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Characteristics of hot water springs in a region of Rishikund Munger district of Bihar State, India

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Abstract

A thermal water spring is a place where hot ground water issues from the earth on a regular basis for at least a predictable part of year, and it is significantly above the ambient ground temperature, Rishikund Euthermal spring is a sulphur containing hot spring. The hot spring water samples from two selected sites of Rishikund were collected during October 2014 to June 2016 at an interval of four months and were analyzed for various Physico-Chemical parameters, viz., pH, Temperature, Electrical Conductivity (EC), Total Hardness, Total Alkalinity, Chloride, Sulphate, Calcium, Magnesium, Sodium, Potassium and Total Dissolved Solid (T.D.S). The estimated values were compared with the standard value of corresponding parameter as prescribed by WHO for drinking water and it was found that water of these sites are potable.

Keywords: Physico-chemical Parameters, Euthermal Springs.

Introduction

Generally hot water spring locate all over the world at special geological areas, mainly occurs near volcanic zone. Spring provide main source of fresh water for drinking and other purpose like agriculture, and washing clothes etc. Rishikund hot spring is a place of worship 9 Km southeast of Sitakund. It is situated near little valley between two ridges of Kharagpur hills. Many reservoirs have been built to collect water. The water appears to flow towards the west from many crevices of rocks. In some part gas issues could be found along with sand forming cavities in the form of minute craters.

Rishikund hot springs are mainly used as a source of bathing and drinking purposes to cure gastro-intestinal and general skin infections. So the Physico-Chemical Parameters of two hot spring sites of Rishikund were studied and analyzed during October 2014 to June 2016.

The thermal spring of Rishikund are considered as Euthermal Spring. Scientist has studied some Physico-chemical aspect of thermal spring of Bihar and West Bengal[1,2].

Study Area: Rishikund hot spring site lies in Munger district of Bihar state and its headquater is located on the southern bank of the river Ganga. It lies between 24^0 22"N to 25^0 30"N latitude and $85^0$30''E to $87^0$30"E longitude. From administrative and development point of view Munger is divided into three subdivision namely Munger, Khargpur and Tarapur. The Munger district lies on an average 30 to 60 meter above the sea level.

Materials and methods

Sample collection: Water Samples were collected from two selected sites of Rishikund hot spring of Munger district for investigation. These two selected sites are 1st Central kund and Karelia point. Water samples from these two sites were collected in pre-cleaned sterilized polythene bottles of two litre capacity without any air bubbles and brought into the laboratory and preserved as per sampling methods and preservation[3-5]. During period October 2014 to June 2016 within an interval of four months.

Physico-Chemical analysis: Physico-Chemical analysis were carried out for various water quality parameters such as Temperature, pH, Electrical Conductivity, Total Hardness, Chloride, Sulphate, Total Alkalinity, Total Dissolved Solid (TDS), Calcium, Magnesium, Sodium and Potassium. High purity analytical grade reagent; double distilled de-ionized water and Borosil glass were used. SAR (Sodium Adsorption Ratio) was estimated by using concentration of Sodium, Calcium and Magnesium for suitability of water for irrigation.

Results and discussion

Temperature: The temperature is basically important for its effect on the chemistry and biological reaction in the carbonate – bicarbonate equilibrium etc.

The water temperature observed from both 1st central kund and Karelia sites of Rishikund hot spring during period October 2014 to June 2016 varies from 38^0C to 43^0C and 39^0C to 44^0C respectively.

pH: It is a measurement of the intensity of acidity and alkalinity and it also measures the concentration of Hydrogen ion in waters. The permissible limit for pH ranges between 6.5-8.5 for potable drinking water as per WHO standard.

The observed pH concentration of both 1st Central kund and Karelia point sites of Rishikund hot spring during period October 2014 to June 2016 varies from 6.70 to 7.2 and 6.80 to 7.15 respectively, which are well within the permissible limit.

Table-1: Analytical methodology used for various parameters analysis.

Parameters	Analytical Method
Temperature	Mercury Thermometer
pH	Digital pH meters
Electrical Conductivity	Conductivity meters
Total Hardness	EDTA Titrimetric method
Total Alkalinity	Titrimetric method
Calcium	EDTA Titrimetric method
Magnesium	EDTA Titrimetric method
Chloride	Argentometric titration
Sulphate	UV- Visible Spectro-Photometer
Sodium	Flame photometer
Potassium	Flame photometer
Total Dissolved Solid	Evaporation method

Electrical conductivity: Electrical conductivity of water samples shows the presence of ionic mobility at the temperature of measurement. Higher value of conductivity shows higher concentration of dissolved ions.

The observed electrical conductivity of both 1st Central Kund and Karelia point sites of Rishikund hot spring during period October 2014 to June 2016 varies from 46 µs/cm to 80 µs/cm and 52µs/cm to 55 µs/cm respectively, which are within the permissible limit as per WHO standard [6] (250µs/cm).

Total Hardness as $CaCO_3$: Total Hardness is due to the concentration of alkaline earth metal. Calcium and Magnesium ions are the principal cation imparting hardness. Principal source of hardness in water are the sedimentary rocks. Chloride and Sulphate salt of Calcium and Magnesium causes permanent hardness of water while carbonate and bicarbonate salt of calcium & magnesium causes temporary effect of hardness.

The observed Total Hardness concentration of both 1st Central Kund and Karelia Point sites of Rishikund hot Spring during period October 2014 to June 2016 varies from 12 mg/l to 24 mg/l and 12 mg/l to 20 mg/l respectively, which are within permissible limit as per WHO standard (300 mg/l).

Total Alkalinity as $CaCO_3$: It is a measure of the capacity of waters to neutralize strong acid. Alkalinity is generally imparted by a salt of carbonate, bicarbonate, phosphate, nitrates, borates, silicates and together with hydroxyl ion concentration in free state.

The observed Total Alkalinity concentration of both 1st Central Kund and Karelia point sites of Rishikund hot spring during period October 2014 to June 2016 varies from 12 mg/l to 24 mg/l and 10 mg/l to 14 mg/l respectively. The observation shows that Total alkalinity is well within the permissible limit as per WHO standard (200 mg/l).

Calcium: Calcium is supposed to be one of the major contributors to the hardness of water. Prolonged use of drinking water containing excess amount of Calcium may lead to the formation of kidney and Gallbladder stones[7].

The observed Calcium ion concentration of both 1st Central Kund and Karelia point of Rishikund hot spring during period October 2014 June 2016 varies from 2.40 mg/l to 6.40 mg/l and 2.40 mg/l to 3.20 mg/l respectively, which are within the permissible limit as per WHO standard (75 mg/l).

Magnesium: High concentration of Magnesium in drinking water gives unpleasant taste to the water. It has been suggested that it is mainly the incidence of sudden death from ischemic heart disease[8]. The lower level of magnesium ion concentration in drinking water may lead to vasoconstriction or arrhythmias[9,10].

The observed magnesium ion concentration of both 1st Central Kund and of Karelia point sites of Rishikund hot spring during period October 2014 to June 2016 varies from 1.46 mg/l to 3.90 mg/l and 1.46 mg/l to 2.92 mg/l respectively, which is within permissible limit as per WHO standard (30 mg/l).

Chloride: Chloride is the major anion present in ground water. Generally higher concentration of chloride ion indicate the pollution level.

The observed chloride concentration of both 1st Central Kund and Karelia point sites of Rishikund hot spring during period October 2014 to June 2016 varies from 4 mg/l to 10 mg/l and 4 mg/l to 8 mg/l respectively, which are well within the permissible limit as per WHO standard (250 mg/l).

Sulphate: The Sulphate is an important chemotherapeutic agent which acts as antiseptic and natural drugs. Excess Sulphate

concentration in water can cause diarrhoea as well as many gastrointestinal problems.

The observed Sulphate ion concentration of both 1st Central Kund and Karelia point sites of Rishikund hot spring during period October 2014 to June 2016 varies from 1.12 mg/l to 1.80 mg/ l and 1.02 mg/l to 1.42 mg/l respectively, which are well within the permissible limit as per WHO standard (250 mg/l).

Sodium: Sodium is one of the important contains occurring in natural water. The excess concentration of sodium in drinking water concentration is physiologically harmless. However Sodium may affect the taste of drinking water at levels above 200 mg/l. The maximum Sodium level of 44 mg/l in the period of April 2003 to April 2004 from Yarseli Lake, Hatay, Turkey[11].

The observed Sodium ion concentration of both 1st central kund and Karelia point sites of Rishikund hot spring during period October 2014 to June 2016 varies from 1.32 mg/l to 2.12 mg/l and 0.49 mg/l to 1.35 mg/l respectively, which are well within the permissible limit as per WHO standard (200 mg/l).

Potassium: Although potassium is not hazardous in waters, but its high concentration lead to nervous as well as digestive disorder. Potassium is also a naturally occurring element however its concentration remains lower than Sodium, Calcium and Magnesium. The Potassium ion concentration of Abu Za' baal ponds Egypt in three different season in the year 2003, it varies from 13.6 mg/l to15.31 mg/l ,13.2 mg/l to 16.11 mg/l and 13.28 mg/l to 15.50 mg/ l respectively[12].

The observed Potassium ion concentration of both 1st Central Kund and Karelia point sites of Rishikund hot spring during period October 2014 to June 2016 varies from 0.71 mg/l to 1.52 mg/l and 0.49 mg/l to1.35 mg/l respectively, which is well within the permissible limit as per WHO standard (12 mg/l) for drinking water.

Total Dissolved Solid (T.D.S): Total Dissolved Solid (T.D.S) is a measure of the combined content of all inorganic and organic substances contained in a liquid as micro granular suspended form.

The observed dissolved solid concentration of both 1st Central Kund and Karelia point sites of Rishikund hot spring during period October. 2014 to June 2016 varies from 26 mg/l to 40 mg/l and 24 mg/l to 36 mg/l which are well within the permissible limit as per WHO standard (500 mg/l).

Table-2: Variation of Physico-Chemical Parameters of water samples at 1st Central Kund site of Rishikund hot spring.

Parameter	Temp.	pH	EC	TH (mg/l)	TA (mg/l)	Ca^{++} (mg/l)	Mg^{++} (mg/l)	Cl^{-} (mg/l)	SO_4^{--} (mg/l)	Na (mg/l)	K (mg/l)	TDS (mg/l)
Oct-14	43^0C	6.7	46µs/cm	12	8	2.40	1.46	4	1.38	1.42	0.96	26
Feb-15	40^0C	7.2	62µs/cm	24	16	6.40	1.94	10	1.12	2.12	1.48	40
June-15	39^0C	7.10	68µs/cm	24	16	3.20	3.90	8	1.20	1.85	1.52	38
Oct-15	42^0C	7.10	70µs/cm	16	10	3.20	1.95	4	1.62	1.32	1.02	32
Feb-16	38^0C	7.20	80µs/cm	18	10	3.20	2.44	8	1.80	2.12	1.21	34
June-16	41^0C	7.15	68µs/cm	20	10	3.20	2.88	8	1.38	1.70	0.71	34

Table-3: Variation of Physico-Chemical Parameters of water samples at Karelia point hot spring site of Rishikund hot spring.

Parameter	Temp.	pH	EC	TH (mg/l)	TA (mg/l)	Ca^{++} (mg/l)	Mg^{++} (mg/l)	Cl^{-} (mg/l)	SO_4^{--} (mg/l)	Na (mg/l)	K (mg/l)	TDS (mg/l)
Oct-14	44^0C	6.80	52µs/cm	12	6	2.40	1.46	4	1.42	0.94	0.49	24
Feb-15	42^0C	7.00	54.8µs/cm	20	10	3.20	2.92	8	1.02	1.52	1.35	36
June-15	40^0C	7.15	48 µs/cm	16	10	3.20	1.95	6	1.20	1.92	1.08	30
Oct-15	41^0C	6.90	48 µs/cm	12	8	2.40	1.40	4	1.32	1.36	1.13	25
Feb-16	39^0C	7.00	50 µs/cm	16	8	2.40	2.44	4	1.42	1.02	0.68	28
June-16	42^0C	7.10	55 µs/cm	16	8	3.20	1.95	4	1.41	1.04	0.87	28

Table-4: Anova: Single Factor. Multiple correlation coefficients of different parameters at 1st Central kund site Rishikund.

Summary				
Groups	Count	Sum	Average	Variance
Temp. ^{0}C	6	243	40.5	3.5
pH	6	42.45	7.075	0.0358
EC (micro simen per cm)	6	394	65.67	127.07
TH (mg/l)	6	114	19	22
TA (mg/l)	6	70	11.67	11.867
Ca^{++} (mg/l)	6	21.6	3.6	1.984
Mg^{++} (mg/l)	6	14.57	2.428	0.755
Cl^- (mg/l)	6	42	7	6
$SO4^{--}$ (mg/l)	6	8.5	1.417	0.0652
Na (mg/l)	6	10.53	1.755	0.116
K (mg/l)	6	6.9	1.15	0.0992
TDS (mg/l)	6	204	34	24

Table-5: ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	27315.86	11	2483	150.89	2E-39	1.9522
Within Groups	987.4422	60	16.46			
Total	28303.3	71				

Table-6: Correlation Coefficients (Concentration in mg/l).

	Temp.	pH	EC	TH (mg/l)	TA (mg/l)	Ca++ (mg/l)	Mg++ (mg/l)	Cl- (mg/l)	SO4-- (mg/l)	Na (mg/l)	K (mg/l)	TDS (mg/l)
Temp. ^{0}C	1											
pH	-0.7209	1										
EC (micro simen per cm)	-0.7492	0.8492	1									
TH (mg/l)	-0.6610	0.7329	0.4010	1								
TA (mg/l)	-0.5276	0.5067	0.1614	0.9160	1							
Ca^{++} (mg/l)	-0.2732	0.5257	0.0504	0.6539	0.6925	1						
Mg^{++} (mg/l)	-0.6035	0.4410	0.4782	0.6659	0.5236	-0.1288	1					
Cl^- (mg/l)	-0.7419	0.7125	0.3911	0.8704	0.7111	0.6956	0.4520	1				
$SO4^{--}$ (mg/l)	-0.1214	0.0891	0.5277	-0.5578	-0.6837	-0.5116	-0.2234	-0.4029	1			
Na (mg/l)	-0.8648	0.6344	0.4527	0.6924	0.5847	0.5987	0.3200	0.9134	-0.1451	1		
K (mg/l)	-0.5974	0.3123	0.1498	0.6390	0.8443	0.5446	0.3153	0.5029	-0.3940	0.6002	1	
TDS (mg/l)	-0.6983	0.8205	0.4925	0.9748	0.9007	0.7420	0.5478	0.8667	-0.4413	0.7336	0.6792	1

Table-7: Anova: Single Factor. Multiple correlation coefficients of different parameters at karelia point site Rishikund.

Summary				
Groups	Count	Sum	Average	Variance
Temp. ^{0}C	6	248	41.33333	3.066667
pH	6	41.95	6.991667	0.016417
EC (micro simen per cm)	6	307.8	51.3	9.98
TH (mg/l)	6	92	15.33333	9.066667
TA (mg/l)	6	50	8.333333	2.266667
Ca^{++} (mg/l)	6	16.8	2.8	0.192
Mg^{++} (mg/l)	6	12.12	2.02	0.33884
Cl^- (mg/l)	6	30	5	2.8
Sulphate (mg/l)	6	7.79	1.298333	0.025937
Na (mg/l)	6	7.8	1.3	0.1424
K (mg/l)	6	5.6	0.933333	0.099707
TDS (mg/l)	6	171	28.5	18.3

Table-8: ANOVA.

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	19645.78	11	1785.98	462.9361	1.15E-53	1.952212
Within Groups	231.4765	60	3.857942			
Total	19877.26	71				

Table-9: Correlation Coefficients (Concentration in mg/l).

	Temp.	pH	EC	TH (mg/l)	TA (mg/l)	Ca++ (mg/l)	Mg++ (mg/l)	Cl- (mg/l)	Sulphate (mg/l)	Na (mg/l)	K (mg/l)	TDS (mg/l)
Temp. ^{0}C	1											
pH	-0.5645	1										
EC (micro simen per cm)	0.5495	0.0321	1									
TH (mg/l)	-0.2529	0.6048	0.5130	1								
TA (mg/l)	-0.5057	0.7430	-0.0421	0.7647	1							
Ca^{++} (mg/l)	0.0000	0.7837	0.4508	0.7276	1	1						
Mg^{++} (mg/l)	-0.3178	0.4197	0.4601	0.9494	0.6344	0.4767	1					
Cl^- (mg/l)	0.0000	0.3265	0.2800	0.7939	0.7939	0.6547	0.7104	1				
Sulphate (mg/l)	0.0378	-0.2916	-0.1498	-0.6956	-0.8221	-0.6008	-0.6014	-0.9722	1			
Na (mg/l)	-0.3571	0.5502	-0.3899	0.3661	0.8449	0.5612	0.1999	0.6715	-0.7497	1		
K (mg/l)	-0.2230	0.4185	0.0221	0.5581	0.8470	0.5782	0.4234	0.7419	-0.8572	0.7409	1	
TDS (mg/l)	-0.1869	0.5200	0.4218	0.9627	0.8384	0.7255	0.8963	0.9220	-0.8636	0.5278	0.7122	1

Significance of Correlation Coefficients: The Correlation coefficient between 1st Central Kund and West Point Karelia of Rishikund hot spring of district Munger Bihar = 0.9721 this means there is a resemblance in water of two selected hot springs sites of Rishikund.

Sodium Adsorption Ratio (SAR): It is an irrigation water quality parameter used in the management of Sodium affected soils. It is an indicator of the suitability of water for use in agriculture irrigation as determined from the concentration of the main alkaline cations present in the water. It is related with the ionic concentration of Sodium, Calcium and Magnesium as per the following formula.

$$SAR = \frac{Na}{\sqrt{\frac{Ca+Mg}{2}}}$$

SAR value can be used to predict the degree to which irrigation water tend to enter into cation exchange section in soil. The higher value of SAR means water is less suitable for irrigations. In case of Rishikund hot water springs first Central Kund and Karelia point are the selected sites for analysis.

Table-10: SAR values of both 1st Central kund and Karelia point sampling sites at Rishikund Munger.

	Oct – 14	Feb-15	June-15	Oct-15	Feb-16	June-16
SAR value of 1st Central Kund Rishikund	1.02	1.03	0.98	0.82	1.26	1.03
SAR value of Karelia Point Rishikund	0.48	0.87	1.20	0.99	0.65	0.65

Table-11: Classification of ground water based on SAR value given by Todd 1980.

SAR Values	Classification	Suitability for irrigation
<10	Excellent	Suitable for all soils
10-18	Good	May be used on coarse textured or organic permeable soils.
18-26	Fair	May be used provided Gypsum is added.
>26	Poor	Generally not suitable

Conclusion

On the basis of the estimation of all the physico-chemical parameters of both sites of Rishikund hot spring sites suggest that the concentrations of all parameters lies below permissible limit but variation in all the season arises due to dilution of water by raining. For maintaining the aesthetic and hygienic values of hot spring water we can suggest proper monitoring and management of Rishikund hot water spring sites on regular basis. This can also be concluded from the SAR values that hot water spring of both 1st central kund as well as Karelia sites are excellent for irrigation to the agriculture land at suitable temperature.

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