Journal of Geosciences and Geomatics, 2021, Vol. 9, No. 4, 177-183
Available online at http://pubs.sciepub.com/jgg/9/4/2
Published by Science and Education Publishing
DOI:10.12691/jgg-9-4-2

A Comparative Study on Water Quality Parameters of a Hot Water Spring and Its Surrounding Water Resources at Irde, Panaje Puttur, Karnataka

Anupama Natesh[1,*], Dr. Radhakrishnan[2], Thangamani R[2]

[1]Department of Civil Engineering, Shree Devi Institute of Technology, Mangalore, India
[2]Department of Civil Engineering, NMAMIT Nitte, Karkala, India
*Corresponding author: pama.bhat@gmail.com

Received November 11, 2021; Revised December 14, 2021; Accepted December 22, 2021

Abstract Thermal spring is a natural phenomenon and is known in various names as hot springs, mineral springs, magic water, geysers, fumaroles, etc. based on their nature, qualities, and modes of formation on the earth's surface. The present study discusses the physicochemical analysis of Irade hot spring water with a comparative study of physicochemical characters of the samples collected from nearby locations during two different seasons like post-monsoon and pre-monsoon (2019). Irde hot spring is located about 15 km from Puttur town in the Dakshina Kannada district of Karnataka, India. The samples were collected at a distance of 196.82m (OW1), 239.48m (OW2), 163.13m (BW), and 61.30m from the hot spring. Analytical results of Irade hot spring water shows concentrations of fluoride about 2.92 mg/L in the post-monsoon season and within the limit during pre-monsoon. Generally, a hot spring contains some amount of fluoride due to the acidic nature (low pH) of water which reacts with rock at the time of percolation. Hot spring water can be used for drinking purposes only after the proper treatment. The sulfate concentration in hot spring water is 528mg/L (pre-monsoon) and 325mg/L (post-monsoon) and it is higher when compared to near by water sources. The turbidity of open wells samples OW1 and OW2 shows 6.1NTU and 5.18 NTU respectively and it should be treated before using it for drinking purposes. Previous research concluded that the hot nature of spring water is due to the sulfate concentration. With the influence of climatic changes and reduction in sulfate concentration the temperature of water getting reduced every year.

Keywords: *fluoride, hot spring, physicochemical analysis, sulphate*

Cite This Article: Anupama Natesh, Dr. Radhakrishnan, and Thangamani R, "A Comparative Study on Water Quality Parameters of a Hot Water Spring and Its Surrounding Water Resources at Irde, Panaje Puttur, Karnataka." *Journal of Geosciences and Geomatics*, vol. 9, no. 4 (2021): 177-183. doi: 10.12691/jgg-9-4-2.

1. Introduction

The hot springs were such a natural wonder that in 1832, President Andrew Jackson designed hot springs as the first federal reservation. Technically Todd (1980) describes "the thermal springs, which discharge water that has a temperature above that of the normal groundwater". Hot spring is generated by the rise of geothermal heated groundwater on to the surface of the Earth. Surface and groundwater reaching great depths in a geothermal basin get heated and partly get converted into steam. A thermal spring can be called a 'hot spring' when the temperature of the water reaches the boiling point (100°C) and is charged with various mineral constituents due to its ability to dissolve the minerals which are present in the rocks while moving through them due to high temperatures. Thus, the hot springs are also known as "mineral springs" [1]. The occurrences of these thermal areas are controlled by the basic structural and tectonic framework of peninsular and extra peninsular India. Based on available data ten well-defined geothermal provinces could be recognized in India by considering their geographical location, geo-tectonic setting, and geothermal characteristics [1,2].

Oldham, T., a veteran geologist, recorded the thermal springs of India as early as 1882 [3]. He located a thermal spring in a remote and inaccessible part of Puttur taluk in the South Kanara district [4]. This spring, referred to as "BendruThirtha" by the locals, is located about 15km from Puttur town in Dakshina Kannada, Karnataka, India, which is situated in an area near the river Seeresude a small tributary of the River Chandragiri (Figure 1). Now it is considered government of Karnataka as a tourist spot of the Dakshina Kannada district. BendruTheertha is a pilgrimage center for Hindus. Bendru Theertha contains traces of sulfur and is known to have curative properties. It is listed by the Archaeological Survey of India (ASI) as the only natural hot spring of South India. A unique fact about Bendru Theertha is that it is located in a non-volcanic region. As such, it is a rare phenomenon to find a hot spring there. It is believed that the geothermal energy of the hot rocks underground heats the water table.

As the density of the heated water is lower than normal water, it comes out in the form of a spring.

Geologically the Irde area is of high grade metamorphic terrain with Pre-cambrian gneisses, overlaid by granulites and schists bands. The overburden of laterite and lithomarge clay above this varies from 10m to 30m thickness in many places. The hot water spring at this location is found in a river side pond with a sharp intrusive body on one side and a two-metre-thick laterite cover on granitic gneiss. The major lineament Baddanthadka river channel is intersected by the three other lineaments viz: Bettampadi, Bailadka and Cheladka rivers in an approximately right-angled fashion suggesting a tectonic control of these features. The Irde hot spring is located on southwestern quadrant very close to this intersection (sangama). The flow of water in this spring has been weakened due to a shallow borewell drilled (1992) within 30m from the spring. The temperature of the spring water generally remains at 99F to 106F and the water in the bore well reported about 39°C.

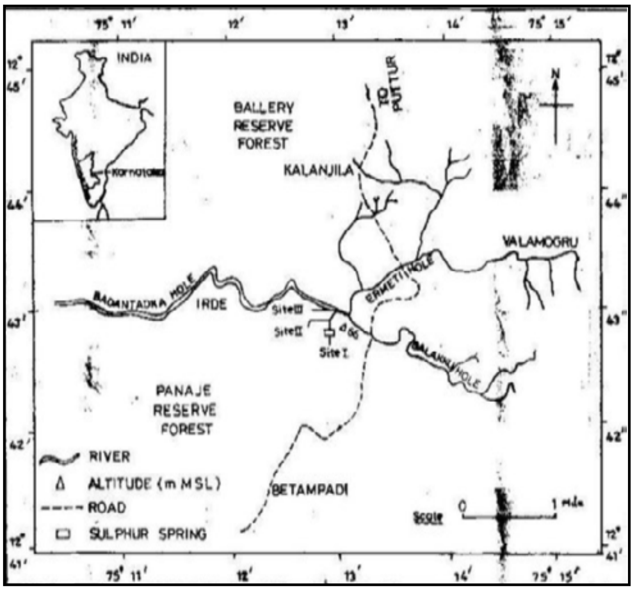

Figure 1. Map showing the location of BendreThirha Spring [4]

Today Bendre Theertha is slowly inching towards extinction due to the developmental activities in the area over the years. Dense forest has been switched to areca nut plantations. The number of bore wells increased greatly in the area is directly affecting the hot spring. It is estimated that the depth of the hot spring is about 85 ft. However, there are more than 18 bore wells in that area with a depth of about 100 ft. Due to this, the warm water is drawn to a lower water table instead of springing out. As such, during summer, the spring turns into a shallow pool of muddy water. It is only during the monsoon season that the spring jumps back to life. This paper aims to investigate the hydrochemical characteristics of spring water in Panaje area part of Puttur taluk in the Dakshina Kannada district concerning different seasons.

2. Materials and Methods

2.1. Study Area and Sample Locations

Bendru Theertha is located on the south bank of the Badantadka river, which emerges after the confluence of two tributaries, Balakku and Ermatiand now it issurrounded by a private areca garden [4]. The sample locations around the hot spring are within North latitudes 12°40’44” N - 12°40’52” N and East longitudes 75°11’42” E-75°11’ 53” E (Figure 2). Geologically, this area is occupied by the Peninsular Gneissic Complex of the Archaean age, primarily composed of crystalline rocks granites, gneisses, and the sedimentary deposits of Upper Proterozoic to recent periods [5,6]. The location of the thermal spring is not indicated in the Survey of India toposheet 48 P/2. The elevation is 66 m above MSL. The temperature of the spring water is 38°C - 57°C.The spring is fenced by a rectangular wall built of laterite blocks that were constructed about 40 years ago (Figure 8a & 8b). The floor of the pond was found to be uneven and showed a banded gneiss traversed by joints. The gneissic rock is charged with pyrites and the water had a faint sulphurous odour [7]. Bendru Theertha hot spring area comes under the coastal agroclimatic zone of Karnataka [8] experiences maximum temperature in the months March-May (31°C) and minimum in the months November to January (25°C). The normal annual rainfall of coastal Karnataka is around 3456 mm.

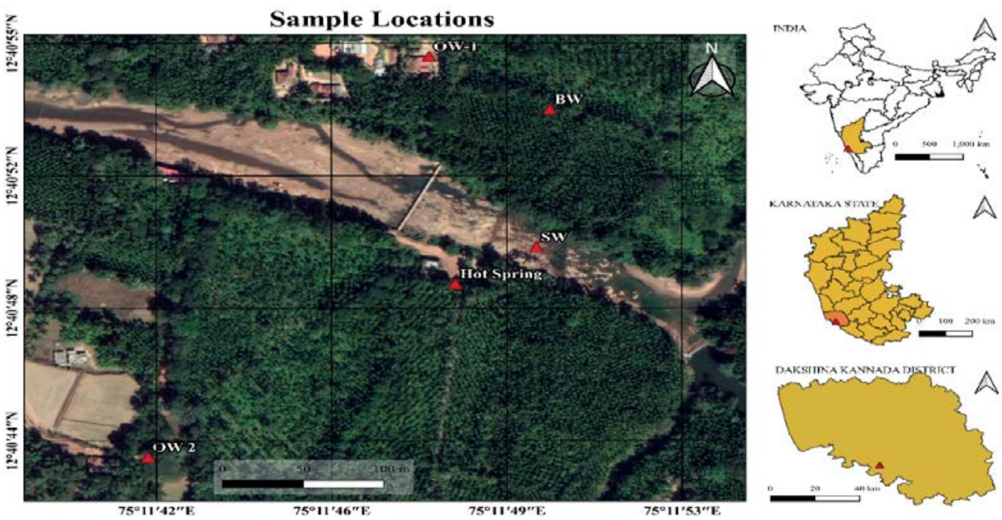

Figure 2. Sample locations and Hot spring

2.2. Sampling and Analytical Procedure

Water samples including groundwater samples (OW1, OW2) surface water (SW), borewell water (BW), and hot springs were collected during pre-monsoon (2020April) and post-monsoon (2019October) seasons. The samples were collected at a distance of 196.82m (OW1), 239.48m (OW2), 163.13m (BW), and 61.30m from the hot spring. Geographical locations of samples were marked using Montana 650 GPS handset. Analysis of physio-chemical parameters was done using standard analytical procedures as recommended by the American Public Health Association (1995) [9,10]. All the water samples were analyzed for various hydrochemical parameters such as pH, electrical conductivity (EC), total hardness (TH) as $CaCO_3$, calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^+), potassium (K^+), iron (Fe^+), carbonate (CO_3), bicarbonate (HCO_3), chloride (Cl^-), sulphate (SO_4^{2-}), nitrate (NO_3^-), and fluoride (F^-) phosphate, and Ammonia. Analytical methods were adapted for analysing the water quality parameters. The drinking water quality assessment of the samples were done by comparison the obtained values with the BIS (2012) Standards [11,12]. The analytical precision for the total measurements of ions was checked again by calculating the ionic balance errors and was found generally within ±5%.

3. Results and Discussions

The statistical analysis of water samples for two seasons viz: pre-and post-monsoon have been computed and tabulated below (Table 1). All the water samples including hot spring water are colourless and odorless. The temperature of hot spring water has a major role in evaluating the uses of thermal springs [1]. The major process of thermal water is meteoric water that brings the heat from the interior to the surface through a permeable path of the aquifer. The main heat source is from magmas within the crust that intrudes to shallower levels from unstable areas such as active volcanic belts or fault zones [13]. There are not many variations in the temperature of the water samples and the hot spring water samples. The surface temperatures of hot spring water and other water samples were measured from the field using a laboratory thermometer. At present the recorded temperature of water samples are ranging from 33°C to 35°C. Earlier the temperature of the water was recorded and it was found to be steady at 39°C [7]. Oldhamtoo has mentioned the temperature as 102°C and it would appear that the temperature has remained constant without much variation during the last 100 years [3,7]. The information regarding the geology and the existence of any major fault or fracture or crushed zone is not well known [7]. The flow of the Batanadka stream in a straight stretch is suggestive of its flow over a structurally weak zone. The rocks in the area appear sheared and brecciated. Oldham in the paper earlier described the thermal springs which are more or less fall along a straight line aligned north-south between the coast and the precipitous edge of the ghats. There is a gap of nearly 430 km between the southernmost spring at Rajapur and Irade. There may be springs along the line connecting the two places. The area not having been closely surveyed geologically, the existence of such springs is not known. The detailed study may bring to light several more springs between the edge of the ghats and the coast [7].

Generally, water in hot springs is basic, and in some hot springs the water is acidic [13]. The variation in pH in the analyzed samples shows that during post-monsoon is within the desired limit and during pre-monsoon slightly acidic in open-well samples. Electrical conductivity (EC) is a good indicator of the quality of water. It is defined as the conductance of a cubic centimeter of water at a standard temperature of 25 °C [14].

The Electrical conductivity (EC) of the hot spring water and other samples were determined in the field itself and the value ranges from 695 µs/cm (post-monsoon) to 1365 µs/cm (pre-monsoon).Total dissolved solids in water include all inorganic salts that include carbonates, bicarbonates, chlorides, fluoride, sulphates, nitrates, calcium, magnesium sodium, and potassium [15,16,17].

Table 1. Statistical Analysis of Water Quality Parameters

Parameters	BIS(2012	Pre Monsoon				Post Monsoon			
		Min.	Max.	Mean	Std. Dev	Min.	Max.	Mean	Std. Dev.
Temperature		33.60	35.00	33.90	0.62	32.10	34.00	32.60	0.80
pH	6.5-8.5	5.00	6.60	6.06	0.73	6.00	7.80	7.10	0.69
Turbidity	10	2.80	25.80	9.44	9.27	0.90	6.50	4.28	2.58
EC µs/cm	1500	162.00	1365.00	488.60	506.78	86.00	695.00	369.40	263.11
TDS (mg/l)	500-2000	122.85	887.25	318.99	326.38	55.90	451.75	240.11	171.02
Ca^{++} (mg/l)	200	7.21	64.00	19.93	24.70	2.41	20.00	10.57	7.23
Mg^{++}(mg/l)	100	0.97	19.44	5.73	7.81	0.97	13.62	4.38	5.31
Na^+(mg/l)	200	14.54	36.00	26.88	8.40	4.76	34.96	20.58	11.41
K^+(mg/l)	12	5.28	9.28	6.91	1.49	1.27	3.75	2.54	0.96
Fe (mg/l)	0.3	0.00	0.11	0.04	0.05	0.00	0.12	0.07	0.05
HCO_3 (mg/l)	400	22.00	124.00	48.00	42.73	22.00	124.00	48.00	42.73
Cl (mg/l)	1000	20.00	44.00	33.60	9.10	40.00	56.00	46.00	6.93
NO_3 (mg/l)	45	0.00	0.52	0.19	0.27	0.00	1.49	0.33	0.65
SO_4 (mg/l)	400	34.30	528.00	151.60	212.07	20.00	325.00	128.40	132.87
F (mg/l)	1.5	0.50	0.95	0.70	0.17	0.00	2.92	0.89	1.20
TH (mg/l)	200-600	8.67	83.44	25.66	32.34	3.38	33.62	14.94	12.09

Total dissolved solids concentrations were within the permissible limits in all the samples in both seasons. Hot spring samples have a high concentration of EC and TDS in both seasons which is much higher when compared to the other four samples (Figure 3A, 3B, and Figure 4A, 4B). This indicates the influence of anthropogenic sources, such as domestic sewage, septic tanks, and agricultural activities [18]. Even the geochemical processes are also responsible for the higher concentrations in electrical conductivity [16]. The hardness of hot springs is slightly high during the pre-monsoon season. It may be due to the presence of TDS and turbidity. During the pre-monsoon season, in hot spring water, the turbidity is very high when compared to other locations (Figure 5A, 5B).

Other parameters like alkalinity, acidity, iron, nitrate, chloride calcium, and magnesium were within the permissible limit in all the samples. Ammonia, residual chlorine, and phosphate were not detected in any of the samples. Sulphate ion concentrations in hot spring water are 528mg/L in the pre-monsoon and 325mg/L in the post-monsoon season. It is observed that during the pre-monsoon period there is a slight increment in the concentration of sulphate when compared to the BIS 2012 (400 mg/L) standards. This may be due to the leaching of gypsum and sulphate containing minerals [19]. The lowest sulphide levels generally corresponded to periods after heavy rainfall [20], especially in the post-monsoon season. Figure 6a, 6b shows the sulphate distribution in nearby locations. Generally, the hot spring water absorbs sulphur from the minerals which are present in the rocks at the time of percolation of water and gives the odour of hydrogen sulphide [1].

Fluoride is one of the main trace elements as a natural constituent in groundwater, its concentration results in groundwater contamination which is one of the important issues in water quality studies [21]. During the post-monsoon season, the concentration of fluoride ions in hot springs is very high and in other samples is within the limit. Fluoride variation in the hot spring water and other samples were shown in Figure 7a and 7b. The high concentrations of fluoride measured in hot spring water samples explain the relationship between the groundwater and bedrocks in these areas, for this reason, we suggest that the investigated groundwater is not acceptable as drinking water.

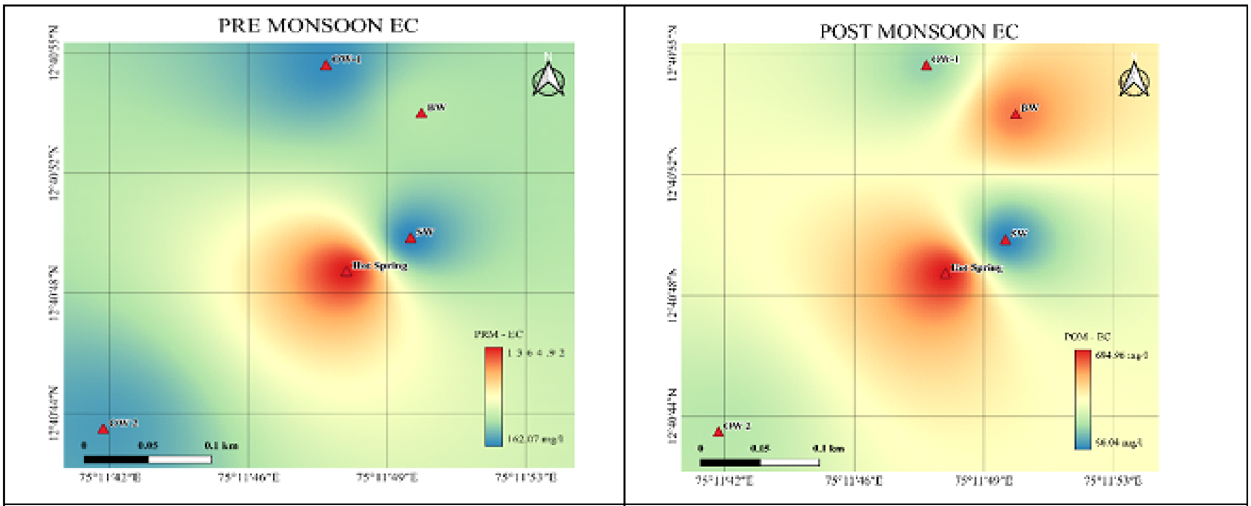

Figure. 3A.Electrical conductivity- Pre Monsoon | Figure. 3B. Electrical conductivity- Post Monsoon

Figure 3.

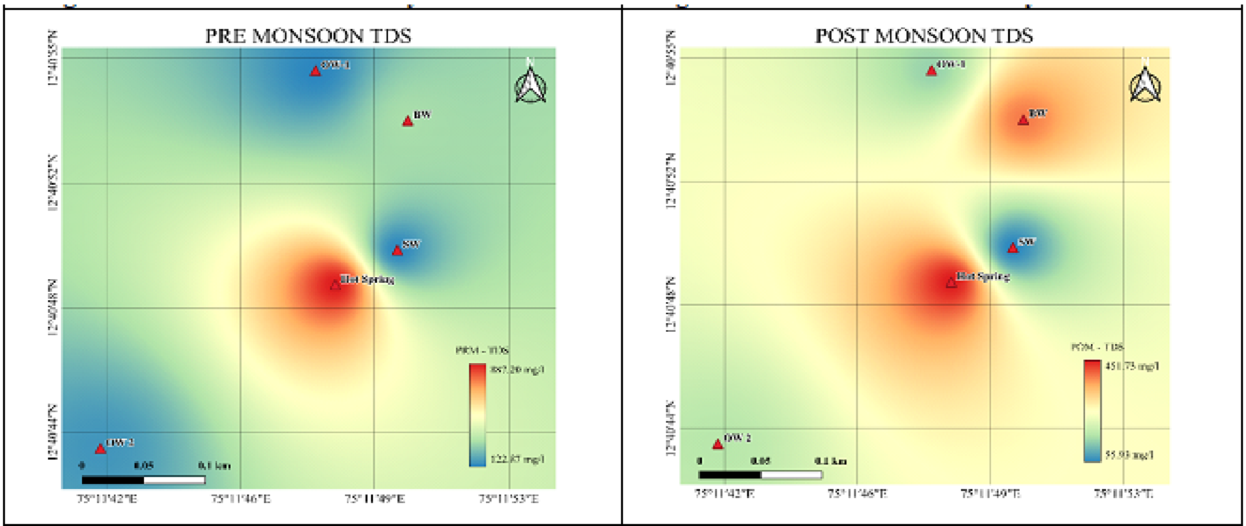

Figure. 4A. Total dissolved solids - Pre Monsoon | Figure. 4B.Total dissolved solids - Post Monsoon

Figure 4.

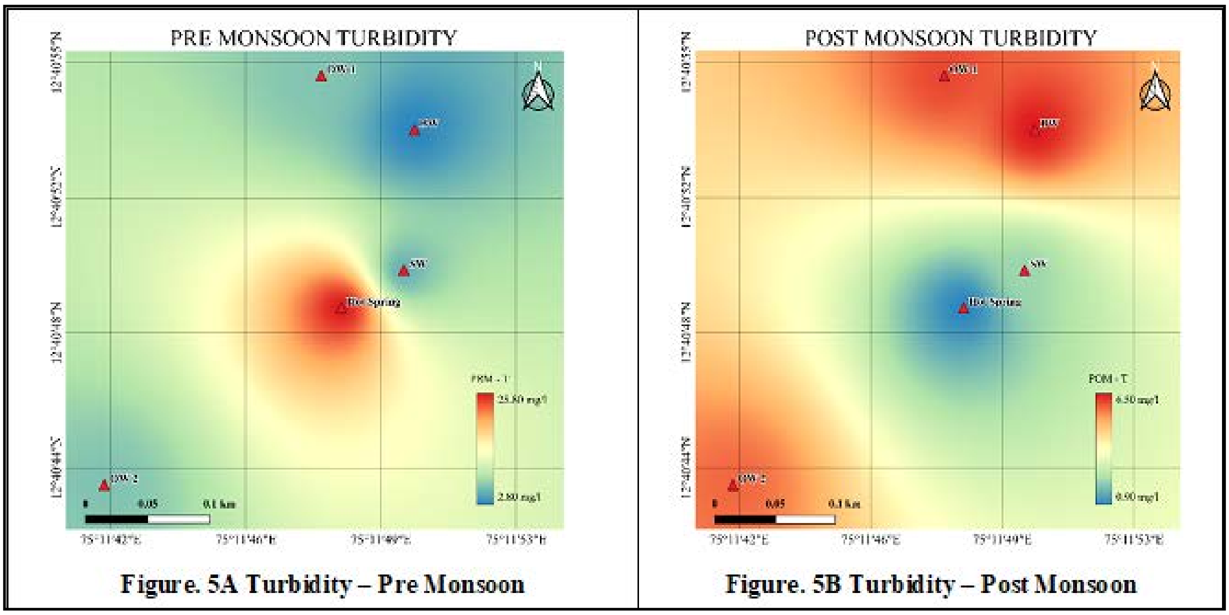

Figure. 5A Turbidity – Pre Monsoon

Figure. 5B Turbidity – Post Monsoon

Figure 5.

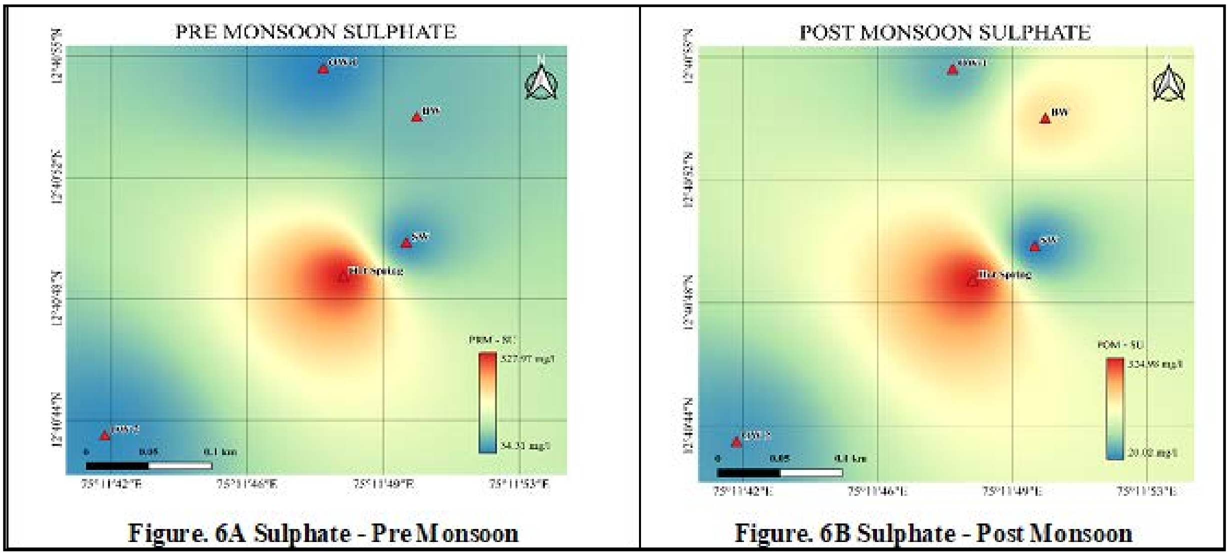

Figure. 6A Sulphate - Pre Monsoon

Figure. 6B Sulphate - Post Monsoon

Figure 6.

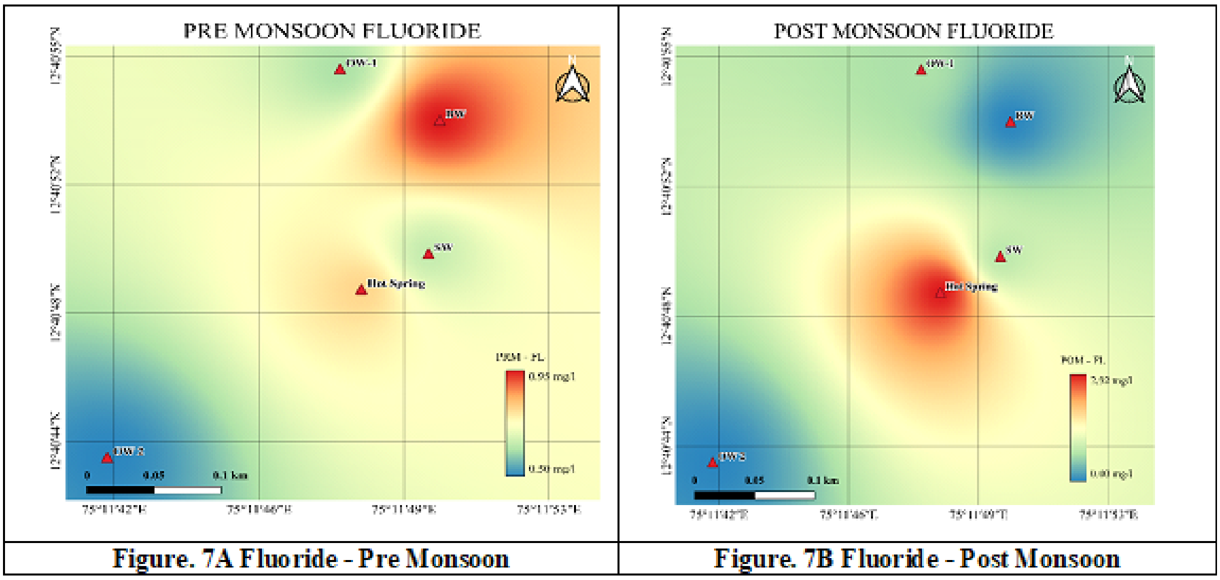

Figure. 7A Fluoride - Pre Monsoon

Figure. 7B Fluoride - Post Monsoon

Figure 7.

Figure. 8A BendreTheertha Fluoride –Earlier view (Monsoon)

Figure. 8B BendreTheerthaPre-monsoon view

Figure 8.

4. Conclusions

The hydrochemical analysis of the hot spring located at Irade suggests that at present Bendre Theertha is slowly edging towards extinction due to the developmental activities in the area over the years (Figure 8a and 8b). The temperature of the hot spring water is decreased due to the gradual increase in the number of borewells with a depth of about 100 ft. in the area is directly affecting the hot spring. It is estimated that the depth of the hot spring is about 85 ft. Due to this the warm water is drawn to a lower water table instead of springing out. As such, during summer, the spring turns into a shallow pool of muddy water. The water quality is within the Indian standard limit but except the fluoride content which was 2.916 mg/L during the post-monsoon season and within the limit during pre-monsoon. Generally, a hot spring contains some amount of fluoride due to the acidic nature of water which reacts with rock at the time of percolation. The surface water and groundwater which is located near the hot spring can be used for drinking purposes since all parameters are within standard limits. As already mentioned the thermal springs are mostly confined to tectonic zones in Pre-Cambrian terrain, the spring water may be heated due to the deep circulation of water inside the earth. It is assumed that exothermic reactions e.g. oxidation of sulphide to sulphate, formation of carbonates, and also radioactive disintegration inside the crust might have contributed some amount of heat to the hot spring.

References

[1] S. Chandra, Geology, Chemistry and Genesis of Thermal Springs of Odisha, India. Springer briefs in earth sciences, 2019.

[2] G. S. of I. Shanker, R., “Geothermal atlas of India.,” Geol. Surv. India., 1991.

[3] T. Oldham, “Thermal springs of India,” Geol. Surv. Ind. Mem., vol. 19, no. 2, pp. 1-63, 1882.

[4] K. R. Chandrashekar and K. R. Sridhar, “Thermal springs of Dakshina Kannada,” no. January, 2000.

[5] M. Ramakrishnan, “Precambrian Mafic magmatism in the Western Dharwar Craton, southern India,” J. Geol. Soc. India, vol. 73, no. 1, pp. 101-116, 2009.

[6] A. Ramanathan and D. Chandrasekharam, “Geochemistry of Rajapur and Puttur thermal springs of the West Coast, India,” J. Geol. Soc. India, vol. 49, no. 5, pp. 559-565, 1997.

[7] B. P. Radhakrishna, “On a little known thermal spring from near Puttur, Mysore State, India,” J. Geol. Soc. India., vol. 10, pp. 88-94, 1971.

[8] P. Ravikumar and R. K. Somashekar, “Assessment and modelling of groundwater quality data and evaluation of their corrosiveness and scaling potential using environmetric methods in Bangalore South Taluk, Karnataka state, India,” Water Resour., vol. 39, no. 4, pp. 446-473, 2012.

[9] APHA American Public Health Association, Standard Methods for the Examination of Water and Wastewater, vol. 552. 1995.

[10] R. Thangamani, K. Radhakrishnan, and K. V. Sindhu, “Hydrogeochemical evaluation for developmental activity in part of belma microwatershed, Dakshina Kannada district, Karnataka,” vol. 99, 2021, pp. 853-864.

[11] R. W. Herschy, “Water quality for drinking: WHO guidelines,” Encycl. Earth Sci. Ser., pp. 876-883, 2012.

[12] Bureau of Indian Standards, “Bureau of Indian Standard Drinking Water Specification.,” 2012.

[13] B. M. M. Rajapaksha, R. A. Maithreepala, and H. B. Asanthi, “Water quality and biology of hot springs waters of Mahapelessa, Sri Lanka,” Sci. Res. J., vol. 2, no. 12, pp. 1-6, 2014.

[14] Todd, Hydrology Handbook. 1980.

[15] P. L. Sawyer, C. N., & McCarty, “Chemistry for environmental engineering.,” McGraw-Hill, 1978.

[16] V. Sunitha and Y. Sudharshan Reddy, “Hydrogeochemical evaluation of groundwater in and around Lakkireddipalli and Ramapuram, Y.S.R District, Andhra Pradesh, India,” HydroResearch, vol. 2, no. April 2020, pp. 85-96, 2019.

[17] P. Ravikumar, M. Aneesul Mehmood, and R. K. Somashekar, “Water quality index to determine the surface water quality of Sankey tank and Mallathahalli lake, Bangalore urban district, Karnataka, India,” Appl. Water Sci., vol. 3, no. 1, pp. 247-261, 2013.

[18] S. Krishna Kumar et al., “Evaluation of water quality and hydrogeochemistry of surface and groundwater, Tiruvallur District, Tamil Nadu, India,” Appl. Water Sci., vol. 7, no. 5, pp. 2533-2544, 2017.

[19] V. B. Yannawar, A. B. Bhosle, P. R. Shaikh, and and Surekha R. Gaikwad, “Water Quality of Hot Water Unkeshwar Spring of Maharashtra, India,” Int. J. Innov. Appl. Stud., vol. 3, no. 2, pp. 541-551, 2013.

[20] J. I. Field and J. Webster, “Effects of sulphide on survival of aero-aquatic and aquatic Hyphomycetes.,” Trans. - Br. Mycol. Soc., vol. 85, no. 2, pp. 193-199, 1985.

[21] N. Adimalla, R. Dhakate, A. Kasarla, and A. Kumar, "Groundwater for Sustainable Development Appraisal of groundwater quality for drinking and irrigation purposes in Central Telangana, India," Groundw. Sustain. Dev., vol. 10, no. 126, p. 100334, 2020.