Himalayan Journal of Science and Technology, Vol 7. (2023) 110-116

Himalayan Journal of Science and Technology

Original Article

doi: FOR PEER REVIEW

Suitability Analysis of Drinking Water from The Springs of Deumai Watershed Ilam, Nepal

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Abstract

Spring is one of the major sources of drinking water in hilly and Himalayan region. The overall purpose of this study was to analyse the suitability of drinking water by studying the physicochemical properties. Springs of Deumai watershed Ilam, Nepal was investigated for water samples and the physicochemical parameters studied were TDS, pH, temperature, total hardness, alkalinity, total iron and major ion concentrations (Na^+, K^+, Mg^{2+}, Ca^{2+}, Cl^-, SO_4^{2-}, NO_3^-) to describe the water's chemical characteristics. The physical parameters were determined using pH meter, laboratory thermometer etc. The determination of concentration of chemical parameters was performed by using spectrophotometric method, flame photometric method and titration method. The average pH was found 7.47 and average temperature was found to be 19.4ºC. The dominance trend for major cations was $Ca^{2+} > Na^+ > Mg^{2+} > K^+ > Fe$ and for anions was $HCO_3^- > Cl^- > NO_3^- > SO_4^{2-}$. All the values obtain were within the range specified by WHO and NDWQS guidelines of drinking water. According to the findings and comparison with the guidelines of drinking water given by World Health Organization (WHO) and National Drinking Water Quality Standard (NDWQS), the water quality for drinking water was found within the standards set by them.

Article Info

Article history:

Received date: 30 October 2023
Accepted date: 13 December 2023

Keywords:
Watershed,
Physicochemical,
Spectrophotometric,
pH,
Dominance

1. Introduction

A spring is a place from where water below the ground is discharged creating flow which can be seen on the surface of the ground. The reason for discharge of water is due to the difference in the altitudes of aquifer's hydraulic head and the surface of land at that spot (Kresic & Stevanovic, 2009). Water below the ground in the higher geographical region like hills and mountains appears on the surface in the form of springs, the natural discharge features of groundwater system. People in Nepal's mountainous regions depend heavily on springs for their survival and are valuable resources that play main roles in fulfilling the requirements of human, maintaining balance in ecosystem and providing riverine base flow (Khadka & Rijal, 2020). One of the most precious resources is groundwater, as it concerns with many sectors of human consumption and is regarded superior than other resources. Worldwide water assets are defenceless due to the expanding drift of populace, contamination potential, and alteration of climate (Ahmed et al., 2020). In the Hindu Kush Himalaya (HKH) region, a major source of water for millions of people is groundwater in the form of springs. Mountain springs address human requirements for dependable, sustainable freshwater, enhance livelihoods, and preserve environmental equilibrium. In the mid-hills of the HKH, springs contribute significantly to riverine base flows. For mountain communities, they also have a great deal of cultural significance (Dhakal et al., 2015). Groundwater has been widely used for drinking, irrigation, and numerous industrial applications across the world as an essential source of water supply (Baloch et al., 2021).

Hydrogeochemistry of groundwater provides an informative basis for its management and conservation for domestic, industrial, and agricultural

purposes. Groundwater quality can be predicted using hydro-geochemical information. In hydrogeochemistry, the chemistry of water is used to determine where groundwater has come from and what it has experienced (Karegi et al., 2018). Additionally, it aids in water resource management by determining water's quality and suitability. We define "springshed" and emphasize the significance of springshed governance in the Nepal Himalaya. (Rijal, 2016).

The quality of drinking water is being deteriorated due to the unwanted activities of living beings near the water sources. The main aim of this study is to determine the suitability of drinking water. The study also helps in determining the average amount of ions present in water. The result of this study provides baseline data for further study of suitability of water and to check the change in hydro geochemistry of ground water.

The present study offers important details about the condition of drinking water. It also gives detail about the amount of different ions present in the water. This helps in determining the usefulness of water for living beings. The result aids for betterment of condition of drinking water as well as preservation of the source of drinking water of the study area as there is no other research performed in that area before this study.

2. Materials and Method

2.1 Study Area

The study area is located in Ilam district of Koshi Province, Eastern Nepal (Fig. 1). The Deumai Khola watershed is a rainfed perennial river system in Eastern Nepal. It is a sub-watershed of the greater Kankai River Basin. Its water is used for various purposes. There is presence of numerous springs in the area from where the local people utilize water for drinking and household purposes. The people living in this area highly depend on ground water for drinking as it is the natural and available source of water found in that area. Hence, the analysis of groundwater for drinking is important for such regions.

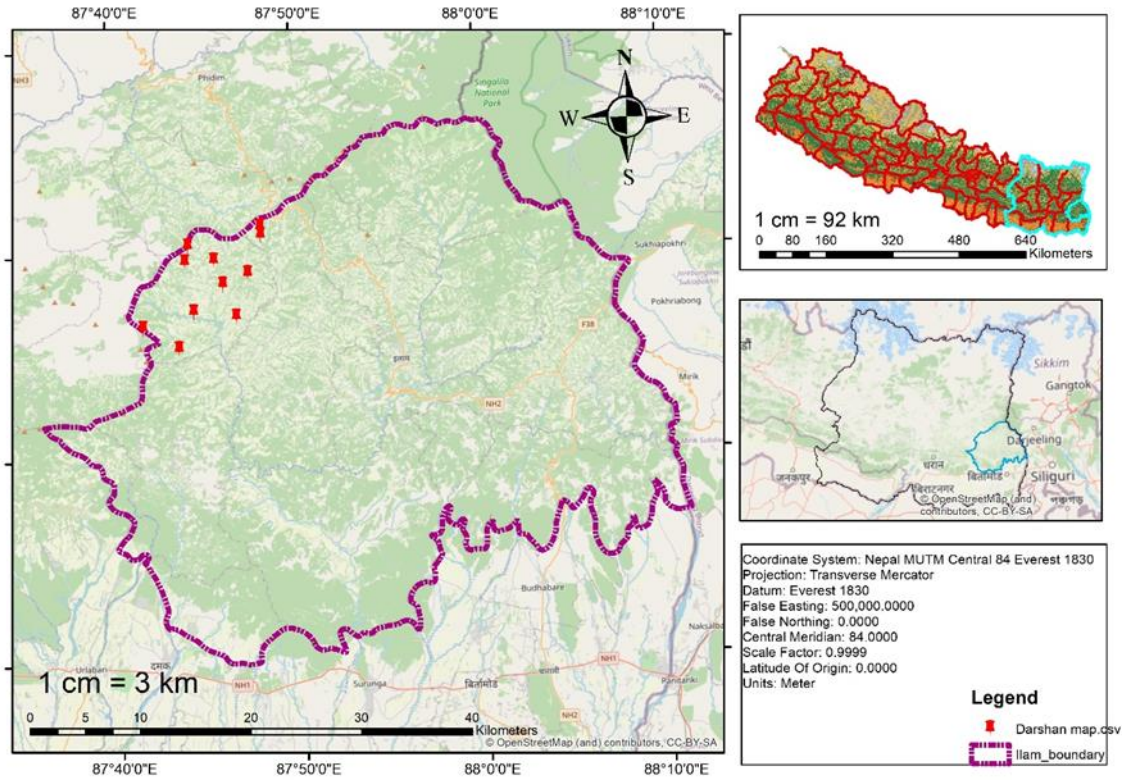

Figure. 1: Map showing study area.

2.2 Methods

For the suitability analysis of drinking water, 11 water samples from different springs found in Deumai watershed Ilam, Eastern Nepal were collected, for laboratory analysis (Fig.1). The water samples were collected in properly rinsed 1 L capacity plastic water bottles, until analysis. The bottles were rinsed with same sample water before filling with water sample to minimize the chances of contamination. For sample preservation and analytical procedures, American Public Health Association (APHA, 2005) was accepted as the standard approach. The physicochemical parameters: Total Dissolved Solids (TDS), Hydrogen ion concentration (pH) and temperature were measured in field using EC/TDS meter (HI98312) by Hanna Instruments, pH meter model LT-10 and laboratory thermometer respectively. The concentration of Sodium (Na^+) and potassium (K^+) was determined by Flame emission photometric method. Sulphate (SO_4^{2-}), Nitrate (NO_3^-) and Iron (Fe^{3+}) was measured by Spectrophotometric method. Total hardness, Alkalinity (HCO_3^-), Calcium (Ca^{2+}) and Chloride (Cl^-) concentrations were determined by titration method. APHA (2005) calculation method was used to determine the concentration of Magnesium (Mg^{2+}). The suitability analysis was determined by comparing the results of parameters with the standard value of respective parameters given by National Drinking Water Quality Standard (NDWQS, 2005) and World Health Organization (WHO).

3. Results and Discussion

The Government of Nepal published the National Drinking Water Quality Standard (NDWQS) in 2062 B.S as an effort to take step towards assuring drinking water quality. So, it is necessary to evaluate and differentiate the suitability of drinking water with National Drinking Water Quality Standard (NDWQS) and WHO.

The suitability analysis of drinking water is performed using different methods and different physicochemical parameters are studied. The parameters taken into account are TDS, pH, temperature, total hardness, alkalinity, total iron, Na+, K+, Ca2+, Mg2+, NO¬3– and SO42–. These parameters help to determine the suitability of drinking water..

3.1 *The physicochemical parameters*

The physicochemical parameters of all 11 spring water samples were analysed statistically (Shown in Table 1). The TDS level ranges from 16-226 mg/L, with the average value of 59.818 mg/L. The pH values lie within the range of 6.52-8.74, with an average of 7.47. This indicates the spring's water is slightly acidic to alkaline. The temperature ranges from 17.4ºC to 23ºC with an average value of 19.4ºC. The results are presented in box and whisker plots (Fig. 2)

Table 1: Summary statistics of measured physicochemical parameters.

Statistic	TDS (mg/L)	pH	Temperature (ºC)
Minimum	16	6.52	17.4
Maximum	226	8.74	23
Mean	59.818	7.47	19.4
Standard deviation (n)	58.891	0.735	1.623
Coefficient of variation	98.45	9.84	8.366

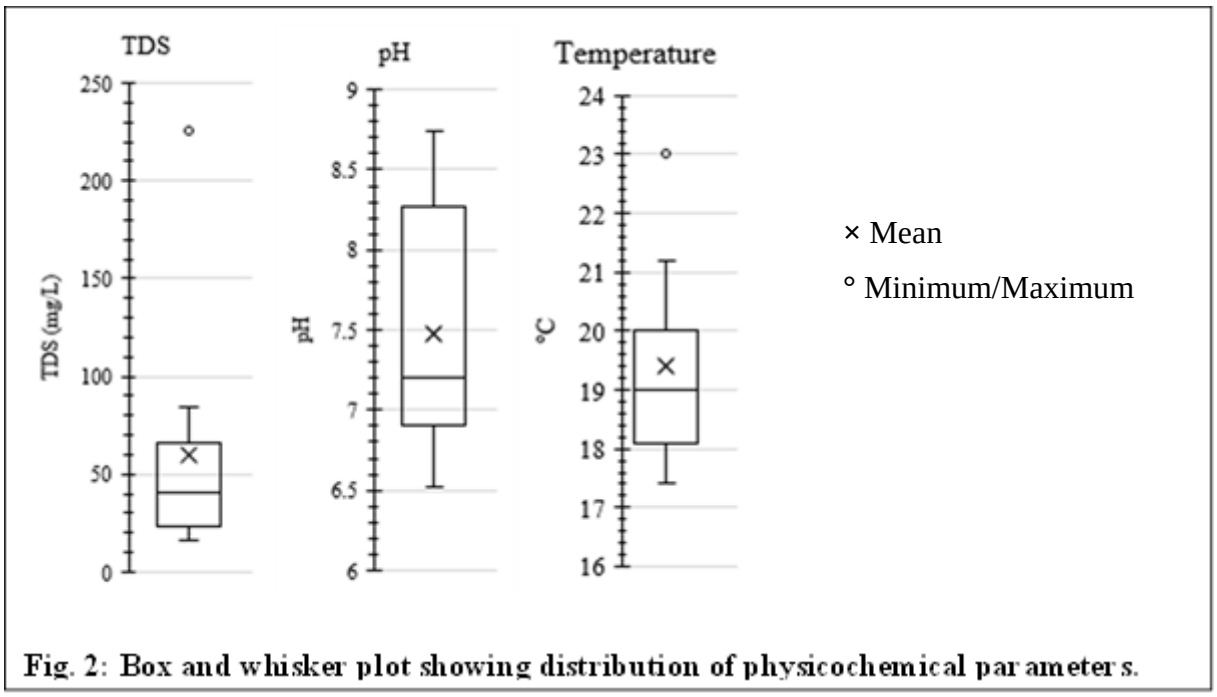

Figure.2: Box and whisker plot showing distribution of physicochemical parameters.

3.2 The Chemical Parameters

The chemical parameters of all 11 samples were determined using various methods like titration method, flame photometry method and spectrophotometric method. For the suitability of drinking water, these chemical parameters should lie within the range set by the WHO and NDWQS guidelines. The chemical parameters studied are total hardness, alkalinity, iron, sodium, calcium, potassium, magnesium, sulphate, chloride and nitrate.

The Table 2 shows the concentration ranges of major ions obtained from laboratory analysis. It was found that HCO_3^- has a higher concentration and central value than the other ions present in the water. The general order of dominance of major cations is $Ca^{2+} > Na^+ > Mg^{2+} > K^+ > Fe$. For anions the order of dominance is $HCO_3^- > Cl^- > NO_3^- > SO_4^{2-}$. The result for the chemical parameters is also presented in box and whisker plots (Fig. 3).

Table 2: Summary statistics of major cations and anions in spring water.

Statistic	Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	SO_4^{2-}	NO_3^-	HCO_3^-	Fe
Minimum	4.9	0.35	4.8	0.98	2.84	0.17	1.63	54	0.09
Maximum	15.3	4.4	91.27	6.81	24.14	2.77	4.81	252	3.38
Mean	10.06	2.79	24.16	5.22	9.68	0.65	2.49	101	0.17
Standard deviation (n)	4.34	1.55	23.29	1.96	7.72	0.73	1.10	53.6	0.089
Coefficient of variation	43.09	55.41	96.37	37.5	79.75	113.51	40.77	52.8	52.28

Fig. 4 shows the bar graph of comparison between total cation and anion within each water sample. The data plotted in the bar graph gives the information that 7 samples out of 11 has higher concentration of cation and rest are dominated by anions. The sample WS-10 contain the highest concentration of cation and anion among all the water sample.

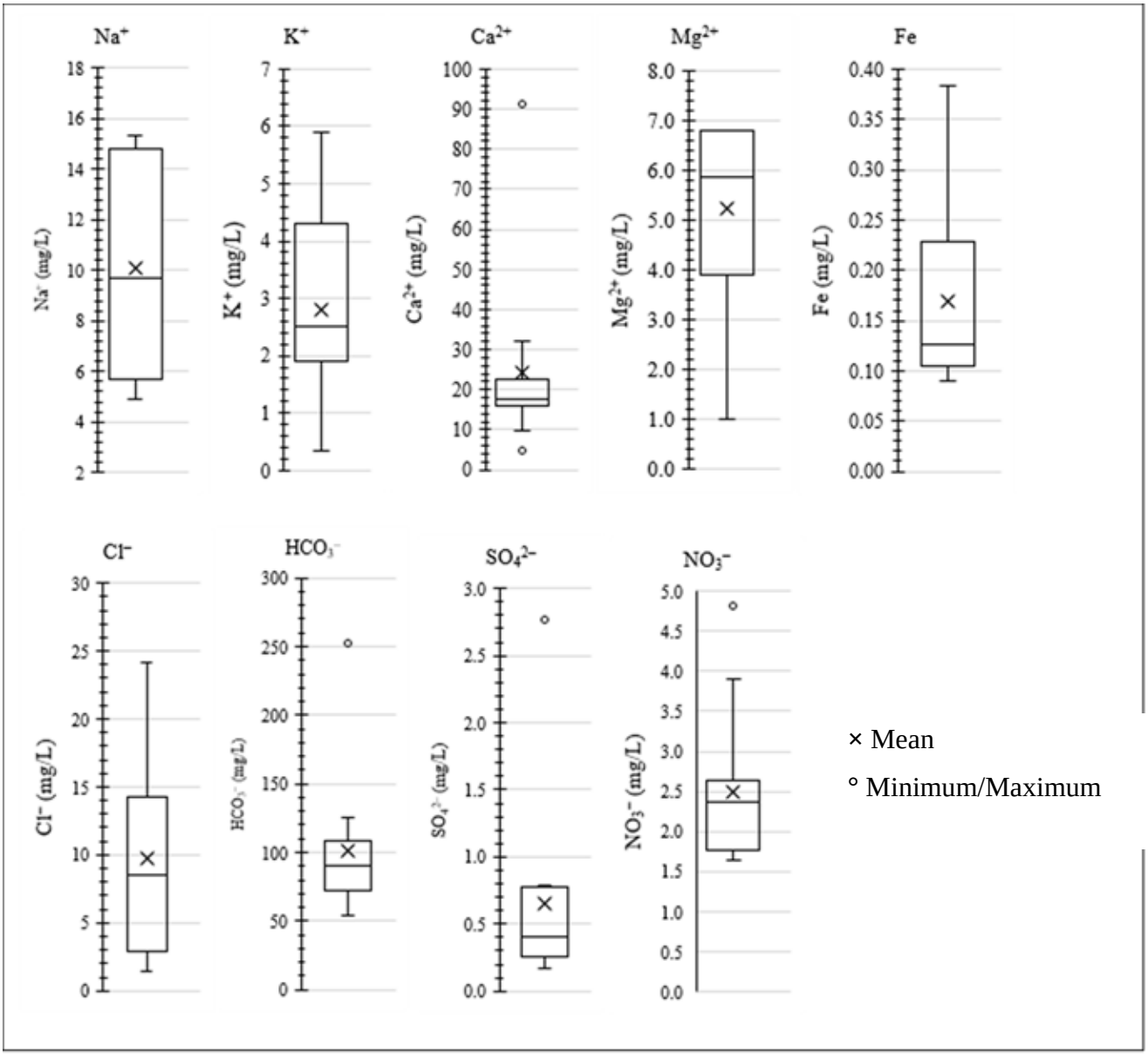

Figure. 3: Box and Whisker plot showing the ionic parameters of spring water.

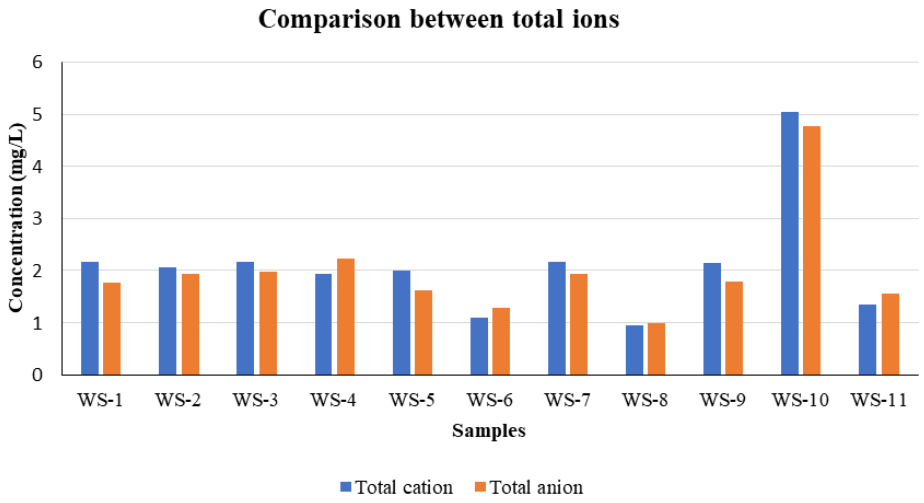

Figure. 4: Bar graph showing the total cations and anions in spring water samples.

The Table 3 shows the standard value for each parameter, given by WHO and the result obtained from the laboratory analysis.

Table 3: WHO standard value and laboratory results (Mean) of studied parameters.

S.N.	Parameters	WHO Standards	Laboratory Results (mean)
1	pH	6.5-9.2	7.47
2	Sodium (Na^+)	< 20 mg/L	10.06 mg/L
3	Potassium (K^+)	< 12 mg/L	2.79 mg/L
4	Total hardness	10-500 mg/L	29.38 mg/L
5	Calcium (Ca^{2+})	< 100 mg/L	24.16 mg/L
6	Magnesium (Mg^{2+})	< 50 mg/L	5.22 mg/L
7	Chloride (Cl^-)	< 250 mg/L	9.68 mg/L
8	Nitrate (NO_3^-)	< 10 mg/L	2.49 mg/L
9	Sulphate (SO_4^{2-})	< 100 mg/L	0.65 mg/L
10	Iron (Fe)	< 0.3 mg/L	0.170 mg/L
11	Alkalinity (HCO_3^-)	20-200 mg/L	101.454 mg/L
12	TDS	< 1000 mg/L	59.818 mg/L

By observing the concentration value of parameters (from Table 3) in all the water sample and comparing it with the drinking water guidelines given by WHO, the values are found within the guidelines set for the drinking water.

4. Conclusion

Springs are the major source of water in hilly and Himalayan region of our country. The spring water from the study area is slightly acidic to marginal alkaline (pH=7.47). The average temperature was found to be 19.4ºC. The other physicochemical parameters are also within the acceptable limit. HCO3– has a higher concentration (101.454 mg/L) and central value than the other ions present in the water. The dominance trend for major cations is Ca2+ > Na+ > Mg2+ > K+ > Fe. Similarly, the dominance trend for major anions is HCO3– > Cl– > NO3– > SO42–. The concentrations of all the chemical parameters i.e. major ions are also within the acceptable limit.

The water from the springs is good for drinking. No threat of quality deterioration is seen on the present scenario of water quality along the watershed. However, maintaining chemical integrity of the local spring water requires constant monitoring and appropriate management and protection procedures.

Acknowledgments

The authors acknowledge and extend sincere thanks to Department of Chemistry, Central Campus of Technology, Dharan for facilitating the research.

Conflicts of Interest

The authors declare that there is no conflict of interest.

Funding

No Funding resource.

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