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Oligotrophic/Eutrophic Dynamics in the Potable Water of Hilly Area of Champawat (India)

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Abstract In the present investigation, the physicochemical and microbiological properties of water in the hilly area of Champawat district Uttarakhand, India in pre-monsoon season of 2017 were studies. For the study, the variation of parameters was recorded in natural sources of water and their corresponding supply water. The analysis was carried out for the parameters like Colour, Odour, Turbidity, pH, Temperature, TDS, EC, Total Hardness, Total Alkalinity, Cl^-, F^-, SO_4^{2-}, NO_3^-, PO_4^{3-}, Total coli and E. coli. In the study, 3 the pH was found to be slightly alkaline, the high value of Turbidity was observed in few sites and some analysed samples were also contaminated by total coliform and *E. coli*. By comparing the studied parameters, the result showed minor differences between the parameters of source water and supply water. The study concluded that either the value of physicochemical parameters falls under the permissible limits of WHO and BIS, but some sampling sites are microbial contamination was observed.

Keywords: *physicochemical and microbiological properties, variation, parameters, natural source water, supply water*

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1. Introduction

Water is the most abundantly available substance in nature and forms about 75% of the earth crust [1]. As the water is essential for the survival of human beings, animals, and plants therefore, the periodic study of water is a must for life on earth. But still, it is not surprising to say the clean water supply is persistent problem in word wide [2]. This is the sole reason that the first and primary search for availability of water is the prime objective of the scientist on mars and other planets. In human life, pure water has an important role, but still, about 35% urban and 65% rural are receiving untreated water. Urbanisation, Industrialisation, and human activity were observed the main reasons for the water contamination during the last few decades [3]. The human population suffers from a variety of waterborne diseases because of having infected water [4]. Factors like geology of surrounding, seepage contamination, soil condition have high impact in alteration in the quality of water. In recent years the effect of seasonal variation of drinking water quality has been highly documented. Monsoons influence the Indian climate effectively [5]. The type of water which do not contain any kind of hazardous health microorganisms and chemical substances is known as potable water [6]. It has, therefore, become essential to check the physical, chemical, and microbiological parameters of water. The different pathogens such as viruses, bacteria, and parasites classified as microbial contaminants in water. These contaminants are spread into the water by human and animal waste [7]. The physical, chemical, and biological characteristics define the quality of drinking water which arise due to point or non-point sources. In the rapid growth of economic and world population, our dependency on freshwater has accelerated in the last century [8]. Identification of water quality from several samples in which each containing concentrations for many parameters is difficult [9]. The proper classification, modelling, and interpretations of monitoring data are some significant tools in the evolution of water quality. It is a difficult and laborious task that are regularly checking all the parameters even if ample workforce and laboratory facilities are available [10]. This study focused at analysing the physical, chemical, and bacteriological variation in pre-monsoon season of 2018 from natural water sources and their corresponding tap water supply in forty selected sites from habitat areas in the hilly area of Champawat district. The analysed data compared with standard values described by WHO and BIS.

This paper aims to analyse the physicochemical and microbial quality of water to check its potability for drinking purpose. The physical parameters like pH, EC, TDS, temperature, DO were analysed in situ. Other physicochemical parameters were analysed by the

standard methods given in APHA, 2017 and microbial contamination were analysed by most probable number method in the laboratory.

2. Material and Methods

2.1 Study Area

District Champawat lies between 29°5’ and 29°30’ in Northern Altitude and 79°59’ and 80°3’ at the centre of Eastern Longitude. The long chain of mountains in the southwestern region act as a border between Champawat and Nainital district. Geographic coverage of District is about 1613 sq. km (Gov. of India ministry of MSME).

2.2. Sampling

40 samples collected from habitat areas of Champawat district in 500 mL sterilised polypropylene bottles for physicochemical and bacteriological analyses over the pre-monsoon season of 2017 as per standard methods [11] (APHA, 2017). The sampling site was divided into (1) 20 natural sources of water (2) 20 their corresponding supply water. Before sample water collecting from supply tap, the water can run off for 2-3 minutes to remove the unwanted residues at the mouth of opening [12]. The analysis compared to standards for drinking water given by BIS and WHO [13,14] to check the potability of water. Sampling locations of natural sources of water and their corresponding supply water presented in Figure 1.

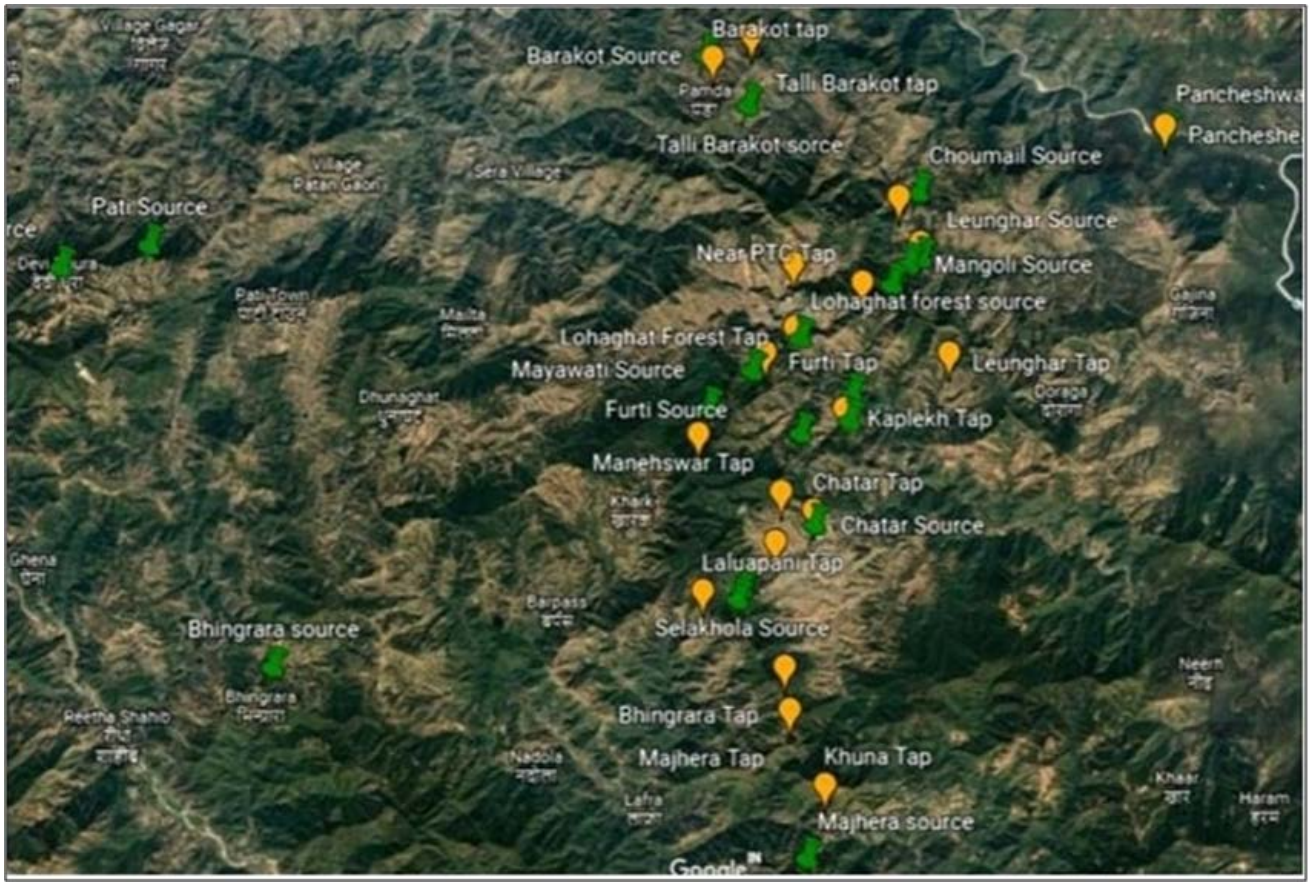

Figure 1. Geographic presentation of sapling area

3. Analytical Measurement

Out of all analysed parameters, the changeable and sensitive parameters like temperature, pH, EC, TDS, DO, Turbidity were done on the spot of sampling location [15] by using digital multi-meter Digital multi-meter photometer HI-83300). Turbidity was determined by the Nephelometric method (APHA, 2017 IS3025-1984, part10) [11]. The analysis of Temperature was by Mercury Thermometer, EC by Conductivity Cell Potentiometric method, Odour by Qualitative Human Receptor, pH by Potentiometric meter and DO of water was measured by sodium thiosulphate titration method. The analysis of total hardness done by EDTA titration, Chloride by Mohar’s methods and alkalinity by neutralising with 0.1N HCl solution and methyl orange as indicator accordingly standard method. SO_4^{2-}, PO_4^{3-}, NO_3^- & F^- ion were analysed as per standard guidelines and procedures suggested by the American Public Health Association (APHA, 2017). Total coliform and E. coli were measured Most Probable Number (MPN) (APHA, 2017).

4. Result and Discussion

4.1. Physicochemical Parameters

The mean value of physicochemical analysis of water from different habitat areas of Champawat district is present in Table 1 - Table 2.

Table 1. Chemical parameters

S. No	pH		EC (µS/cm)		TDS (mg/L)		Chloride (ppm)		Fluoride (ppm)		Nitrate (mg/L)		Sulphate (mg/L)		Phosphate (mg/L)		DO (ppm)		Total Hardness (mg/L)		Alkalinity (mg/L)	
	NS	SW	NS	SW	NS	SW	NS	SW	NS	SW	NS	SW	NS	SW	NS	SW	NS	SW	NS	SW	NS	TS
1	7.24	7.67	145.1	177.4	97.9	100.8	16.88	18.34	0	0	BDL	BDL	4	6	0.04	0.06	7.7	7.5	72	64	96	128
2	7.55	7.41	170.9	188.3	113.5	129.8	42.54	44.52	0	0.01	0.2	0.4	2	3	0.13	0.1	7.4	7.9	64	60	98	114
3	7.84	7.62	78.3	83.5	50.7	56.1	28.36	56.72	0.54	0.72	BDL	BDL	6	1	0.12	0.19	7.8	7.5	48	61	92	68
4	6.85	7.31	198.8	203.8	149.0	160.0	44.66	50.76	0	0	1.3	1.5	16	2	0.29	0.31	7.8	7.4	74	80	56	100
5	6.91	6.97	38.4	78.5	26.8	52.4	18.22	35.45	0	0.05	0.5	0.8	3	4	0.12	0.16	8.1	8.4	24	48	77	32
6	6.0	6.78	49.3	73.2	33.2	48.6	36.32	42.54	0	0.05	BDL	BDL	10	3	0.16	0.1	7.1	7.5	56	78	82	66
7	6.2	6.0	180.3	174.3	152.2	160.5	18.56	44.58	0	0	BDL	1.2	13	7	0.78	0.44	8.5	7.9	112	128	58	69
8	7.34	7.52	113.1	130.5	74.7	87.42	18.22	24.64	0.04	0.06	0.6	BDL	4	2	0.18	0.13	7.2	7.6	46	40	99	70
9	9.2	7.3	242.8	212.3	140.3	162.2	42.54	44.64	0	0	1.0	0.6	14	13	1.1	1.07	7.6	7.1	152	136	168	152
10	8.8	8.5	580.3	484.2	442.9	456.8	35.88	36.42	0	0.06	BDL	BDL	11	12	1.1	1.27	7.7	7.6	208	192	176	184
11	6.2	6.4	480.3	432.4	418.3	392.2	56.72	62.63	0.16	0.03	BDL	BDL	13	14	1.09	1.03	8.2	7.5	192	168	208	188
12	7.45	6.84	70.2	92.46	46.5	53.22	35.52	38.22	0	0.15	0.4	0.4	5	3	0.03	0.11	7.6	7.8	40	32	88	40
13	8.5	8.8	225.6	194.3	187.3	175.3	36.42	42.88	0	0.13	BDL	BDL	18	16	0.25	0.15	7.6	8.2	168	152	184	48
14	6.9	7.74	165.5	158.7	107.7	105.0	35.45	44.82	0	0.21	BDL	BDL	2	3	0.16	0.17	7.5	7.6	70	77	140	107
15	7.4	7.26	75.1	74.3	49.8	49.7	28.60	40.62	0	0	BDL	BDL	4	3	0.02	0.06	7.6	7.9	58	55	88	96
16	6.8	7.31	80.8	56.7	38.1	27.6	26.32	40.65	0	0	BDL	BDL	5	12	0.06	0.03	7.6	7.3	34	24	28	34
17	7.18	7.12	99.7	80.53	66.2	43.0	28.42	17.73	0	0.03	0.2	1.5	3	3	0.15	0.1	7.3	7.8	32	50	58	50
18	6.41	7.14	72.7	78.4	49.8	61.1	35.45	32.66	0.01	0.13	BDL	1.3	2	4	0.11	0.13	8.1	7.5	55	51	68	76
19	6.91	7.14	78.1	85.3	59.4	85.3	42.54	38.46	0	0	BDL	BDL	2	3	0.07	0.1	7.3	7.2	59	64	70	83
20	6.46	7.24	408	399	273	286	55.32	58.32	0.5	0.6	BDL	BDL	13	10	0.02	0.08	7.5	7.6	150	172	227	202

Table 2. Physical parameters

S. No	Colour		Odour		Turbidity (NTU)		Temp (°C)	
	NS	SW	NS	SW	NS	SW	NS	SW
1	LY	CL	OL	OL	<10	<5	16.4	15.3
2	CL	CL	OL	OL	<5	<5	11.5	10.5
3	CL	CL	OL	OL	<5	<5	15.4	8.8
4	CL	CL	OL	OL	<10	<5	15.3	15.9
5	CL	LY	OL	OL	<5	<5	10.9	11.9
6	LY	CL	OL	OL	<10	<5	13.7	14.3
7	CL	CL	OL	OL	<5	<5	14.2	9.5
8	CL	LY	OL	OL	<5	<10	15.2	17.3
9	LY	CL	OL	OL	<5	<5	9.7	14.9
10	CL	CL	OL	OL	<5	<5	9.6	11.5
11	CL	CL	OL	OL	<5	<5	9.8	9.9
12	LY	CL	OL	OL	<5	<5	12.3	10.5
13	CL	CL	OL	OL	<5	<5	10.2	9.6
14	CL	CL	OL	OL	<5	<5	10.2	12.5
15	CL	CL	OL	OL	<5	<5	9.45	10.3
16	CL	CL	OL	OL	<5	<10	11.2	10.5
17	LY	CL	OL	OL	<10	<5	11.9	10.2
18	CL	CL	OL	OL	<5	<5	12.3	12.2
19	CL	CL	OL	OL	<5	<5	11.8	9.65
20	LY	CL	OL	OL	<10	<5	19.8	15.2

The colour in all the sample is found agreeable in both natural and supply water except sample no 1, 6, 9, 12, 17 & 20 in natural source water and sample no 5 & 8 of corresponding supply water was observed light yellow. The odour of the all-analysed samples of source and supply water samples was found to be agreeable. The temperature was in the range of 9.6°C to 16.4°C in the natural source and from 8.8°C to 14.9°C in the

corresponding tap water in the residential areas. The temperature of the water may or may not affect the quality of drinking water. But in polluted water, the temperature affects the aquatic life, and it affects DO and BOD [16]. The pH value was found to vary from 6.0 to 7.84 in natural source water and from 6.0 to 8.8 in corresponding tap water. The permissible limit of pH set by WHO is 6.5-8.5. Some of the samples deflect from the permissible range. Sample no 6, 7, 11, 18 & 20 of natural source water are below the permissible limit and sample no 9 & 10 are above the permissible limit. The comparison between the value of natural source water and corresponding supply water is shown in Figure 2. The pH has no immediate direct effect in humans but indirectly it influences the solubility of minerals and activity of essential pathogens [17]. Turbidity is one of the very important parameters for the acceptability of drinking water. Permissible guidelines for turbidity for drinking water is given <5 [18]. The turbidity of analysed samples was found <5 NTU except sample number 1, 4, 6, 17, and 20 from a natural source and sample number 8, 16 from tap supplied water it was found < 10 NTU. In the treatment of biological and physical contamination if water total dissolve count has great influence [19]. The analysis showed the values of TDS in source water vary from 26.6 mg/L to 418.3 mg/L in natural source water and from 27.6 mg/L to 456.8 mg/L in corresponding tap water. The permissible limit of TDS in drinking water is 500 mg/L and all the value fall under the permissible limits for both natural source of water and supply water and the comparison of the change in values between natural source water and its supply water given in Figure 3. EC is the tendency of water to hold the electrical current and the ability of the solution to relate with ionic force. EC measures of the amount of water dissolve salts in it [20]. The value of EC was analysed from 70.2 µS/cm to 580.3 µS/cm in the natural source of water and from 73.2 to 484.2 µS/cm in the supply water. All the values are under the permissible limit and shown in Figure 4.

The dissolved oxygen is the measure of molecular oxygen concentration in water. By the direct diffusion from atmospheric oxygen, win and action of wave DO is supply into water [21]. The value observed for DO was in the range of 7.2 mg/L to 8.5 mg/L in the natural source of water and from 7.1 mg/L to 8.4 mg/L in the corresponding supply water. The source of Cl^- is the dissolution of salt like common salt (NaCl), $NaCO_2$, sewage, and industrial waste [22]. The Cl^- concentration was found from 14.18-56.72 mg/L in the analysed samples of natural source of water and from 16.8-62.6 mg/L in the corresponding supply water. The comparison of the analysed value of the source water and the supply water is given in Figure 5.

The F^- content in most samples of natural source of water and a few samples of supply water didn't detect. The concentration of F^- ranged from 0.01-0.54 ppm in the natural source of water and from 0.01-0.72 ppm in the supply water. Most of the samples are below the detectable limit in both natural source water and its corresponding supply water. Industrial and Sewage run-off and fertilisers are responsible sources of NO_3 in water [23]. A very few samples showed the presence of NO_3^- which varied 0.2-1.3 mg/L in natural source water and from 0.4-1.5 in the tap supply water. The recorded value of SO_4^{2-} in the natural source of water is 2-18 mg/L and in the corresponding supply is 2-14 mg/L. the occurrence of PO_4^{3-} in water is because of sewage, detergent, and agriculture effluvium [24]. The PO_4^{3-} level recorded in the study area from 0.01-0.29 mg/L in the natural source of water and 0.03-0.31 mg/L in the supply water. The low concentration of PO_4^{3-} in samples might be due to geology of the area. The hardness of water is caused by the multivalent cations, especially by divalent like Ca^{2+}, Mg^{2+}, Sr^{2+} and fe^{2+} ion [16]. Water could be classified as hard (150-300 mg/L $CaCO_3$), moderately hard (75-150 mg/L $CaCO_3$) and soft (<75mg/L $CaCO_3$) [25]. The hardness found in the range of 24-208 mg/L $CaCO_3$ in the source of water and 24-192 mg/L $CaCO_3$ in the supply water. Analysed values showed the hardness vary from soft to hard, but all the concentrations fall under the permissible limit of WHO and BIS. The high concentration of hardness in sample no 20 for both natural and supply water may be the presence of a high concentration of heavy and trace metals [26]. The comparison of values shown in Figure 6. The alkalinity of water was the measure of tendency neutralising to acid. Weak acid or strong base may contribute to alkalinity. It is impacted by carbonates, bicarbonates, and hydroxides [27]. The analysis was found to be in the range of 28-227 mg/L in the natural source water and from 32-202 mg/L in the supply water. Comparison of alkalinity concentration between source and supply water presented in Figure 7.

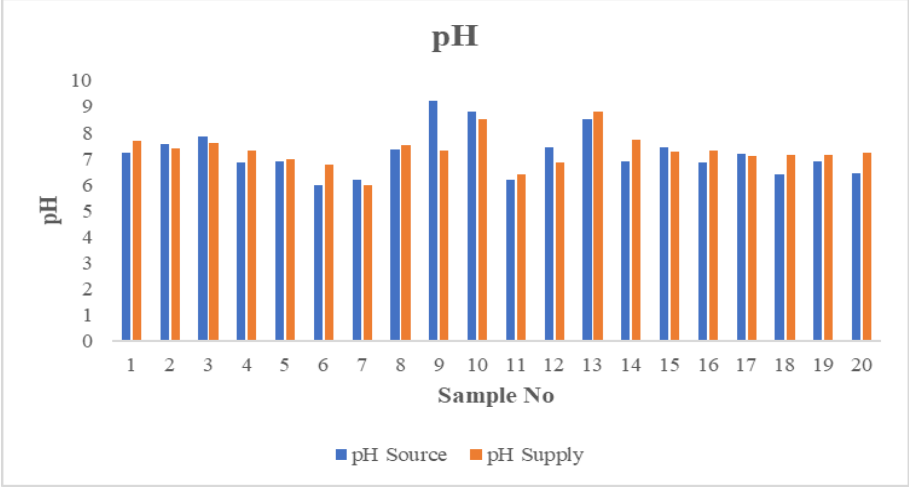

Figure 2. pH of natural source water and its corresponding supply water

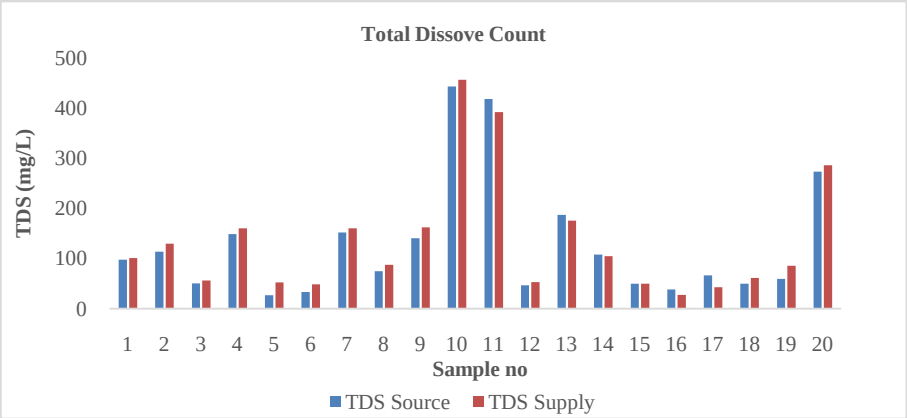

Figure 3. TDS of natural source water and its corresponding supply water

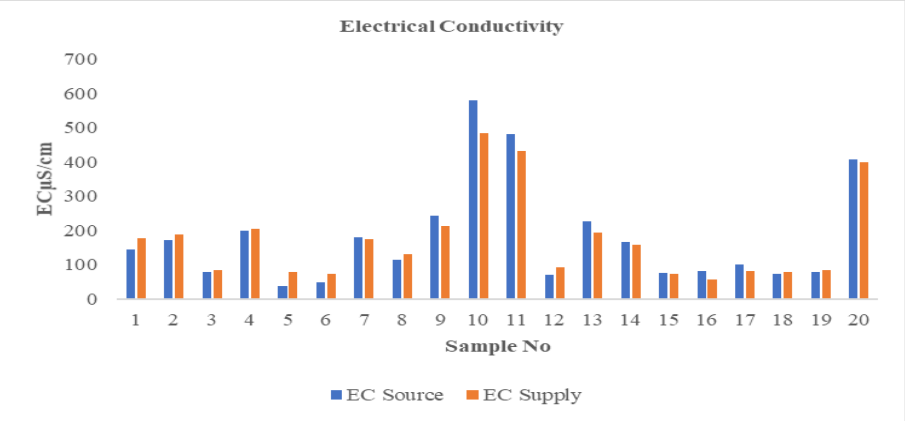

Figure 4. Electrical conductivity of natural source water and its corresponding supply water

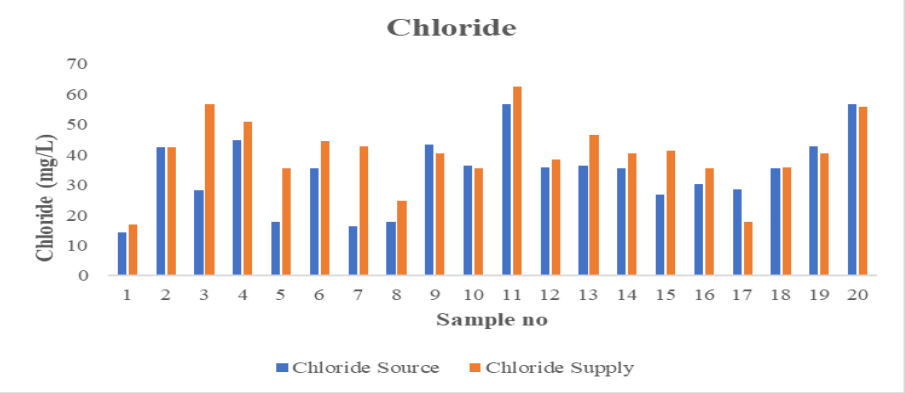

Figure 5. Cl^- of natural source water and its corresponding supply water

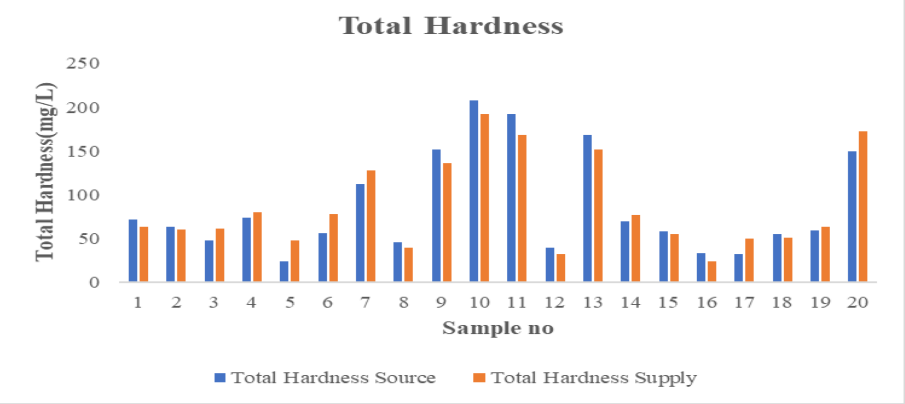

Figure 6. Total Hardness of natural source water and its corresponding supply water

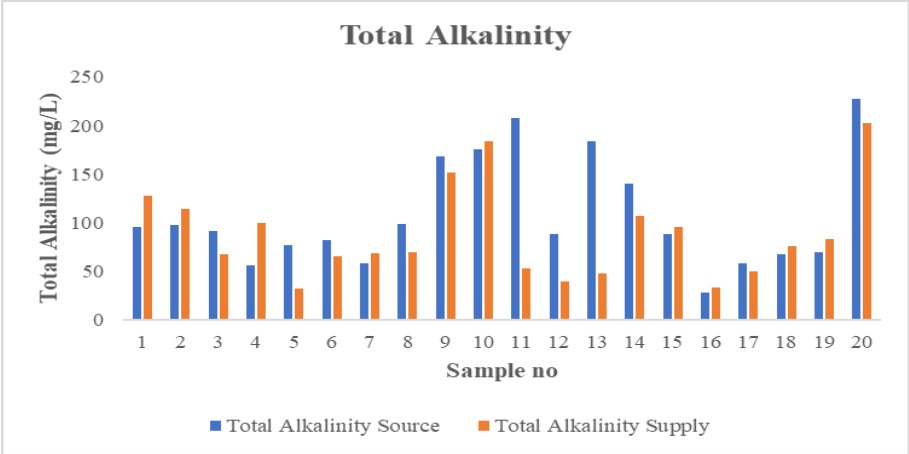

Figure 7. Total Alkalinity of natural source water and its corresponding supply water

4.2. Microbiological Quality

Microbial quality of different natural sources and their corresponding supply water are reported in Table 3. The contaminated water is the most common and widespread health risk associated with drinking water, which spreads either by human or animal excreta, mainly by faeces [28]. The microbial analysis was done by the most probable number (MPN) for the probable total coliform count and *E. coli* for the water samples of natural source of water and supply waters. Out of 20 samples of natural source water in only seven samples, total coliform was detected, and *E. coli* was found in only eight samples. In supply water total coliform count was found in 12 samples, and *E. coli* was analysed in 9 samples.

Table 3. Most Probable Number (MPN) of Water Samples:

S. No	Total Coliform (MPN/100mL)		E. coli (MPN/100mL)	
	NS	SW	NS	SW
1	ND	ND	ND	ND
2	2	2	ND	8
3	ND	ND	5	ND
4	ND	ND	ND	ND
5	ND	9	ND	ND
6	ND	ND	ND	ND
7	ND	ND	ND	ND
8	5	6	ND	ND
9	3	ND	15	2
10	ND	ND	ND	ND
11	ND	8	6	ND
12	ND	ND	12	13
13	3	ND	ND	ND
14	ND	ND	ND	7
15	ND	ND	4	ND
16	ND	3	ND	ND
17	14	11	ND	11
18	ND	ND	12	12
19	ND	ND	ND	ND
20	ND	ND	ND	ND

5. Conclusion

The catchment areas, where there are houses and trees influence the natural sources of water not only to a great existent but also pollute the water sources to make these eutrophic which of course is virtuous for plant and trees but harmful for human beings and animals. The proper treatment of this water is, therefore, a must to take it oligotrophic which is less polluting. This water should then be made potable before use by using standard methods. Drinking water should be safe, pure and must be free from all pathogenic organisms. In the present study, it has been checked that how many changes came in parameters of water occurs from natural sources of water to the supply water. The findings of the current work indicate that the physicochemical parameters of the natural source water and their corresponding supply water do not have any significant variation and fall under the permissible limits of WHO and BIS.

The range of turbidity found to be exceeding the permissible limits of BIS specification in a few samples. Another significant finding of the work indicates the presence of total coliform and *E. coli* in the drinking water samples. The bacterial count is not very high. The water of analysed samples is classified as soft (<75mg/L, $CaCO_3$) to moderately hard (75-150 mg/L, $CaCO_3$). It is recommended that water should be used by boiling for drinking purpose. A perusal of the entire work revealed that routine monitoring of supply water coming from natural sources is a must special concern to eliminate the possible intimidations.

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Statement of Competing Interest

The authors have no competing interest

Abbreviations

LY- Light yellow, CL- Colourless, OL-Odourless, NS-Natural Source, SW-supply water, ppm- parts per million, BDL- below detectable limit, ND- not detected

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