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Assessment of Seven Conventional Natural Drinking Water Sources in the Periphery of Chamba Town of Himachal Pradesh in India

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Abstract: Chamba town of Himachal Pradesh in India is renowned for its conventional natural underground drains, springs and well water sources known as Panihar, Nara and Boury in the local dialect. These are the major traditional freshwater sources for human consumption in the valley. Water is one of the most essential natural sources required for the survival of human beings. But the quality of water in these natural sources is deteriorating day by day due to the universal impact of climate change and the increasing pollutant load of unplanned human activities. The deterioration of natural water sources is a major concern to human well-being all around the world. Therefore, a study was designed for the assessment of the quality of drinking water from randomly selected seven major traditional water sources in the periphery of historic Chamba town. This paper consists of the historic importance of these water sources, the perception and perspectives of their users along with qualitative analysis of total dissolved solids, total hardness and metal salts. The qualitative and physiochemical analysis confirms that the quality of water in all these sources is still within the safe limits of drinking water with limited variation in range but requires special attention for their safe guard.

Key words: Underground water sources, Chamba town, water quality, water pollution, physiochemical analysis.

Introduction

Despite the lack of organic nutrient value in clean potable water, it is the essence of life. Three quarter of the Earth's surface is filled with water but it is not less than a mammoth challenge to fulfill the daily needs of supplying clean water to the entire population across the world because out of this only 2.5% is fresh water (Annan, 2005). The demand for water is increasing at double the rate of population growth (Postel, 1997). Recently, environmental issues, such as climate change, sustainability, and scarcity of clean drinkable water have become the central theme of policy makers around the globe (Gupta, 2001). Urban civilisation requires more water than rural areas and also the quality of discharged water in the urban area is chemically toxic (Bandy, 1984). A multidimensional study on the physiochemical aspect of water and its pollutants has been published by Dugan (1972) and Edwards et al. (1989).

India is also suffering from scarcity of pure water. It has only 4% of the world's fresh water to cater to the need of more than 17% of the world's population. Many researchers have investigated the quality of water in India. The suitability of the water for various uses in Amritsar city was studied by Panesar et al. (1985). Pollution in the Chambal River at Kota was reported by

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Olaniya et al. (1976). A comparative study of surface water in rivers Godavari, Krishna and Tungabhadra was conducted by Mitra (1982). A similar comparative study was also conducted between rivers Ganga, Yamuna and Kali by Bhargava (1977). The chemistry of river water from Godavari was studied in Rajamundhary by Ganpati and Chacko (1951). Management of fresh water pond in Varanasi was conducted by Mishra (1993). Pollution in Gandak River at Samastipur was studied by Hakim (1984). The influences of anthropogenic factors on water quality in rural and urban areas were studied by Khatri and Tyagi (2015) and Dwivedi (2017). Groundwater quality and hydrochemistry of the Manimuktha River basin, Tamil Nadu; India was explored by Kumar et al. (2009). The water was reported to be moderately polluted at most of the study sites.

Gupta et al. (2018) studied the management of water resources by the people of the gaddi community of Chamba in Himachal Pradesh. The evaluation of groundwater quality and its suitability for drinking and agricultural use in the district Kangra of Himachal Pradesh was studied by Dev and Bali (2018). Perspective prognosis and quality of water resources in Kullu valley in Himachal have been studied extensively by Thakur et al. (2018). Most of the studies show that the quality of water is deteriorating day by day. Chamba town is among the rural area of the Himalayan regions having an acute shortage of water. The traditional water sources i.e., Panihar, Naun, Nara and Baury are the main conventional sources of drinking water. Here the Panihar or Nara refers to the opening of a water source which releases the water of spring and Baury is a type of ditch made after digging the soil, where a space is created for the collection of water from the natural source.

In spite of the heavy dependency on these traditional natural water sources for drinking and potable needs, there are no detailed studies on the quality of these water resources in the periphery of Chamba town. Therefore, in this study, qualitative and physiochemical evaluations of the water resources in the periphery of Chamba town were carried out to evaluate the quality of drinking water. For the purpose of this study the seven major sources of water i.e. Rajnaun Nara, Tatwani Nara, Sarol Baury, Kuranh Panihar, Lohari Nara at Mehla, Kandu Nara, Nanikhad Nanra in the periphery of Chamba town have been selected for investigation. This study aimed at assessing the impact of urbanization on these water resources. A schematic view of the underground sources of water in the periphery of Chamba town is shown in Figure 1.

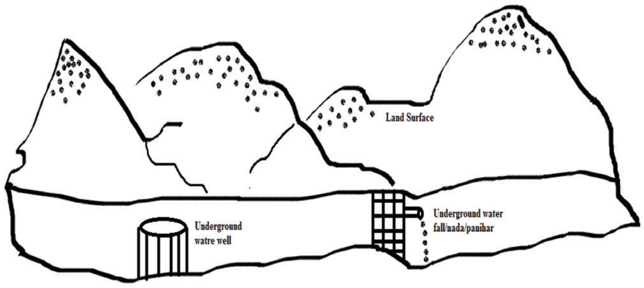

Figure 1: Schematic view of the underground sources of water in the periphery of Chamba town.

Geographical Location of Chamba Town in Himachal Pradesh

Chamba town in general is a part of the Lesser Himalayas. It is located in northwestern India in the states of Himachal Pradesh and Uttar Pradesh, in north-central India in the state of Sikkim, and in northeastern India in the state of Arunachal Pradesh, and ranges from 1,500 to 5,000 metres in height. The terrains of the area are rugged with steep-sided valleys and very narrow spurs and thick forest cover. The soil cover of the entire area is very thin and acidic with an increase in altitude. The major physiographic units of Chamba town are dissected hills and valley fills. The main rivers of the Chamba district are Ravi, Budhil, Suil, and Tundah and the main glaciers of the district belong to the Bara-Bhangal and Tantagiri-glacier area. The geographical location of Chamba town is highlighted in Figure 2.

Description of Water Sources Under Study

Ground water is the water that seeps below the earth's surface and is found in cracks and spaces in soil and rocks. As the major soils in the periphery of Chamba town are either sandy loam or sandy clay loam with water-bearing formation as valley fills and sediments as well as secondary porosity in Paleozoic to Triassic rocks. The concentration of springs was found more along the rivers and khads. Usually, the springs contribute water to the base flow of these khads and rivers, which in turn is utilised at favourable places for irrigation and domestic purposes. Several natural ground water sources exist in Chamba town. But the study was mainly focused on seven major traditional underground water sources in the domain of 20 to 40 kilometer from Chamba town. Rajnaun [WS1] and Tatwani [WS2] natural water sources are located in the extreme upper and lower corners of the main Chamba

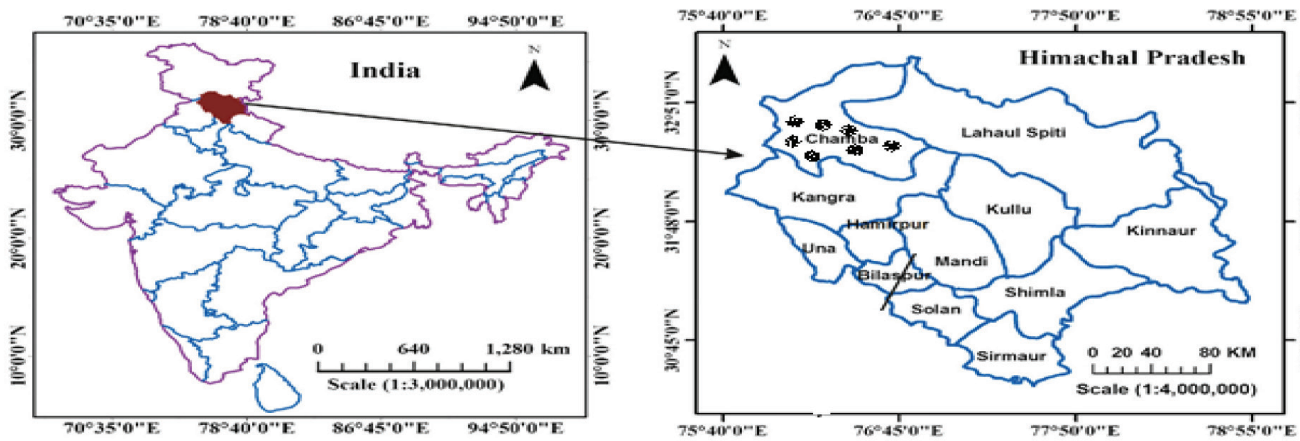

Figure 2: Geographical location of Chamba Town in Himachal Pradesh of India.

town as the main source of drinking water. Lohari [WS3] and kuranh nada [WS4] are in Mehla and Kuranh villages on Bhormour road at a distance of about 12 km from Chamba city. Kandu Nara [WS5] and Nanikhad [WS6] water sources are located on the road side of Pathankot Chamba highway in the vicinity of Kandu and Nanikhad villages, respectively. Sarol [WS7] water boury is situated in the centre of the Sarol village at a distance of 6 km from the main Chamba town on Chamba Tissa road. Three samples with 250 ml of water has been collected in the bottle from each source with proper coding in the summer season. The photographs of water sources (Panihar, Nara or Boury) under study are displayed in Figures 3 and 4.

Measurements

Three sets of water samples from described water sources were tested for physio-chemical parameters. Calibration was carried out using suitable standard solutions and buffers. Sample water was collected from the running Boury and flowing Nara to obtain the representative sample. The gathered water samples were investigated in the aqua check research center at Chandigarh. The water sample conforms to international standard 10500-2012 (Second revision) for various parameters under investigation. For statistical analysis, MINITAB 16 and Microsoft Excel were used. Peripheral twenty residents each in two age groups ranging from

Figure 3: Photographs of (WS1-7) 1. Rajnoun 2. Tatwani 3. Kuranh 4. Lohri nada 5. Kandu 6. Naini Khad underground natural drinking water sources.

Figure 4: Photograph of Sarol water body natural well drinking water source.

20 to 30 years and 50 years and above were also personally interviewed to include their social perception and perspectives about the quantity and quality of water.

Physio-chemical Analysis Parameters

First, the most important physiochemical parameter of water is Turbidity, which is the cloudiness of a fluid caused by large numbers of individual particles that are generally invisible to the naked eye. Second, parameter is pH value, which if lower than 7 is considered acidic and greater than 7 is basic. The normal range for pH in water systems ranges from 6 to 8.5. Alkalinity is a measure of the capacity of the water to resist acidification. TDS comprise inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides, and sulphates) and some small amounts of organic matter that are dissolved in water. Water hardness is the amount of dissolved calcium and magnesium in the water.

Results and Discussion

People residing in the peripheral areas of water sources were interviewed personally about their perception of the changes observed by them in the quality and quantity of water in the passage of time. They revealed that the water from these sources detoriated in terms of quality and quantity over time. They feel that now water has become tasteless. Decrease in quantity of water and negative temperature gradient difference has been also observed. They feel that a decrease in theism is also one of the causes of the deterioration of water sources as people have started bathing, washing clothes and washing their vehicles here. Educated youngsters believe that deterioration might be due to global environmental issues due to human perturbation. The preliminary data of the people interviewed is summarised in Table 1.

Table 1: People's qualitative perception on natural water resources under study

Activities leading to pollution of ground water sources	*Effect*
Renovation:-Use of concrete, cement, tiling, alteration of drainage system	Decrease of quantity of water/drying of natural sources
Residential:-Construction of building, roads poor rural planning	Deteriorating the quality of water
Global issues:-climate change, greenhouse effect, deforestation	Decrease in difference of temperature of water in hot and cold
Waste disposal:-washing of clothes, vehicles and use of plastic	Decrease in the quality and quantity of water
Industrial:- Disposal of waste, waste of chemicals	Deteriorating of water quality
Theological:-washing of clothes and not maintaining the sanctity of the sources	Drying of water resources.

The results of the qualitative analysis of water samples collected from natural water sources have been tabulated in Table 2 and analysed graphically in Figure 5. A significant difference appeared in the variables observed in water samples.

Turbidity: Physio-chemical analysis reveals that the turbidity of Rajnaun, Sarol water body, Lohari and Kandu Nara exceeds the accepted limit and at Kuranh and Nanikhad Nara it is very close to the accepted limit. Although turbidity is exceeding the acceptable limit but within the maximum permissible limit. The construction of roads in the upper region of Chamba Town leads to soil erosion and landslides at a large scale which may be the major causes of high turbidity. Whereas Sarol water Boury is enclosed in four walls and people drain water by putting their utensils in the water. There are

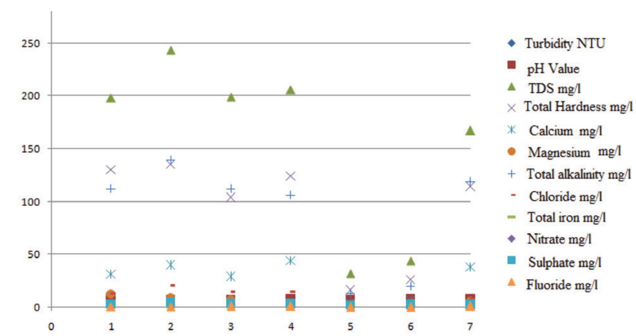

Figure 5: Summary statistics of physiochemical analysis of underground natural drinking water sources (WS1-7) under study.

Table 2: Physiochemical analysis of natural water source (WS1-7) at 1. Rajnaun 2.Tatwani 3. Kuranh 4. Lohari Nada 5. Kandu 6. Nanikhad 7. Sarol water Boury in the periphery of Chamba town.

Parameter Tested	*Units*	*Drinking water specification*								
		Required (Accept. Limit)	*Max. Perm. Limit*	*WS1*	*WS2*	*WS3*	*WS4*	*WS5*	*WS6*	*WS7*
Odour	-	Ag	Ag	Ag	Ag	Ag	Ag	Ag	Ag	Ag
Taste	-	Ag	Ag	Ag	Ag	Ag	Ag	Ag	Ag	Ag
Turbidity	NTU	1	5	1.2	0.1	2.7	0.9	2.3	2.1	0.9
pH Value	-	6.5-8.5	No	7.39	7.31	6.86	7.89	6.87	7.94	7.81
TDS	mg/L	500	2000	198	243	199	206	32	44	167
Total Hardness ($CaCO_3$)	mg/L	200	600	130	135	104	124	16	26	114
Calcium as Ca^{++}	mg/L	75	200	31	40	29	44	4	6	38
Magnesium as Mg^{++}	mg/L	30	100	12	9	7	4	1	2	5
Total Alkalinity ($CaCO_3$)	mg/L	200	600	112	139	112	106	13	20	119
Chloride as Cl^-	mg/L	250	1000	13	21	15	15	6	7	8
Total Iron as Fe^-	mg/L	0.3	No	0.24	0.18	0.12	0.26	<0.1	<0.1	0.18
Nitrate as No_3^-	mg/L	45	No	1.4	2.1	2.1	1.8	1.3	1.3	1.8
Sulphate as SO_4	mg/L	200	400	2.9	4.3	3.7	3.4	2.1	2.5	2.4
Fluoride as F^-	4mg/L	1.0	1.5	0.22	0.32	0.68	0.82	<0.1	<0.1	0.78
Free Residual Chlorine	mg/L	0.2	1.0	Nil	Nil	Nil	Nil	Nil	Nil	Nil

also fishes in the water body and people used to feed them due to theological regions. These factors may be responsible for the high turbidity of its water.

pH value: pH value affects the taste, mucous membrane and water supply system. The pH value of all the samples WS1-7 lies between 6.5 and 8.5 as the values recommended by the FEPA (1998) indicate that they are recommended for drinking.

Salinity Behaviour: The salinity behaviour of natural water sources was investigated by analyzing the total dissolved solids (TDS), where the water with TDS >500 mg/L is undesirable for drinking water supplies (BIS, 2014). The high value of TDS decreases palatability and may cause gastrointestinal irritation in humans. TDS values shown in Table 2 varied from 32 to 243 mg/L with a mean value of 156 mg/L of all the samples.

Hardness: As the permissible value of total hardness is between 200 and 600 mg/L, the hardness of all the samples 1-7 was found below the lower accepted limit. Hence the natural water of all the sources in general is soft.

Chloride, Sulphate, Nitrate and Sulphate Ions: The characteristic ionic ratios were often used to interpret the rock water weathering processes. The measurable value of chloride and sulphate is very few which is not good in drinking water as chlorides are common constituents of all-natural water. The extremely soluble form is $NO^-{}_3$ which could reach easily the drinking water supply through the soil. The major sources of nitrogen compounds are fertilisers and domestic wastes which could be converted into nitrates in the soil (Kumar et al., 2009). We can also find that measurable values of iron and fluoride were within the limits. All the sources of water under study are neither below nor adjoin to the agricultural land and industrial area and thus are least affected by human activities.

Khatri and Tyagi (2015) indicated the effects of natural processes and human influences in rural and urban aquatic systems. In rural regions, the anthropogenic influences due to industrialization and commercialisation may not be present at all. Water pollution due to industrial wastewater is also absent in rural areas. The quality of groundwater is a sensitive

Table 3: Correlation coefficient between different studied variables in natural water sources

Parameter tested	*Mean*	*Minimum*	*Maximum*	*S.D.*	*Bureau of Indian Standards (BIS) July 8, 2014*
Turbidity	1.457143	0.1	2.7	0.861655	1
pH Value	7.438571	6.86	7.94	0.425959	6.5-8.5
Total Dissolved Solids	155.5714	32	243	77.20262	500
Total Hardness as $CaCO_3$	92.71429	16	104	46.40417	200
Calcium as Ca^{++}	27.42857	4	44	14.96527	75
Magnesium as Mg^{++}	5.714286	1	12	3.614032	30
Total Alkalinity as $CaCO_3$	88.71429	13	139	46.7263	200
Chloride as Cl^-	12.14286	6	21	5.026461	250
Total Iron as Fe^-	0.165714	0.09	0.26	0.063664	0.3
Nitrate as No_3^-	1.685714	1.3	2.1	0.327015	45
Sulphate as SO_4	3.042857	2.1	4.3	0.732622	200
Fluoride as F^-	0.428571	0.09	0.82	0.298684	1.0

issue as far as health is concerned. Contamination of these resources should be prevented, controlled and reduced. All the samples were collected in the summer of the dry season which may be the cause of the less content of the chloride, fluoride and sulphate ions. The correlation coefficient and standard deviation of all the parameters in comparison with BIS 2014 are tabulated in Table 3 for more elucidation.

Conclusion

The qualitative study of natural drinking water sources in the vicinity of Chamba town reveals that the turbidity of Rajnaun, Sarol water body, Lohari Nada and Kandu exceeds the accepted limit and at Kuranh and Nanikhad it is very close to it. The pH value is very close to the accepted limit at Kandu, Kuranh and Nanikhad water sources. TDS values varied from 32 to 243 mg/L with a mean value of 156 mg/L for all the samples. The measurable value of chloride, sulphate, iron and fluoride were within the limits whereas the turbidity in most of the water samples exceeded the accepted limits and other quality variables lie within the accepted limit but are not up to the mark. The study revealed the deterioration affirmation with limitations. It was a preliminary study which further needs more detailed sampling including other parameters and techniques on seasonal basis throughout the Chamba valley.

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