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The study of physico-chemical parameters and bacteriological examination of Rishikund hot water spring, (Dist-Munger), Bihar, India

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Abstract
Spring water is the main source of water providing life to the people in the mountain region especially in the Himalaya. Springs are a natural source of ground water. Springs are generally community-owned and community-managed. The hot water spring samples were taken from the main water source where maximum peoples were using them for drinking purpose. The present study was carried out on the Physico-Chemical as well as Bacteriological analysis of two selected hot water spring sites at Rishikund region of Munger district of Bihar namely– 1st central kund site and Karelia point site. The samples were collected on quarterly basis from October 2014 to June 2016. The various parameters like T.S, T.S.S, Fe, Silica, Fluoride, Nitrate, Dissolved Oxygen, Chemical Oxygen Demand, Calcium, Magnesium, Sulphide, Colour, and Turbidity, Carbonate Alkalinity, Bicarbonate Alkalinity, SPC and MPN count of these water samples were analyzed. The results indicate that these sources of water are suitable for drinking and other house hold consumption for the people of the region.

Keywords: Spring, Physico-Chemical, T.S, T.S.S, SPC, MPN

1. Introduction
Springs are the places where ground water is discharged at specific location on earth and they vary dramatically as to the type of water they discharge. Most of the springs are as a result of long cracks or joint in sedimentary rock (APHA, 2005) [3]. Hot springs are defined as spring where the temperature of water lies significantly above the mean of annual air temperature (Anupma and Begawan, 2011) [2]. Hot ground water can be used to drive turbines and generate electricity. Energy expected from the earth's heat is called geothermal energy (Balakrishnan V. and Karuppusamy, 2005) [4]. 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 (Brenda and Lerner, 2009) [5].

2. Description of study area
Geographical location of Rishikund is 24^0 22'N to 25^0 30'N latitude and 85^0 30'E to 87^0 30' E longitude. It is situated at around 6-7 km south from river Ganga. It is located 9 km south east of Sitakund hot spring sites of district Munger, Bihar. Nearest railway station is Ratanpur. These springs are said to possess medicinal value and can cure skin diseases.
Rishikund hot spring in Munger subdivision situated about six miles south of Sitakund at the head of picturesque little valley between two ridges of the Kharagpur hills. A reservoir has been made to collect hot spring water where people take bath on regular basis. Many temples are there in Rishikund for worship. The people who are living nearby areas of Rishikund collect water from kund and transport to the different region of Munger district for earning money. Due to the presence of sulphur in water it removes many types of skin related problems and also cures gastro-intestinal problems.
So, the Physico-Chemical as well as Bacteriological parameters of two selected hot water spring sites of Rishikund were studied and analyzed during October 2014 to June 2016.

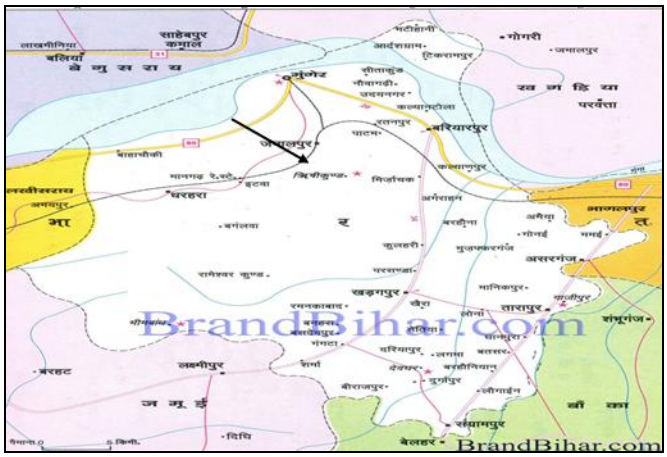

Fig 1: Location of study area of Rishikund hot water spring sites at Munger district, Bihar

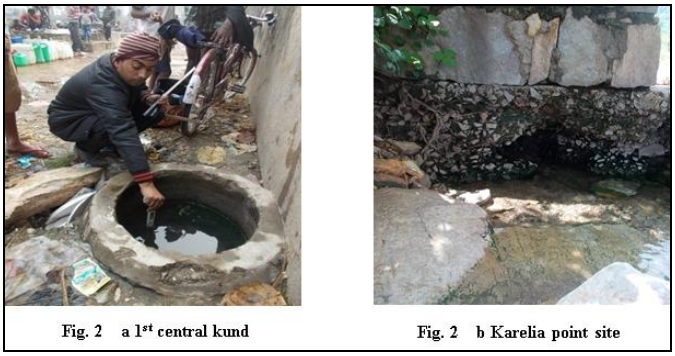

Fig. 2 a 1st central kund

Fig. 2 b Karelia point site

Fig 2: Photographs of selected sampling sites

3. Sampling and Estimation method

For the present investigation the water samples were collected from the Rishikund hot water spring sites in pre- cleaned polyethylene bottles. The water quality parameters were estimated by standard methods given by (APHA 2005) [3]. First central kund and Karelia point are two selected hot water spring sites of Rishikund for investigation.

Total Suspended Solid (T.S.S), T.S (Total Solid) of water samples were determined by evaporation method. Iron, Silica, Fluoride & Nitrate were estimated by using ultraviolet - Visible spectrophotometer.Dissolved Oxygen, Chemical Oxygen Demand and Sulphide were estimated by using acid titration. Calcium and Magnesium hardness were estimated by using EDTA titration method. Carbonate and Bicarbonate alkalinity were estimated by using Acid titration method. Colour was estimated by Visual method while Turbidity was estimated by Digital Nephelometer.SPC as well as MPN counts were estimated by Plate dilution methods and Tube dilution method respectively.

4. Results and Discussion

4.1 Total Solid (T.S.)

Total solid is a sum of Total Dissolved Solid (TDS) and Total Suspended Solid (TSS) in water. It is generally measured in mg/l. It also affect water clarity. A high concentration of Total Solid makes drinking water unpalatable and might have adverse effect on people health.

The observed Total Solid concentration of both 1st central kund and Karelia point sites of Rishikund hot water spring during period October 2014 to June 2016 varies from 40 mg/l to 64 mg/l and 38 mg/l to 48 mg/l respectively.

4.2 Total Suspended Solid (T.S.S)

Total Suspended Solid is a measure of the quality of the water. The residue left after the evaporation of un-filtered sample is regarded as Total Suspended Solid. The residue present in water might be health hazard if present in higher concentration.

The observed T.S.S concentration of both 1st central kund and Karelia point sites of Rishikund hot water spring during period October 2014 to June 2016 varies from 12 mg/l to 24 mg/l and 10 mg/l to14 mg/l respectively. The observed T.S.S ranged from 8 mg/l to 84 mg/l and 6 mg/l to 38 mg/l respectively from the water sample of two different sight of Gulbarga, Karnataka in the year 2011 (Gautam SK. *et, al.* 2011) [8].

4.3 Iron

Iron is the metal that occurs naturally in soil. Iron dissolved in ground water is in the reduced oxidation state of iron (II). The concentration of iron varies from 0.71 mg/l to 1.88 mg/l in Thampraparani river during its flow in Kanyakumari district Tamil Nadu in a year 2007 (Sheeja, B.D., *et al*., 2008) [13].

The observed iron concentration of both 1st central kund and Karelia point sites of Rishikund hot water spring during period October 2014 to June 2016 varies from 0.54 mg/l to 0.90 mg/l and 0.52 mg/l to 0.72 mg/l respectively.

4.4 Silica

Silica is compound of silicon and oxygen (SiO_2). It is hard, glassy mineral substances that occur in a variety of forms such as Sand, Quartz, and Sandstone. It is slightly soluble in water. High silica content in ground water implies more intense water-rock interaction.

The observed silica concentration of 1st central kund and Karelia point sites of Rishikund hot water spring during period October 2014 to June 2016 varies from 2.04 mg/l to 3.80 mg/l and 2.02 mg/l to 3.86 mg/l respectively, which are within desirable limits as per (WHO, 2011- 50 mg/l) [16].

4.5 Fluoride

Higher concentration of fluoride above 1.5 mg/l carry an increased risk of dental fluorosis even higher concentration could lead to skeletal fluorosis (Vyas and Sawant 2008) [15]. The obtained fluoride content range 0.102 mg/l to 0.894 mg/l, 0.254 mg/l to 0.83 mg/l and 0.115 mg/l to 1.61 mg/l from Western, Eastern zone and BED village drinking water ponds of Kolleru lake region respectively (Rao A. *et. al*., 2001) [12].

The observed fluoride concentration of both 1st central kund and Karelia point sites of Rishikund hot water spring during period October 2014 to June 2016 varies from 1.10 mg/l to 1.94 mg/l and 1.02 mg/l to 1.68 mg/l respectively, which is approximately within permissible range (1.5 mg/l) as per WHO standard.

4.6 Nitrate

Nitrates are regarded as the highly oxidized form of nitrogen compounds. It is commonly the end product of aerobic decomposition of organic nitrogenous matter (Gichuki J.G. and Gichumbi, 2012) [9]. It is a dangerous indicator of pollution in children who drink water containing nitrate can develop symptom like shortness of breath and Blue baby diseases.

The observed nitrate ion concentration of both 1st central kund and Karelia point sites of Rishikund hot water spring during period October 2014 to June 2016 varies from 1.72 mg/l to 4.30 mg/l and 1.46 mg/l to 2.86 mg/l respectively, which lies within permissible limit as per WHO standard (45 mg/l).

4.7 Dissolved Oxygen

Dissolved Oxygen analysis measure the amount of gaseous oxygen dissolved in aqueous solution. Oxygen gets into the water by diffusion from the surrounding air by aeration. Adequate Dissolved Oxygen is necessary for good water quality.

The observed Dissolved Oxygen concentration of both 1st central kund and Karelia point sites of Rishikund hot water

spring during period October 2014 to June 2016 varies from 5.55 mg/l to 7.77 mg/l and 5.55 mg/l to 7.77 mg/l respectively, which are nearly within desirable limit as per WHO standard (7 mg/l).

4.8 Chemical Oxygen Demand (COD)

COD analysis is commonly used to measure the amount of organic compound in water. This is a standard method for indirect measurement of the amount of pollution in a sample of water. Higher the chemical oxygen demand higher the demand of pollution in test sample.

The observed COD concentration of both 1st central kund and Karelia point sites of Rishikund hot water spring during period October 2014 to June 2016 varies from 8 mg/l to 12 mg/l and 8 mg/l to 14 mg/l respectively, which lies within desirable limit as per WHO Standard (250 mg/l).

4.9 Calcium Hardness

The higher value of Calcium Hardness imparts unpleasant odor to the water. Calcium hardness is a measure of the Calcium ion concentration in water expressed as Calcium Carbonate ($CaCO_3$).

The observed Calcium Hardness concentration of both 1st central kund and Karelia point sites of Rishikund hot water spring during period October 2014 to June 2016 varies from 6 mg/l to 16 mg/l and 6 mg/l to 8 mg/l respectively.

4.10 Magnesium Hardness

The observed Magnesium hardness concentration of both 1st central kund and Karelia point sites of Rishikund hot water spring during period October 2014 to June 2016 varies from 6 mg/l to 16 mg/l and 6 mg/l to 12 mg/l respectively.

Prajapati and Mathur (2005) [11] obtained magnesium hardness varied from 2 mg/l to 133 mg/l from rural ground water samples of Sheopurkalan, Madhya Pradesh during year 1998-99.

4.11 Sulphide

The observed sulphide ion concentration of both 1st central kund and Karelia point sites of Rishikund hot water spring during period October 2014 to June 2016 varies from 1.56 mg/l to 1.98 mg/l and 1.26 mg/l to 2.16 mg/l respectively, which are within permissible limit as per WHO standard (10 mg/l).

4.12 Carbonate Alkalinity as $CaCO_3$

Carbonate alkalinity can determine water hardness. It is measure of the alkalinity of water caused by the presence of Carbonate and Bicarbonate anion. It is either expressed in ppm or mg/l. Carbonate alkalinity as $CaCO_3$, is not detected in both hot water spring sites i.e. 1st central kund and Karelia point during selective period. Hence carbonate alkalinity is nil for both hot water spring sites of Rishikund. (Gupta and Shukla 2002) [10] observed Phenolphthalein alkalinity of drinking water from different sources in industrial area of Auriya district (U.P.), was measured, which varied from 0 mg/l to 5 mg/l during January – December 2002.

4.13 Bicarbonate Alkalinity as $CaCO_3$

This alkalinity due to the presence of bicarbonate ions in water. The bicarbonate ions are the main alkaline factor in almost all water. Bicarbonate alkalinity is due to the presence of CO_2 dissolving carbonate containing minerals in water.

The observed Bicarbonate alkalinity as $CaCO_3$ in both selected hot water spring sites of Rishikund i.e. 1st central kund and Karelia point sites varies from 8 mg/l to 16 mg/l and 6 mg/l to 10 mg/l respectively. All concentration lies within desirable limit as per WHO standard.

4.14 Colour

Colour is a common constituent of many natural waters and it is caused by metallic substances such as Iron and Manganese compounds, Humus material, Peat, tannins, algae and protozoa.

The colour of both selected hot water spring sites of Rishikund namely 1st central kund and Karelia point varied from 2 Hz to 3 Hz and 1 Hz to 3 Hz respectively. All concentration lies within desirable limit as per WHO (2011), BIS (1991) - 5 Hz.

4.15 Turbidity

It is caused by the particles suspended or dissolved water that scatters light making the waters appear cloudy or murky. It is measured by using Nephelometer and its unit is NTU (Nephelometric Turbidity Unit). High turbidity in water causes gastro-intestinal related disease in human (AG Mann *et al* 2007) [1].

The turbidity of 1st central kund and Karelia point hot water spring sites of Rishikund varies from 0.10 NTU to 0.25 NTU and 0.05 NTU to 0.15 NTU respectively. All concentration lies within desirable limit as per (WHO - 5 NTU 2011) [16], (USEPA - 5 NTU 2005) [14].

4.16 SPC (Standard Plate Count)

SPC of two selected hot water spring sites of Rishikund i.e. 1st central kund and Karelia point during period October 2014 to June 2016 varies from 30 cfu /ml to 50 cfu /ml and 0 cfu /ml to 20 cfu/ml respectively.

The value of SPC of both sampling hot water spring sites lies within permissible range according to (De zuane -500 cfu /ml, 1990) [6] and (EPA -100 cfu /ml, 1986) [7].

4.17 MPN (Most Probable Number)

MPN count of selected hot water spring sampling sites of Rishikund i.e. 1st central kund and Karelia point site both varies from ≤ 2 MPN /100 ml to 2 MPN/100 ml. All concentration lies within permissible limit as per WHO recommendation, 2011 (10 MPN/100 ml).

Note 1: CFU –Colony Forming Unit 2. EPA - Environmental Protection Agency. 3.Hz- Hazen

5. Table showing variation of different Physico-Chemical as well as Bacteriological data at selected hot water spring sites of Rishikund.

Table 1: Variation of Physico-Chemical parameters of samples at 1st central kund hot water spring site Rishikund.

Parameter	T.S	TSS	Fe	SiO_2	Fluoride	Nitrate	DO	COD	Ca-H	Mg-H	Sulphide
Oct – 14	40	14	0.62	2.14	1.46	1.85	6.66	12	6	6	1.56
Feb – 15	64	24	0.60	3.80	1.94	3.06	7.77	10	16	8	1.92
June – 15	60	22	0.75	2.84	1.12	1.72	6.66	8	8	16	1.98
Oct – 15	50	18	0.90	3.80	1.10	4.30	5.55	12	8	8	1.82
Feb – 16	52	18	0.85	2.12	1.26	2.45	6.66	10	8	10	1.62
June – 16	46	12	0.54	2.40	1.34	2.20	6.66	12	8	12	1.58

Table 2: Variation of Physico-Chemical parameters of samples at 1st central kund hot water spring site, Rishikund

Parameter	Colour	Turbidity	Carbonate Alkalinity as $CaCO_3$	Bicarbonate Alkalinity $CaCO_3$
Oct – 14	2 Hz	0.15 NTU	ND	8 mg/l
Feb – 15	2 Hz	0.10 NTU	ND	16 mg/l
June – 15	2 Hz	0.25 NTU	ND	16 mg/l
Oct – 15	3 Hz	0.15 NTU	ND	10 mg/l
Feb – 16	2 Hz	0.10 NTU	ND	10 mg/l
June – 16	3 Hz	0.20 NTU	ND	10 mg/l

Note: All concentration of parameter expressed in mg/l.

Table 3: Bacteriological data of samples at 1st central kund hot water spring site Rishikund.

Parameter	SPC count	Bacteria observed, under SPC	MPN Count	Bacteria observed, under MPN Count
Oct – 14	Nil	No growth	≤ 2 MPN/100 ml,	No growth
Feb – 15	30 cfu/ml	Pseudomonas aeruginosa	2 MPN/100 ml,	Enterobacter aerogenes
June – 15	40 cfu/ml	Pseudomonas aeruginosa	2 MPN/100 ml,	Klebsiella pneumoniae
Oct – 15	Nil	No growth	≤ 2 MPN/100 ml,	No growth
Feb – 16	50 cfu/ml	Staphylococcus aureus	2 MPN/100 ml,	E.Coli
June – 16	Nil	No growth	≤ 2 MPN/100 ml	No growth

Table 4: Variation of Physico-Chemical parameters of samples at Karelia point hot water spring site, Rishikund.

Parameter	T.S	TSS	Fe	SiO_2	Fluoride	Nitrate	DO	COD	Ca-H	Mg-H	Sulphide
Oct – 14	38	14	0.58	2.02	1.32	1.84	6.66	12	6	6	1.50
Feb – 15	48	12	0.40	3.86	1.68	2.86	5.55	8	8	12	2.16
June – 15	42	12	0.65	2.82	1.02	1.46	6.66	8	8	8	1.65
Oct – 15	38	13	0.64	2.42	1.10	1.82	5.55	12	6	6	1.26
Feb – 16	38	10	0.72	2.60	1.34	2.82	6.66	14	6	10	1.66
June – 16	39	11	0.52	2.26	1.27	2.06	7.77	10	8	8	1.80

Note: All concentration of parameter expressed in mg/l.

Table 5: Variation of Physico-Chemical parameters of samples at Karelia point hot water spring site, Rishikund.

Parameter	Colour	Turbidity	Carbonate Alkalinity as $CaCO_3$	Bicarbonate Alkalinity as $CaCO_3$
Oct – 14	2 Hz	0.10 NTU	ND	6 mg/l
Feb – 15	2 Hz	0.05 NTU	ND	10 mg/l
June – 15	3 Hz	0.15 NTU	ND	10 mg/l
Oct – 15	2 Hz	0.05 NTU	ND	8 mg/l
Feb – 16	1 Hz	0.10 NTU	ND	8 mg/l
June – 16	1 Hz	0.10 NTU	ND	8 mg/l

Table 6: Bacteriological data of samples at Karelia point hot water spring site, Rishikund.

Parameter	SPC count	Bacteria observed, under SPC	MPN Count	Bacteria observed, under MPN count
Oct – 14	Nil	No growth	≤ 2 MPN/100 ml,	No growth
Feb – 15	Nil	No growth	≤ 2 MPN/100 ml,	No growth
June – 15	Nil	No growth	≤ 2 MPN/100 ml,	No growth.
Oct – 15	Nil	No growth	≤ 2 MPN/100 ml,	No growth
Feb – 16	20 cfu/ml	Staphylococcus aureus	2 MPN/100 ml,	Enterobacter aerogenes
June – 16	Nil	No growth	≤ 2 MPN/100 ml	No growth

Note: ND – Not Detected.

6. Multiple correlation cofficient between various parameters of both selected hot water spring sites of Rishikund.

Table 7

	T.S	*TSS*	*Fe*	*SiO_2*	*Fluoride*	*Nitrate*	*DO*	*COD*	*Ca-H*	*Mg-H*	*Sulphide*
T.S	1										
TSS	0.897423	1									
Fe	0.245934	0.427686	1								
SiO_2	0.581897	0.397366	-0.01864	1							
Fluoride	0.392436	0.268346	-0.50007	0.408685	1						
Nitrate	0.342497	0.27124	0.347827	0.691145	0.281838	1					
DO	0.202795	0.211878	-0.16692	-0.24877	0.339596	-0.2562	1				
COD	-0.48838	-0.30825	0.216793	-0.34313	-0.0478	0.248651	-0.09206	1			
Ca-H	0.774039	0.675338	-0.07676	0.587746	0.648816	0.333339	0.504219	-0.34233	1		
Mg-H	0.532007	0.24202	0.033312	0.238212	-0.01468	0.012985	-0.03765	-0.44982	0.089592	1	
Sulphide	0.617393	0.353226	-0.17092	0.717525	0.438977	0.408987	0.106649	-0.60732	0.475205	0.60001	1

7. Significance

The concentration of TSS, Flouride, Calcium hardness are positively correlated with each other. Flouride, Fe, COD, Magnesium hardness are negatively correlated to each other. COD shows negative correlation with most of the parameters like TS, TSS, SiO_2, Flouride, Dissolved oxygen. Ca-H shows a significantly positive correlation with TS, TSS, SiO_2, Flouride. There is a good correlation between the samples of first central kund site with Karelia point site.

8. Summary and Conclusion

From the results of Physico-Chemical as well as Bacteriological analysis and assessment of this study it is concluded that all the parameters lies within potability range of WHO standard. The variation occurs due to the dilution by rain water. So hot spring water is considered to be aesthetically acceptable for domestic use and the water of these springs are also fit for drinking purposes.

9. Acknowledgement

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