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Assessment of River Beas Water Quality during Summer Season in Himachal Pradesh, India

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ABSTRACT: In present investigations the analysis of water quality parameters of river Beas in Himachal Pradesh during summer season was undertaken. Parameters such as alkalinity, conductivity, pH, temperature, total dissolved solids (TDS), total hardness, turbidity, calcium, magnesium, potassium, sodium, cadmium, copper, iron, lead, chloride, fluoride, nitrate, and Biological parameters such as biological oxygen demand (BOD), chemical oxygen demand (COD), *Colliform* and *Escherichia coli* were analyzed from six sampling stations i.e. Beaskund, Shamshi, Pandohdam, Dharmpur, Nadaun and Pongdam in the study area. The analysis of data reveals that Cadmium, iron and were found to be higher than the acceptable limit prescribed by Bureau of Indian standards (BIS), 2012 for drinking water in India. The mean value of Lead was at par with acceptable proposed by WHO, 2011 and BIS, 2012. The mean pH value was 8.55±0.016 at Nadaun (SS-5). *Colliform* and *E. coli* were present in all the sampling stations of river Beas. All the other physicochemical parameters were within the limit prescribed by World Health Organization (WHO), 2011 and BIS, 2012.

Key Words: River Beas, Water Quality, Summer, parameters.

INTRODUCTION

The rivers and lakes play an important role in lives of human beings. The rivers provide irrigation, potable water, cheap transportation, hydroelectricity and livelihood to large population on the earth (Gleick, 1993 and Smith and Gleick, 2012) The Indian river system is classified in to four major categories i.e. The Himalayan, the rivers traversing the Deccan Plateau, the Coastal and those in the inland drainage basin. Indus river system consist of the Chenab, the Jhelum, the Ravi, the Satluj and the Beas (Maity, 2009). River Beas, an important contributory of the Indus system, is the only tributary of system confined to India. The river Beas is a perennial river fed by snow, rainfall and is covered with extensive cover of vegetation. River Beas originates from Beaskund, in Pirpanjal range near Rohtang pass at 13326 ft above mean sea level. Total length of river Beas is 470 km, out of which it flows 256 km in Himachal Pradesh. The major tributaries of river Beas in Himachal Pradesh are Parvati, Hurla, Sainj, Tirthan, Uhl, Suketi, Looni, Son, Bakkar, Binwa, Neugal, Mankhad, Baner, Banganga and Chakki river. The important settlements on the bank of river Beas in Himachal Pradesh are Manali, Kulu, Pandoh, Mandi, Dharampur, Jaisinghpur, Sujanpur Tira, Nadaun and Dehra Gopipur. The river water quality is highly variable by nature due to environmental conditions such as basin lithology, vegetation and climate (Awasthi and Tamot, 2010 and Sharma and Walia, 2015). There are three major natural sources of dissolved and soluble matter carried by rivers, atmospheric inputs of material, the degradation of terrestrial organic matter and weathering of surface rocks. With continuous growth of population, rapid developments in agriculture, mining, urbanization, industrialization, hydro-electrical generation activities and motor vehicle pollution, the river water contamination with hazardous waste is becoming common phenomena (Shivayoginath *et.al*, 2012; CPCB, 2013 and Sharma and Walia, 2016). The rate of discharge of pollutants in to the water is far higher than rate of purification (Chauhan and Sagar, 2013). As water quality and human health are closely related and it is in this context, that the water quality assessment is critical for pollution control and protection of surface and ground water (Kumar, *et.al*, 2010, FWPCA, 1968 and Thomas *et.al*,1998).

The river Beas and its tributaries are the major source of drinking water for the population of Kulu, Mandi, Hamirpur and Kangra districts of Himachal Pradesh (Balpande, (2007). Besides this, Beas river water is also used for Irrigation and hydroelectricity generation activities. As no systematic study has been undertaken to assess the water quality of river Beas, hence the present investigation was undertaken.

MATERIALS AND METHODS

In order to assess the water quality of river Beas, six sampling stations i.e. first sampling station (SS-1) Beaskund, second sampling station (SS-2) Shamshi, third sampling station (SS-3) Pandoh Dam, fourth sampling station (SS-4) Dharampur, fifth sampling station (SS-5) Nadaun and sixth sampling station (SS-6) Pongdam were selected on the basis of identified pollution problem and upon the location of point of source of waste water discharge in the selected stretch of river Beas. The water samples were collected at about 15cm depth from river Beas using dip and grab sampling method. Three water samples were collected during summer season, one every fifteen days in the month of May and June in the year 2015. The temperature was recorded using mercury thermometer, pH was recorded using digital pH meter (Environmental & Scientific Instruments111E), turbidity was recorded using digital turbidity meter (Environmental & Scientific Instruments 331E) and conductivity was recorded using digital conductivity meter (Environmental & Scientific Instruments 611E) respectably. All the samples were preserved with conc. HNO_3 (3ml/L) and conc. HCl (0.5ml/200 ml) solution (RANKAM, RFCL) for analysis of remaining physicochemical and biological parameters at Environtech Laboratory Mohali, Punjab, India, using standard methods (APHA/AWWA/WEF, 2012 and BIS, 1987). Sodium and Potassium were determined using Microprocessor Flame Photometer (Environmental & Scientific Instruments 1382). Iron was determined using Spectrophotometer (Environmental & Scientific Instruments 2373). Cadmium, Copper and Lead were determined using Flame Atomic Absorption Spectrometer (LABINDIA AA7000) after appropriate calibration according to standard calibration procedures. All the data obtained was subjected to statistical analysis mean and standard deviation.

RESULTS AND DISCUSSION

The results of various physical, chemical, and biological parameters recorded during summer season in present study with mean value and standard deviation values are presented in Table 1-6. Comparative data of various parameters at all the six sampling stations during Summer Season of river Beas is presented in Table 7.

Table 1: Showing results of various parameters during pre monsoon season (Summer) at sampling station Beas Kund (SS-1).

Sr. No.	Parameter	Unit	Time of collection	Date of collection			Mean Value		S.D.
				2/5/2015	17/5/2015	1/6/2015			
1.	Alkalinity	mg/L	7am	13	12	11	12	±	0.816
2.	Conductivity	µS/cm	7am	55	52	52	53	±	1.414
3.	pH		7am	6.3	6.29	6.31	6.3	±	0.008
4.	Temperature	°C	7am	-2.6	-2.2	-1.2	-2	±	0.589
5.	TDS*	mg/L	7am	37	34	34	35	±	1.414
6.	Total Hardness	mg/L	7am	15	14	13	14	±	0.816
7.	Turbidity	NTU	7am	0.2	0.5	0.8	0.5	±	0.245
8.	Calcium	mg/L	7am	1.7	1.6	1.5	1.6	±	0.082
9.	Magnesium	mg/L	7am	2.4	2.2	2.3	2.3	±	0.082
10.	Potassium	mg/L	7am	0.21	0.22	0.17	0.2	±	0.022

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Sr. No.	Parameter	Unit	Time of collection	Date of collection			Mean Value		S.D.
				2/5/2015	17/5/2015	1/6/2015			
11.	Sodium	mg/L	7am	5.9	5.8	5.7	5.8	±	0.082
12.	Cadmium	mg/L	7am	0.004	0.005	0.006	0.005	±	0.001
13.	Copper	mg/L	7am	0.0002	0.0003	0.0004	0.0003	±	0.000
14.	Iron	mg/L	7am	0.07	0.08	0.09	0.08	±	0.008
15.	Lead	mg/L	7am	0.0048	0.0049	0.005	0.0049	±	0.000
16.	Chloride	mg/L	7am	8.3	7.9	8.1	8.1	±	0.163
17.	Fluoride	mg/L	7am	0.31	0.32	0.33	0.32	±	0.008
18.	Nitrate	mg/L	7am	2.3	2.1	2.2	2.2	±	0.082
19.	BOD at 27°C for 3 days**	mg/L	7am	0	0	0	0	±	0.000
20.	COD***	mg/L	7am	0	0	0	0	±	0.000
21.	Colliform	P/A'	7am	P	P	P			
22.	*Escherichia coli*	P/A'	7am	P	P	P			

*TDS Total Dissolved Solids, **BOD Biological Oxygen Demand, *** COD Chemical Oxygen Demand, 1 P/A, Present/Absent

Table 2: Showing results of various parameters during pre monsoon season (Summer) at sampling station Shamshi (SS-2).

Sr. No.	Parameter	Unit	Time of collection	Date of collection			Mean Value		S.D.
				2/5/2015	17/5/2015	1/6/2015			
1.	Alkalinity	mg/L	11am	25	24	23	24	±	0.816
2.	Conductivity	µS/cm	11am	92	88	90	90	±	1.633
3.	pH		11am	6.9	7.1	7	7	±	0.082
4.	Temperature	°C	11am	7.5	8	8.5	8	±	0.408
5.	TDS*	mg/L	11am	62	59	59	60	±	1.414
6.	Total Hardness	mg/L	11am	33	31	32	32	±	0.816
7.	Turbidity	NTU	11am	2	3	1	2	±	0.816
8.	Calcium	mg/L	11am	9.7	9.5	9.6	9.6	±	0.082
9.	Magnesium	mg/L	11am	1.8	2	1.9	1.9	±	0.082
10.	Potassium	mg/L	11am	1.2	1.3	1.4	1.3	±	0.082
11.	Sodium	mg/L	11am	5.8	5.6	5.7	5.7	±	0.082
12.	Cadmium	mg/L	11am	0.006	0.005	0.004	0.005	±	0.001
13.	Copper	mg/L	11am	0.0004	0.0006	0.0005	0.0005	±	0.000
14.	Iron	mg/L	11am	0.9	0.92	0.91	0.91	±	0.008

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Sr. No.	Parameter	Unit	Time of collection	Date of collection			Mean Value		S.D.
				2/5/2015	17/5/2015	1/6/2015			
16.	Chloride	mg/L	11am	8.3	8	8	8.1	±	0.141
17.	Fluoride	mg/L	11am	0.27	0.25	0.26	0.26	±	0.008
18.	Nitrate	mg/L	11am	3.2	3.1	3	3.1	±	0.082
19.	BOD at 27°C for 3 days**	mg/L	11am	1	0.8	0.6	0.8	±	0.163
20.	COD***	mg/L	11am	2.2	1.9	1.9	2	±	0.141
21.	Colliform	P/A'	11am	P	P	P			
22.	*Escherichia coli*	P/A'	11am	P	P	P			

*TDS Total Dissolved Solids, **BOD Biological Oxygen Demand, ***COD Chemical Oxygen Demand,1 P/A Present/Absent

Table 3: Showing results of various parameters during pre monsoon season (Summer) at sampling station Pandoh Dam (SS-3).

Sr. No.	Parameter	Unit	Time of collection	Date of collection			Mean Value		S.D.
				3/5/2015	18/5/2015	2/6/2015			
1.	Alkalinity	mg/L	7am	22	23	24	23	±	0.816
2.	Conductivity	µS/cm	7am	87	87	90	88	±	1.414
3.	pH		7am	7.1	7.14	7.18	7.14	±	0.033
4.	Temperature	°C	7am	9	10	11	10	±	0.816
5.	TDS*	mg/L	7am	59	58	60	59	±	0.816
6.	Total Hardness	mg/L	7am	37	38	36	37	±	0.816
7.	Turbidity	NTU	7am	0.5	0.3	1	0.6	±	0.294
8.	Calcium	mg/L	7am	14.5	14.5	16	15	±	0.707
9.	Magnesium	mg/L	7am	4.3	4.6	3.1	4	±	0.648
10.	Potassium	mg/L	7am	1.7	1.9	1.5	1.7	±	0.163
11.	Sodium	mg/L	7am	3.84	3.77	3.79	3.8	±	0.029
12.	Cadmium	mg/L	7am	0.005	0.006	0.007	0.006	±	0.001
13.	Copper	mg/L	7am	0.0003	0.0004	0.0002	0.0003	±	0.000
14.	Iron	mg/L	7am	0.81	0.83	0.82	0.82	±	0.008
15.	Lead	mg/L	7am	0.0099	0.0098	0.0097	0.0098	±	0.000
16.	Chloride	mg/L	7am	9.4	9.6	9.5	9.5	±	0.082
17.	Fluoride	mg/L	7am	0.22	0.23	0.21	0.22	±	0.008
18.	Nitrate	mg/L	7am	1.9	2.1	1.7	1.9	±	0.163
19.	BOD at 27°C for 3 days**	mg/L	7am	1.4	1.1	0.8	1.1	±	0.245
20.	COD***	mg/L	7am	2.9	2.6	2.3	2.6	±	0.245
21.	Colliform	P/A'	7am	P	P	P			
22.	*Escherichia coli*	P/A'	7am	P	P	P			

Table 4 Showing results of various parameters during pre monsoon season (Summer) at sampling station Dharampur (SS-4).

Sr. No.	Parameter	Unit	Time of collection	Date of collection			Mean Value		S.D.
				3/5/2015	18/5/2015	2/6/2015			
1.	Alkalinity	mg/L	11am	72	70	68	70	±	1.633
2.	Conductivity	µS/cm	11am	239	236	236	237	±	1.414
3.	pH		11am	7.59	7.53	7.53	7.55	±	0.028
4.	Temperature	°C	11am	16.5	18	19.5	18	±	1.225
5.	TDS*	mg/L	11am	160	157	157	158	±	1.414
6.	Total Hardness	mg/L	11am	76	76	79	77	±	1.414
7.	Turbidity	NTU	11am	1	0.7	1	0.9	±	0.141
8.	Calcium	mg/L	11am	15.6	15.4	14	15	±	0.712
9.	Magnesium	mg/L	11am	9.9	9.8	9.7	9.8	±	0.082
10.	Potassium	mg/L	11am	2.7	2.6	2.5	2.6	±	0.082
11.	Sodium	mg/L	11am	24.5	24.5	23	24	±	0.707
12.	Cadmium	mg/L	11am	0.009	0.008	0.007	0.008	±	0.001
13.	Copper	mg/L	11am	0.0002	0.0002	0.0002	0.0002	±	0.000
14.	Iron	mg/L	11am	0.22	0.2	0.21	0.21	±	0.008
15.	Lead	mg/L	11am	0.0195	0.0196	0.0197	0.0196	±	0.000
16.	Chloride	mg/L	11am	30.5	30	29.5	30	±	0.408
17.	Fluoride	mg/L	11am	0.53	0.52	0.51	0.52	±	0.008
18.	Nitrate	mg/L	11am	2.21	2.2	2.19	2.2	±	0.008
19.	BOD at 27°C for 3 days**	mg/L	11am	1	0.9	0.8	0.9	±	0.082
20.	COD***	mg/L	11am	2.2	1.9	1.6	1.9	±	0.245
21.	Colliform	P/A'	11am	P	P	P			
22.	*Escherichia coli*	P/A'	11am	P	P	P			

*TDS Total Dissolved Solids, **BOD Biological Oxygen Demand, ***COD Chemical Oxygen Demand

Table 5: Showing results of various parameters during pre monsoon season (Summer) at sampling station Nadaun (SS-5).

Sr. No.	Parameter	Unit	Time of collection	Date of collection			Mean Value		S.D.
				4/5/2015	19/5/2015	3/6/2015			
1.	Alkalinity	mg/L	7am	56	55	54	55	±	0.816
2.	Conductivity	µS/cm	7am	205	203	201	203	±	1.633
3.	pH		7am	8.57	8.55	8.53	8.55	±	0.016
4.	Temperature	°C	7am	20.3	21	21.7	21	±	0.572
5.	TDS*	mg/L	7am	136	133	133	134	±	1.414

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Sr. No.	Parameter	Unit	Time of collection	Date of collection			Mean Value		S.D.
				4/5/2015	19/5/2015	3/6/2015			
6.	Total Hardness	mg/L	7am	63	60	60	61	±	1.414
7.	Turbidity	NTU	7am	0.8	1	0.5	0.76667	±	0.205
8.	Calcium	mg/L	7am	19.6	18	16.4	18	±	1.306
9.	Magnesium	mg/L	7am	4.1	3.6	3.7	3.8	±	0.216
10.	Potassium	mg/L	7am	3.2	3.1	3	3.1	±	0.082
11.	Sodium	mg/L	7am	24.8	24.2	23	24	±	0.748
12.	Cadmium	mg/L	7am	0.006	0.008	0.007	0.007	±	0.001
13.	Copper	mg/L	7am	0.0002	0.0002	0.0002	0.0002	±	0.000
14.	Iron	mg/L	7am	0.16	0.15	0.14	0.15	±	0.008
15.	Lead	mg/L	7am	0.0131	0.0132	0.0133	0.0132	±	0.000
16.	Chloride	mg/L	7am	18.4	18.6	17	18	±	0.712
17.	Fluoride	mg/L	7am	0.63	0.62	0.61	0.62	±	0.008
18.	Nitrate	mg/L	7am	1.9	1.8	1.7	1.8	±	0.082
19.	BOD at 27°C for 3 days**	mg/L	7am	0.9	0.7	0.5	0.7	±	0.163
20.	COD***	mg/L	7am	2.1	1.9	2	2	±	0.082
21.	Colliform	P/A'	7am	P	P	P			
22.	*Escherichia coli*	P/A'	7am	P	P	P			

*TDS Total Dissolved Solids **BOD Biological Oxygen Demand ***COD Chemical Oxygen Demand, 1 P/A Present/Absent

Table 6: Showing results of various parameters during pre monsoon season (Summer) at sampling station Pong Dam, (SS-6).

Sr. No.	Parameter	Unit	Time of collection	Date of collection			Mean Value		S.D.
				4/5/2015	19/5/2015	3/6/2015			
1.	Alkalinity	mg/L	11am	69	68	67	68	±	0.816
2.	Conductivity	µS/cm	11am	187	189	191	189	±	1.633
3.	pH		11am	7.61	7.62	7.6	7.61	±	0.008
4.	Temperature	°C	11am	21.7	22.1	22.2	22	±	0.216
5.	TDS*	mg/L	11am	125	126	127	126	±	0.816
6.	Total Hardness	mg/L	11am	72	74	73	73	±	0.816
7.	Turbidity	NTU	11am	0.4	0.5	0.9	0.6	±	0.216
8.	Calcium	mg/L	11am	18.5	17.7	20.8	19	±	1.314
9.	Magnesium	mg/L	11am	5.7	6.1	5.9	5.9	±	0.163
10.	Potassium	mg/L	11am	0.3	0.1	0.2	0.2	±	0.082
11.	Sodium	mg/L	11am	15.5	16	16.5	16	±	0.408
12.	Cadmium	mg/L	11am	0.009	0.008	0.007	0.008	±	0.001
13.	Copper	mg/L	11am	0.0002	0.0002	0.0002	0.0002	±	0.000
14.	Iron	mg/L	11am	0.31	0.3	0.32	0.31	±	0.008
15.	Lead	mg/L	11am	0.0164	0.0165	0.0166	0.0165	±	0.000
16.	Chloride	mg/L	11am	19.3	18.7	19	19	±	0.245
17.	Fluoride	mg/L	11am	0.31	0.3	0.29	0.3	±	0.008
18.	Nitrate	mg/L	11am	0.13	0.12	0.11	0.12	±	0.008
19.	BOD at 27°C for 3 days**	mg/L	11am	1.3	1.5	1.1	1.3	±	0.163
20.	COD***	mg/L	11am	3	3.3	2.7	3	±	0.245
21.	Colliform	P/A'	11am	P	P	P			
22.	*Escherichia coli*	P/A'	11am	P	P	P			

*TDS Total Dissolved Solids, **BOD Biological Oxygen Demand, ***COD Chemical Oxygen Demand,1 P/A Present/Absent

Table 7: Showing results of various parameters during pre monsoon season (Summer) at all the six sampling stations.

Sr. No.	Parameter	Unit	Sampling Stations*						Mean Value		S.D.
			SS-1	SS-2	SS-3	SS-4	SS-5	SS-6			
1.	Alkalinity	mg/L	12	24	23	70	55	68	42.00	±	23.14
2.	Conductivity	µS/cm	53	90	88	237	203	189	143.33	±	68.90
3.	pH		6.3	7	7.14	7.55	8.55	7.61	7.36	±	0.69
4.	Temperature	°C	-2	8	10	18	21	22	12.83	±	8.45
5.	TDS*	mg/L	35	60	59	158	134	126	95.33	±	45.77
6.	Total Hardness	mg/L	14	32	37	77	61	73	49.00	±	22.96
7.	Turbidity	NTU	0.5	2	0.6	0.9	0.8	0.6	0.90	±	0.51
8.	Calcium	mg/L	1.6	9.6	15	15	18	19	13.03	±	5.92
9.	Magnesium	mg/L	2.3	1.9	4	9.8	3.8	5.9	4.62	±	2.66
10.	Potassium	mg/L	0.15	1.3	1.7	2.6	3.1	0.2	1.51	±	1.11
11.	Sodium	mg/L	5.8	5.7	3.75	24	24	16	13.22	±	9.57
12.	Cadmium	mg/L	0.005	0.005	0.006	0.008	0.007	0.008	0.007	±	0.00
13.	Copper	mg/L	0.0003	0.0005	0.0003	0.0002	0.0002	0.0002	0.0003	±	0.00
14.	Iron	mg/L	0.08	0.91	0.82	0.21	0.15	0.31	0.41	±	0.33
15.	Lead	mg/L	0.0049	0.0119	0.0098	0.0196	0.0132	0.0165	0.01	±	0.00
16.	Chloride	mg/L	8.1	8.1	9.5	30	18	19	15.45	±	7.90
17.	Fluoride	mg/L	0.32	0.26	0.22	0.52	0.62	0.3	0.37	±	0.15
18.	Nitrate	mg/L	2.2	3.1	1.9	2.2	1.8	0.12	1.89	±	0.89
19.	BOD at 27°C for 3 days**	mg/L	0	0.8	1.1	0.9	0.7	1.3	0.80	±	0.41
20.	COD***	mg/L	0	2	2.6	1.9	2	3	1.92	±	0.94
21.	Colliform	P/A'	P	P	P	P	P	P			
22.	*Escherichia coli*	P/A'	P	P	P	P	P	P			

*TDS Total Dissolved Solids, **BOD Biological Oxygen Demand, ***COD Chemical Oxygen Demand
SS-1 Beaskund (Distt. Kulu), SS-2 Shamshi (Distt. Kulu), SS-3 Pandoh Dam(Distt. Mandi)
SS-4 Dharampur (Distt. Mandi), SS-5 Nadaun(Distt. Hamirpur) SS-6 Pong Dam(Distt. Kangra)
1 P/A Present/Absent

(A) Physical Aggregate Properties

1. Alkalinity: The alkalinity is the capacity to neutralize acid and is usually due to the presence of bicarbonates, carbonates and hydroxide. The mean value of alkalinity of river Beas was 42±23.14 mg/L, which was within the acceptable limit of 500 mg/L prescribed by BIS, 2012(BIS, 2012).

2. Conductivity: The conductivity is a numerical expression of water's ability to conduct an electric current. The conductivity depends on the concentration of ions in solution. The mean value of conductivity of river Beas in study area was 143.33±68.90 µS/cm.

3. pH: The pH is measure of acidity or alkalinity of a solution. The mean value of pH in study area of river Beas was 7.36±0.69 which was within the acceptable limit of 6.5-8.5 prescribed by BIS, 2012. The SS-5 recorded the highest value of 8.55±0.016, which was above the acceptable limit prescribed by BIS, 2012.

4. Temperature: The temperature of river water effects chemical and biological reactions, conductivity, pH and soluble gases. The temperature of river Beas varied widely in the study area with SS-1 recording lowest of -2±0.58°C and SS-6 recording highest of 22±0.216°C with a mean value of 12.83±8.45°C.

5. Total Dissolved Solids (TDS): The water is a universal solvent dissolving solid, liquid and gases. The solids are present in water in suspended or dissolved state. Some dissolved chemicals may pose health hazard being toxic and carcinogenic.

The mean value of TDS of river Beas was 95.33±45.77 mg/L, which was within the acceptable limit of 500 mg/L prescribed by BIS, 2012.

6. Total Hardness: The total hardness is a measure of dissolved polyvalent metallic ions, predominantly calcium and magnesium cations. Total hardness is traditional measure of capacity of water to react with soap and produce lather. The mean value of total hardness of river Beas was 49±22.96 mg/L, which was within the acceptable limit of 200 mg/L prescribed by BIS, 2012.

7. Turbidity: The turbidity is the measure of suspended sediment such as clay, silt, organic matter, planktons and microscopic organisms in water sample. Turbidity is the property which measures the extent to which light is absorbed or scattered by the suspended matter present in water. The mean value of Turbidity of river Beas was 0.90±0.51 NTU, which was within the permissible limit of 5 NTU prescribed by BIS, 2012. The higher value of turbidity was due to rain and flooding of river during the observation period.

8. Calcium: Most of surface and ground water contains calcium. The Calcium cause both carbonate and non carbonate hardness. Controlled amount of calcium is good for health and is an important factor influencing metabolism and growth. Hence WHO has not proposed any guideline value of Calcium (WHO, 2011). The mean value of calcium in study area of river Beas was 13.03±5.92 mg/L, which was within the acceptable limit of 75 mg/L prescribed by BIS, 2012. This concentration of Calcium in river water may be due to occurrence of highly soluble halides, gypsum and easily weathered surface rocks (GSI, 2012).

9. Magnesium: Magnesium contributes both carbonate and non carbonate hardness to water. The mean value of magnesium in study area of river Beas was 4.62±2.66 mg/L, which was within the acceptable limit of 30 mg/L prescribed by BIS, 2012.

10. Potassium: Potassium is an essential element in humans and occurs widely in environment and natural water sources. The mean value of potassium in study area of river Beas was 1.51±1.11 mg/L. The BIS, 2012 and WHO, 2011 has not proposed any guideline value of the potassium. However high concentration of potassium affects the health of high risk group of individuals suffering from kidney diseases and heart diseases.

11. Sodium: Sodium is found virtually in all foods and drinking water. The mean value of sodium in study area of river Beas was 13.22±9.57 mg/L and was within acceptable limit prescribed by BIS, 2012.

12. Cadmium: The cadmium compounds are widely used in batteries industry and plastics. The pollution of water with cadmium is caused by contamination from mining, fertilizers and tobacco products. The mean value of Cadmium was 0.007±0.0 mg/L, which was higher than the acceptable limit of 0.003 mg/L prescribed by WHO, 2011, and BIS, 2012.

13. Copper: The copper is both essential nutrient and drinking water contaminant. Copper is used in making pipes, valves and is present in alloys and coatings. The mean value of copper in water of river Beas was 0.0003 mg/L, which was within the acceptable limit of 2 mg/L and 0.5 mg/L and prescribed by WHO, 2011 and BIS, 2012 respectively.

14. Iron: The iron is one of the most abundant metals in earth's crust found in natural water and is an essential element in human nutrition. The mean value of iron in the water of river Beas was 0.41±0.33 mg/L, which was higher than acceptable limit of 0.3 mg/L prescribed by BIS, 2012. However WHO, 2011 has not proposed any guideline value for drinking water as daily requirement of human is 10-50 mg/day.

15. Lead: The lead is used in paints, acid batteries, solder and alloys. Lead is also used as anti knocking and lubricating agent in vehicles fuels. Continuous exposure to lead is associated with neuro-developmental effects, mortality, impaired renal function and hypertension. The mean value of lead in water of river Beas was 0.01±0.0 mg/L, which was at par with the acceptable limit of 0.01 mg/L prescribed by WHO, 2011 and BIS, 2012. The contamination of river water may have been due to exhaust of vehicular traffic along the river Beas and weathering of galena rocks in the study area (Das and Kaur, 2001).

16. Chloride: Chlorides are formed when chlorine combine with other elements. Various sources which contribute chloride in water include mineral deposits, sewage water, human excreta, domestic and industrial waste. The mean value of chloride in water of river Beas was 15.45±7.9 mg /L, which was within the acceptable limit of 250 mg/L prescribed by BIS, 2012. Chloride in drinking water are not detrimental normally to health and hence WHO, 2011 has not proposed any guideline value for drinking water.

17. Fluoride: The fluorides are essential to drinking water for prevention of dental caries, but higher concentration of fluoride may cause dental fluorosis. The mean value of fluoride in water of river Beas was 0.37±0.15 mg/L, which was within the acceptable limit of 1.5mg/L and 1.0 mg/L prescribed by WHO, 2011 and BIS, 2012 respectively.

18. Nitrate: The nitrates are formed due to oxidation of ammonia/nitrogen by oxygen. Basic source of nitrates is nitrogen which is constituent of proteins, chlorophyll and many other biological compounds.

Higher concentration of nitrate in drinking water is a health hazard and has carcinogenic impact on the digestive system. The mean value of nitrate in water of river Beas was 1.89±0.89 mg /L, which was within the acceptable limit of 50 mg and 45 mg/L prescribed by WHO, 2011 and BIS, 2012 respectively.

Biological Parameters:

19. Biological Oxygen Demand (BOD): The BOD is an indicator of organic pollution and is measure of oxygen in water that is required by aerobic organisms. The biodegradation of organic material exert oxygen tension in water and increase BOD. The mean value of BOD in water of river Beas was 0.8±0.41 mg /L. The WHO, 2011 and BIS, 2012 has not proposed any guideline values of BOD for drinking water.

20. Chemical Oxygen Demand (COD): The COD is amount of chemical oxidant for oxidation of organic water that is present in water. Alkalinity is positively correlated with COD. The mean value of COD in water of river Beas was 1.92±0.94 mg/L. The WHO, 2011 and BIS, 2012 has not proposed any guideline values of COD for drinking water.

21. Colliform and ***Escherichia coli*:** The term colliform refers to a group of gram negative aerobic to facultative anaerobic non spore forming rod shaped bacteria and generally refer to genera *Escherichia, Enterobacter, Citrobacter* and *Klebsella.* The *Colliforms* are useful indicators of the possible presence of enteric pathogenic bacteria. The *Colliform* and *E. coli* were found in all sampling stations which was in accordance with the findings of Kumar, *et.al.* 2012. The WHO, 2011 and BIS, 2012 has prescribed nil presence of *Colliform* and *E. coli* in drinking water.

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