and carbonate are the dominant ions in most hard waters. The result of mean value was1.11 ppm and the standard deviation was nearly 0.30 ppm. Its range was1.08 ppm. The minimum value was 0.83ppm and maximum value was 1.91 which is very negligible.

The odor: Of water shows the quality of water. Water supplied to consumers should be free of objectionable taste and odor[30].Pure water shows specific importance according to aesthetic value. The

odor of water change due to the turbidity level.When water becomes highly turbid the odor also goes highly change.In simple the entrance of dust, clay and chemical etc can changes the odor of water quality.The overall result about odor from both river (Hunza and Gilgit)were within limit.

Color: Of water aslo play a key role about the health of water.If any contamiantion is mixed in water then there will be change in color .When turbidity level and suspended solid become high ,consequently the color will also highly change.WHO and the Water Clinic reported that color in drinking water may be due to the presence of colored organic substances, usually humus, metals such as iron and manganese and colored industrial wastes[31, 32]. The observed color was within the limits from both of the rivers.

CONCLUSION

The results of both rivers revealed that all the tested parameters i.e. temperature, pH, turbidity, electrical conductivity, total dissolved solids, E-Coli bacteria, hardness, color and odor were meeting the prescribed standards of WHO and EPA while some parameters were out of range . The level of turbidity, conductivity and total dissolved solid were high in Hunza River while in Gilgit River the temperature and E-coli were high. The presence of E-Coli shows the mixing of human or animal waste in Gilgit River.

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