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Water Quality of Hot Water Unkeshwar Spring of Maharashtra, India

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ABSTRACT: Physical, chemical, ionic, biological studies were conducted at hot springs Unkeshwar in (Maharashtra State, India). It is positioned on south east corner of Maharashtra. Unkeshwar is situated on the bank of river Penganga. *Objective*: This papers aims to study the physical, chemical and biological properties in the ecological system of Unkeshwar spring. *Methods*: The physical and chemical parameters were analyzed as per APHA. *Results*: The physical parameters included: Temperature, Total solids, Total dissolved solids, Total suspended solids and electrical conductivity. The chemical parameters included: pH, free carbon-dioxide, total hardness, calcium hardness, magnesium hardness, Phenolphthalein alkalinity, total alkalinity, Salinity. Ionic parameters like chloride, phosphate, sulphate, calcium, magnesium, sodium, potassium, iron, chromium and manganese. Also the biological parameters studied standard plate count and most probable number. *Conclusions*: The water quality comparison of Unkeshwar spring in Nanded reveals that although the situation is not worst but it has to be maintained. Some of the water characteristics are below the permissible limit in the post-monsoon season and some are above the permissible limits in pre-monsoon season. This may be due to dilution of water by raining. Overall study showed that the water is more polluted in pre-monsoon as compared to post-monsoon. Hence this hot water spring should be preserved for its sulphur contents that possess medicinal value and cure skin diseases.

KEYWORDS: Thermal Springs, Physico-Chemical Parameters, Permissible Limit, Microbiological and chemical standards, drinking water, Unkeshwar.

1 INTRODUCTION

Water is the world's most precious resource because the life of animals and plants depends on it. Most industries also require water for various applications, so the global economy depends on it as well. Springs are the places where ground water is discharged at specific locations on the earth and they vary dramatically as to the type of water they discharge. Many of the springs are the result of long cracks or joints in sedimentary rock [1]. Hot springs are defined as springs where the temperature of water lies significantly above the mean of annual air temperature of that region [1, 2]. Hot ground water can be used to drive turbines and generate electricity, or it can be used directly to heat homes and other buildings. Energy extracted from the Earth's heat is called geothermal energy [3]. An aquifer refers to an underground source of water. The water can be present within cracks and crevasses of rock, sand, clay, gravel or other material and in spaces between adjacent particles of material [4].

The rate and direction of groundwater movement in an aquifer in part depend on both the gradient of the water table, or hydraulic gradient and the type of material found in the aquifer. In general, the hydraulic gradient for an unconfined aquifer is approximately the slope of the water table [5]. Water is one of the abundantly available substances in nature. It is essential constituent of all animal and plants material and forms about 75% of matter of earth crust. It has been argued previously that geochemical energy-yields may be a key determinant of microbial community structure and diversity in thermal environments [6]. Rainfall, an important and largest source of water, other sources are surface water and sub-surface water

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or ground water [7]. Water is mostly important for industrial and municipal purposes. In addition to the direct consumption of water at homes and farms, there are many indirect ways in which water affects our daily life.

The physical, chemical and biological composition of water is influenced to a great extent by different factors including climate, geomorphology and geology. Also the physical variables which include temperature and turbidity; chemical variables in that non-toxic variables such as pH, total dissolved salts, salinity, conductivity, ions, nutrients, organic matter and dissolved gases and toxic variables like biocides and trace metals. The objectives of the present work are to analysis and discuss the suitability of water for drinking and sanitation.

2 MATERIAL AND METHODS

2.1 STUDY AREA

Geographical location of Unkeshwar is latitude (19°34'–19°40'N and 78°22'– 78°34'E) longitude. Unkeshwar is situated on the bank of river Penganga. Unkeshwar are the hot springs which are located close to the famous temple of God Shiva. It is situated at a distance of 19 km from Ambadi, a railway station on Mudkhed – Adilabad railway route. These springs are said to possess medicinal value and cure skin diseases. The temperature of water in one tank stands at 42.2^0 C and is found to contain sulphur in water springs. The excess water flows out from the Gomukh. Near the temple is a holy tank. It was said to be the abode of the Sage Sarabhanga [38]. Many bubbles are seen in the tank which indicates sulphur contents as per the experts.

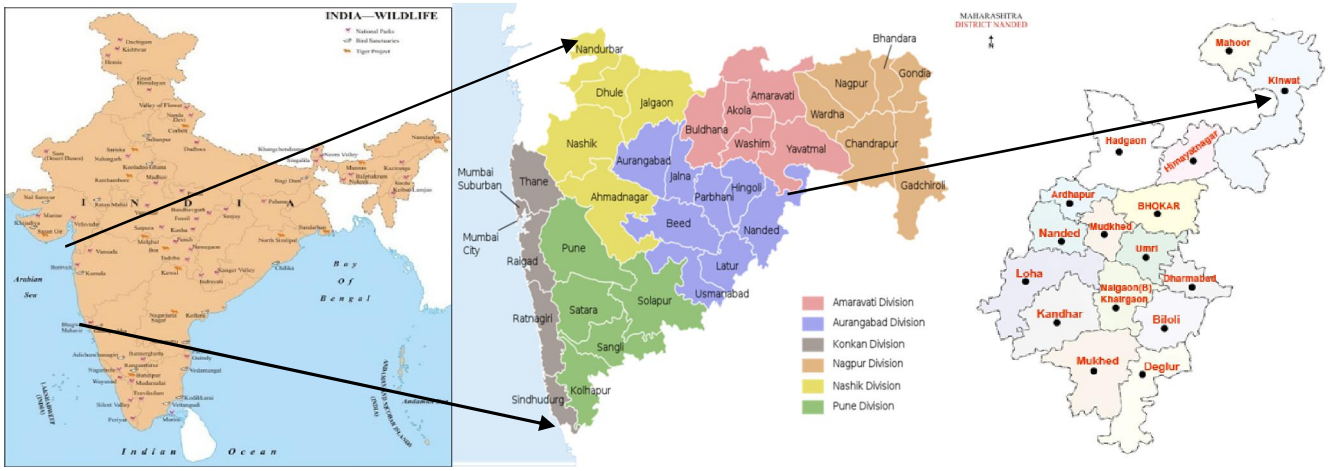

Fig. 1. Showing study areas map of district

Fig. 2. Holy tank of Unkeshwar hot spring

2.2 SAMPLING METHODS

For the present investigation the water samples collected from the Unkeshwar spring and taken in pre-cleaned polyethylene bottle. The all water quality parameters estimated by the standard methods given by APHA [8]. Water temperature recorded immediately on the site by mercury thermometer. TS, TDS and TSS of water samples measured using gravimetric method. EC values of the water sample under investigation were measured using Digital Conductivity meter. The pH value of water sample measured by using Digital pH meter. The carbon dioxide determined by titrating with NaOH using phenolphthalein as an indicator.

The salinity was generally determined by titrating the water samples against standard solution of silver nitrate using potassium chromate as an indicator. The total hardness, magnesium hardness and magnesium of the water sample were determined by complex metric titration with EDTA using Erichrome black T as an indicator. The calcium hardness and calcium of the water sample were determined by complex metric titration with EDTA using Murexide as an indicator. Phenolphthalein and Total alkalinities of the water samples were determined by titrating with H_2SO_4 using phenolphthalein and methyl orange as indicators. The fluoride is estimated by SPANDS method. The iron, chromium and manganese estimated by Thiocynate, Diphenylcarbazide and Persulphate method respectively. The SO_4^{2-} , PO_4^{2-} and NO_3^- were estimated using UV-Visible spectrophotometer. The SPC and MPN determined using Nutrient agar media and Mac -Conkey broth respectively.

3 RESULT AND DISCUSSION

3.1 TEMPERATURE

The water temperature noted from Unkeshwar spring was 42.0^{o}C in pre-monsoon and 40^{o}C in post-monsoon season with an average 41 ^{o}C; this is high as compared to other water bodies so this is a hot spring.

Jayabhaye et al. [9], reported water temperature ranged from 22.5-32.5^{0}C from Kayadhu river, near Hingoli during January-December 2004.

3.2 TOTAL SOLIDS (TS)

The mean value of total solids observed from water sample is 6324 mg/L and 474 mg/L in pre and post monsoon respectively.

Raveen et al. [10], found total solid ranged between 556-762, 542-671 and 608-667mg/L from Chitlapakkam, Selaiyur and Sembakkam Lake during January-December 2006 of Chennai respectively.

3.3 TOTAL DISSOLVED SOLIDS (TDS)

The average total dissolved solids observed from water sample are 5180 mg/L in pre-monsoon and 300 mg/L in post monsoon. Total dissolved solids are above the permissible limiting 500 mg/L recommended by WHO.

Asrari et al. [11], measured the TDS minimum 50mg/L and maximum 3575 mg/L from Kor River, Iran. The amount of TDS related with increasing dissolved ions.

3.4 TOTAL SUSPENDED SOLIDS (TSS)

The mean total suspended solids recorded from water sample are highest 1144 mg/L in pre-monsoon and lowest 174 mg/L in post-monsoon season.

Gautam et al. [12], observed TSS ranged from 8-84 and 6-38 in post and pre monsoon from surface water samples of Gulbarga respectively. Also they found TSS range below detectable limit to 42 and 6-220 from Bagalkot in same seasons.

3.5 ELECTRICAL CONDUCTIVITY (EC)

The average of Electrical conductivity recorded from water sample is 58 uS/cm and 260 uS/cm.

Akoto and Adiyiah [13], recorded EC ranged between 53 to 253 uS/cm from Yokomo stream also they recorded EC from ground water samples 873 and 1216 uS/cm during 0the year 2005 of Brong Ahafo region, Ghana.

3.6 HYDROGEN ION CONCENTRATION (pH)

The average of pH noted from water sample is 7.37 in pre-monsoon and 7.65 in post-monsoon season.

More and Nandan [14], observed high pH 7.66-7.86 and 7.58-7.66 which favored the growth of algae during his study January 1994 to December 1995 from Panzara dam and river respectively.

3.7 FREE CARBON DIOXIDE (CO_2)

The mean values of free carbon dioxide found from water sample are 8.8 mg/L in one season and below detectable limit in another season.

Shaikh and Yeragi [15], observed free carbon dioxide ranged between 2.20-5.28, 1.32-5.28 and 1.54-3.08 mg/L in summer, monsoon and winter from Tansa River, Thane, and Maharashtra during December 1999-November 2001 respectively. This high free CO_2 may due to dissolution from atmosphere, decomposition of organic matter and respiration of aquatic plants.

3.8 SALINITY

The obtained salinity of water sample is 141 mg/L and 128.8 mg/L with an average 134.5 mg/L.

Tripathi et al. [16], found salinity values minimum 655-1370 mg/L and 350.4- 705 from Suvaw nala and Rapti river near Balrampur, Uttar Pradesh, India respectively.

3.9 TOTAL HARDNESS

The average total hardness obtained from water sample is 200 mg/L and 120 mg/L with the mean value of 160 mg/L.

Singh et al. [17], found hardness level as 243 mg/L, 180 mg/L and 149 mg/L during June 1999 from the wells, springs and the rivers respectively in Udhampur, Jammu and Kashmir. Also they found hardness 194 mg/L, 179 mg/L and 146 mg/L in October 1999 from same water sampling sites.

3.10 CALCIUM HARDNESS

The value of calcium hardness observed from water samples are 150 mg/L and 50 mg/L in pre and post-monsoon respectively. The mean calcium hardness was 100 mg/L.

Balakrishnan and Karuppusamy [18], obtained calcium hardness varied from 115.5, 294.0, 390.6 and 398.7 mg/L in S1, S2, S3 and S4 respectively from the selected sites of drinking water. The higher hardness due to Ca and Mg imparts unpleasant odour to water.

3.11 MAGNESIUM HARDNESS

The estimated magnesium hardness of water samples are 50 mg/L and 70 mg/L with an average is 60 mg/L.

Prajapati and Mathur [19], obtained magnesium hardness varied from 2-133 mg/L from rural ground water samples of Sheopurkalan, Madhya Pradesh. During 1998-99. Only two samples exceeded the standard limit i.e. 100 mg/L permitted by ISI standards.

3.12 PHENOLPHTHALEIN ALKALINITY (PA)

The phenolphthalein alkalinity for water sample is below detectable limit in pre-monsoon and 30 mg/L in post-monsoon season.

Gupta and Shukla [20], observed Phenolphthalein Alkalinity 0- 5mg/L in groundwater and canal water showed 0-15mg/L from Auriya district (UP) during January-December 2002.

3.13 TOTAL ALKALINITY (TA)

The observed total alkalinity of water samples are 300 mg/L and 430 mg/L in pre and post-monsoon season respectively. The mean total alkalinity 365 mg/L is above the permissible limit.

Sawant and Telave [21], found total alkalinity 118-264, 197-321,293-499 and 85-120mg/L from Mumewadi, Gijwane, Nool and Mahagaon during different seasons of the period 2006-2007 at Gadhinglaj Tehsil, Maharashtra.

3.14 CHLORIDES (CL)

The estimated chloride of water sample in pre-monsoon is 78.1 mg/L and in post-monsoon is 71 mg/L. The mean value of chloride is 74.5 mg/L.

Rajalakshami and Sreelatha [22], observed the chloride content, which was found within a range of 14.25 to 86.25 mg/L and 16.84 to 92.46 mg/L at station A and B during July 2004 to June 2005 respectively. High chloride content due to organic wastes of animal origin and of industrial effluents.

3.15 PHOSPHATE (PO_4)

The phosphate concentration investigated from water samples are 0.107 mg/L and 0.2 mg/L in pre-monsoon and post-monsoon respectively. Average phosphate content is 0.15 mg/L.

Singh [23], observed high concentration of PO_4 in Damodar river at some selected sites which indicates anthropogenic inputs because naturally PO_4 concentration should not exceed 0.05 mg/L. Its concentration restricted by low solubility of PO_4 bearing minerals in water. He found PO_4 in the range of 0.01 - 1.70 in surface water.

3.16 SULPHATE (SO_4)

The average sulphate concentration investigated from water sample is 92.1 mg/L. The sulphate content 144.34 mg/L observed in pre-monsoon and 40 mg/L in post-monsoon season.

Fadtare and Mane [24], studied water pollution of Mula, Mutha and Pavana River in Pune. They found concentration of sulphate ranged from 36 – 348 mg/L due to leaching of gypsum and minerals.

3.17 CALCIUM (CA)

The mean calcium content observed from water sample is 40.08 mg/L. The calcium concentration 60.12 mg/L in pre-monsoon and 20.04 in post-monsoon observed from spring.

Vijayakumara et al. [25], observed calcium ranged from 8.60 – 94.10 mg/L 75.25 – 124 mg/L in surface and sub-surface water of Bhadra River respectively.

3.18 MAGNESIUM (MG)

The average magnesium content noted from water sample is 14.62 mg/L. The 12.2 mg/L of magnesium found in pre-monsoon and 17.05 mg/L in post monsoon.

Jawale and Patil [26], analyzed Mangrul dam water, Jalgaon during November 2006-October 2007. In that they observed magnesium maximum 30.19 mg/L in December and minimum 6.33 mg/L in October. Also found at site I maximum 27.27 mg/L in December and lowest 7.3mg/l in June at site II.

3.19 SODIUM (NA)

The average sodium content obtained from water sample is 89.05 mg/L. The observed sodium content are130.6 mg/L and 47.5 mg/L in pre and post-monsoon respectively.

Tepe et al. [27], recorded maximum sodium level of 44 mg/L in January from both stations in the period of April 2003 to April 2004 from Yarseli Lake. The average sodium concentrations were 37 and 38 mg/L for Station 1 and Station 2, respectively.

3.20 POTASSIUM (K)

The average potassium content detected from water sample is 22.3 mg/L. The potassium measured from water samples are 40.8 mg/L and 3.9 mg/L.

The slight seasonal variations in the potassium of the ponds indicate that the conservative nature of Potassium. Abdo [28], found ranges of K^+ to be from 13.61 – 15.31, 13.28 – 16.11, 12.87 – 14.76 and 13.28 – 15.50 mg/L during winter, spring, summer and autumn in the year 2003 respectively from Abu Za'baal ponds.

3.21 FLUORIDE (F)

The mean fluoride level analyzed from water sample is 0.89 mg/L.

Rao et al. [29], obtained fluoride content ranged from 0.102-0.894, 0.254-0.83 and 0.115-1.61 mg/L from western, Eastern zone and BED village drinking water ponds of Kolleru lake region respectively.

3.22 IRON (FE)

The average iron obtained from water sample is 0.043 mg/L. The iron metal content 0.086 mg/L in pre-monsoon and below detectable limit in post-monsoon season.

Sheeja et al. [30], observed iron metal 0.71 to 1.88mg/L and manganese was nil in Thampraparani River (West) during its flow in Kanyakumari district on a single day on 6th August 2007.

3.23 CHROMIUM (CR)

The chromium analysed from water samples are 0.008 mg/L in pre-monsoon and below detectable limit in post monsoon.

Tiwary et al. [31], detected chromium concentration ranged between 0.002 mg/L to 0.013 mg/L in summer season of the year March 2000 to February 2001 .For their study they selected different sites from Ganga river at Bihar region.

3.24 MANGANESE (MN)

The manganese metal not detected in water samples.

Siddaramu et al. [32], detected manganese ranged from below detectable limit to 0.20 mg/L and below detectable limit to 0.150 mg/L in post and pre monsoon from Tungabhadra River, Karnataka during the year 2006 respectively.

3.25 STANDARD PLATE COUNT (SPC)

The mean standard plate count from water sample is 235098.8 SPC/ml. 7637.5 SPC/ml and 462560 SPC/ml.

Toroglu1 and Toroglu [33] observed large numbers of bacteria that ranged between $13x10^2$ to $20x10^3$ cfu /ml in all the waters of sampling stations of Golbasi Lake in Adiyaman, Turkey.

3.26 MOST PROBABLE NUMBER (MPN)

The MPN found from water samples are 25 MPN/100ml and 2 MPN/100ml.The water sample having MPN above the permissible limit 10 MPN/100mL which is not suitable for drinking purpose.

Alam et al. [34], found mean values (dry-24.6 MPN/100 ml, monsoon-22.5 MPN/100 ml) as shown in Table 1 are clearly unacceptable as far as drinking purposes are concerned from Surma River, China Samples were collected from September 2001 to July 2003.

The thermophiles survive at relatively high temperatures and are classified as obligate and facultative. Obligate thermophiles (or extreme thermophiles) require such high temperatures for growth, whereas facultative thermophiles (moderate thermophiles) can thrive at high temperatures but also at lower temperatures. This study was done by Sen et al., [35] on hot water spring of Orissa state, India. Similar results are also found on Unkeshwar study area by Pathak and Rekadwad [36]. Unkeshwar area falls under tropical deciduous forest. Vegetation in this area is mainly represented by

Tectona grandis [37]. The microbial diversity of these unique ecosystems was studied and this approach enabled identification of the thermophilic and sulfur bacteria.

4 TABLES AND FIGURES

4.1 TABLES

Table 1. Table of Water quality parameters of Unkeshwar spring

Sr. No.	Water Parameters	Methods	Unkeshwar Stream Pre Mansoon	Unkeshwar Stream Post Mansoon	Permissible limit by WHO (1993)	Mean ± S.D.
Physical parameters						
1	Temperature	Thermometer	42.0° C	40. 0° C	---	41±1.41
2	Total Solids	Evaporation method	6324	474	---	3399 ±4136.5
3	Total Dissolved Solids	Evaporation method	5180	300	500	2740±3450.6
4	Total Suspended Solids	Evaporation method	1144	174	---	659±685.8
5	Electrical conductivity	Conductometry	58 uS/cm	260 uS/cm	250 uS/cm	159±142.8
Chemical parameters						
6	pH	pH Meter	7.37	7.65	6.5-8.5	7.51±0.19
7	Carbon Dioxide	Titrometry	8.8	0.0		4.4±6.2
8	Total Hardness	EDTA method	200	120	150-500	160±56.5
9	Calcium Hardness	EDTA method	150	50	---	100±70.7
10	Magnesium Hardness	EDTA method	50	70	---	60±14.1
11	Phenolphthalein Alkalinity	Acid Titration	Nil	30	---	15±21.2
12	Total Alkalinity	Acid Titration	300	430	200	365±91.9
13	Salinity	Titrometry	141	128.18	---	134.59±9.06
Ionic parameters						
14	Chloride	Argentometric	78.1	71	250	74.55±5.02
15	Phosphate	Stannous chloride	0.107	0.2	---	0.1535±0.06
16	Sulphate	Turbidometry	144.34	40	500	92.17±73.7
17	Calcium	EDTA method	60.12	20.04	75	40.08±28.3
18	Magnesium	EDTA method	12.2	17.05	30	14.625±3.42
19	Sodium	Flame photometry	130.6	47.5	200	89.05±58.76
20	Potassium	Flame photometry	40.8	3.9	----	22.35±26.09
21	Fluoride	SPANDS method	0.89	0.175	0.6-1.5	0.5325±0.50
22	Iron	Thiocynate method	0.086	Nil	0.3	0.043±0.060
23	Chromium	Diphenylcarbazide method	0.008	Nil	0.05	0.004±0.0056
24	Manganese	Persulphate method	Nil	Nil	0.1	0
Biological parameters						
25	Standard plate count	Plate dilution method	7637.5 SPC/ml	462560	---	235098.8 ±321678.8
26	Most probable number	Tube dilution method	25MPN/100ml	2MPN/100ml	10	13.5±16.26

Except Electrical conductivity, P^H, SPC and MPN all the parameters are expressed as mg/Lit.

4.2 FIGURES

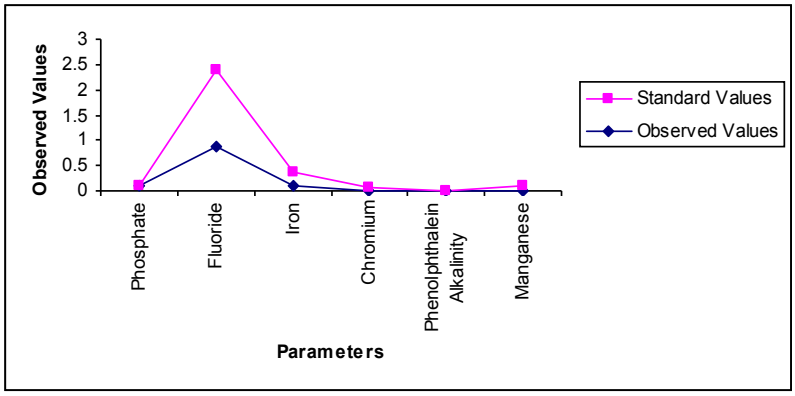

Fig. 3. Comparison of Phosphate, Fluoride, Iron, Chromium, P Alkalinity and Manganese with their standard values

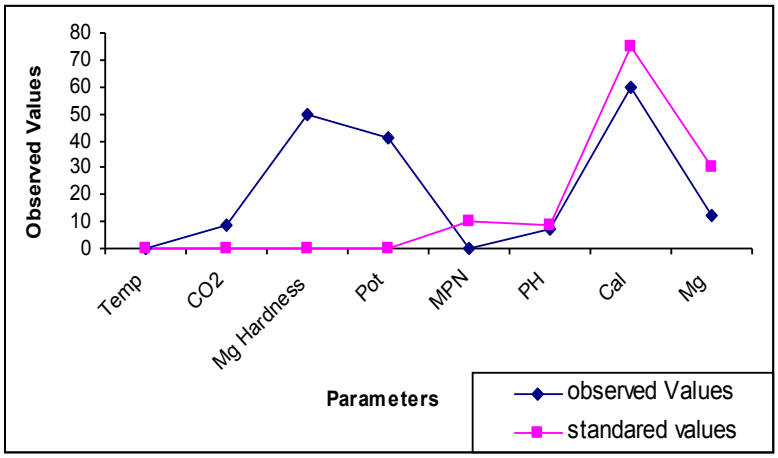

Fig. 4. Comparison of temp, CO2, Mg hardness, potassium, MPN, PH, Calcium and Magnesium with their standard values

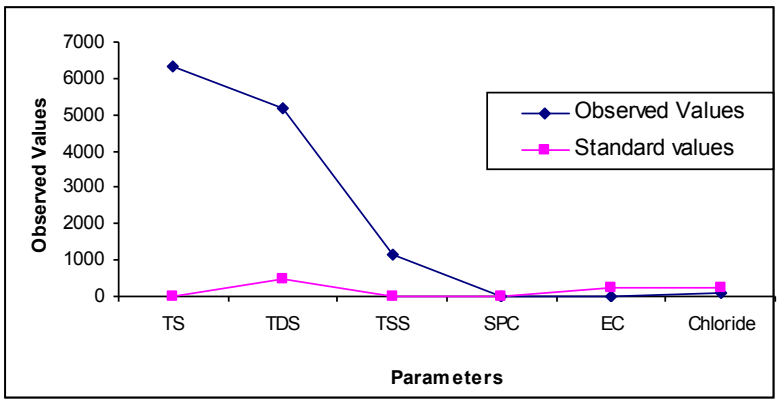

Fig. 5. Comparison of TS, TDS, TSS, standard plate count, electrical conductivity and chloride with their standard values

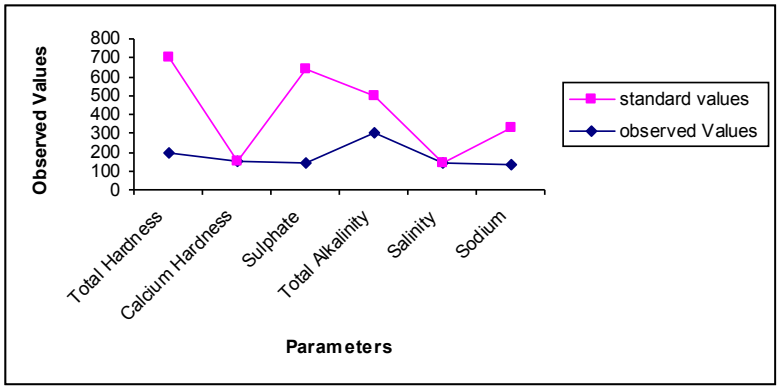

Fig. 6. Comparison of total hardness, Cal hardness, sulphate, total alkalinity, salinity and sodium with their standard values

5 CONCLUSION

On the basis of above discussion it is concluded that the water quality comparison of Unkeshwar spring in Nanded reveals that although the situation is not worst but it has to be maintained. Some of the water characteristics are below the permissible limit in the post-monsoon season and some are above the permissible limits in pre-monsoon season. This may be due to dilution of water by raining. Overall study showed that the water is more polluted in pre-monsoon as compared to post-monsoon. The archaeal and bacterial communities in three hot water samples were investigated within the context of geochemical signatures of their greater geothermal regions. In order to find common ground and to use knowledge to change perceptions and behavior, people and scientists need to work together.

6 RECOMMENDATIONS FOR IMPLEMENTATION

The following general recommendations are nevertheless made to guide decisions, based on the findings of this study.

1. Prevent pollution rather than treating symptoms of pollution.
2. Use the precautionary principle.
3. Apply realistic standards and regulations.
4. Apply water pollution control at the lowest appropriate level.

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