

# Physico-Chemical and Biological Studies of Sitakund Euthermal Springs Sites, Munger District of Bihar

Bikal Kumar Gupta and Prasoon Prakash\*

Marwari College, Tilka Manjhi Bhagalpur University, Bhagalpur, Bihar, India

\*Corresponding author: pprakash133@gmail.com

**Abstract:** A natural discharge of ground water with elevated temperature with respect to the surrounding are called as hot springs. Most of the hot springs is rich in several kinds of chemicals and minerals. The Sitakund hot springs sites are most famous hot spring and it cures many bone related diseases like Arthritis, Osteoporosis and various skin related diseases. The water samples from three selected hot spring sites were collected in pre-cleaned and sterile reagent bottles during October 2014 to June 2016 tri-annually. The collected samples were stored in refrigerator and preserved as per preservation method till the completion of their analysis and compared with W.H.O., C.P.C.B., B.I.S., drinking water quality standards.

**Keywords:** B.I.S., C.P.C.B., Hot Springs, Physico-chemical.

## I. INTRODUCTION

Hot spring of Sitakund are natural and distributed in the range of around 2 km<sup>2</sup>. The main hot spring is centrally located in Sitakund, a holy and religious place of Hindus. This is selected as first sampling station site. The second sampling station of our study is hand pump situated 50 meter west of central Sitakund and third hot spring site of our study is around 200 meter south to central Sitakund named as Bardah village hot spring, which is generally used by villagers of nearby areas. Earlier it was also called Philips Sitakund (stated by old people).

The water of hot spring sites of Sitakund were used by the people suffering from various skin, several bone related problems and bowel associated diseases. The present investigation involves the Physico- chemical and Bacteriological analysis of water samples from these hot spring sites of Sitakund namely Sitakund central site, Hand pump site and Bardah village hot spring site.

*Photograph of Selected Sampling Sites*



Hand Pump Site, Sitakund



Sitakund Central Site, Sitakund



Bardah Village Hot Spring Site, Sitakund

## II. MATERIAL AND METHODS

Three sites have been selected for sampling of hot spring water from the study area of Sitakund. First sampling station site is central Sitakund ( $S_1$ ), second sampling station site is Hand pump site ( $S_2$ ) and the third sampling station site known as Bardah village hot spring site ( $S_3$ ) also known as Philip kund. Hot water samples were collected from these sites tri-annually for two years starting from October 2014. The samples were brought to the laboratory and were stored in Refrigerator and preserved as per preservation method. The estimation of water samples for different physico-chemical and Bacteriological parameters have been done as per APHA 2005 and Trivedy and Goel 1986.

## III. RESULTS AND DISCUSSION

1. *Temperature* - The mean Temperature of selected hot spring sites of central Sitakund during the study period from October 2014 to June 2016 are 42.10 °C, 43.16 °C and 41.83 °C respectively.
2. *pH* - The mean value of pH of selected hot spring sites of Sitakund during study period are 7.8, 7.62 and 7.97 respectively, which is within permissible limit as per WHO, 2011 and BIS 2012 standard of drinking water (6.5-8.5).
3. *Electrical Conductivity* - The mean electrical conductivity of water samples at central Sitakund, Hand pump site and Bardah hot water spring reservoir site during study period October 2014 to June 2016 are 341.6  $\mu\text{S}/\text{cm}$ , 328.33  $\mu\text{S}/\text{cm}$ , and 360  $\mu\text{S}/\text{cm}$  respectively.  
B. K. Gupta, *et al.*, observed electrical conductivity of all three sites of Rajgir namely Vishwamitra kund, Brahm kund and Makhdum kund during period October 2014 to June 2016 (within an interval of four month) varies from 60.6  $\mu\text{S}/\text{cm}$  to 97.75  $\mu\text{S}/\text{cm}$ , 98  $\mu\text{S}/\text{cm}$  to 200.25  $\mu\text{S}/\text{cm}$  and 60  $\mu\text{S}/\text{cm}$  to 82.5  $\mu\text{S}/\text{cm}$  respectively.
4. *Total Dissolved Solid (T.D.S.)* - The mean value of total dissolved solid of water samples at three selected hot spring sampling sites of Sitakund namely Sitakund

central site, Hand pump site and Bardah village hot spring site during study period between October 2014 to June 2016 are 201, 193 and 222 mg/l respectively. T.D.S of all sites in different period lies within desirable limit as per W.H.O., 2011 and U.S.E.P.A., 2012 (500 mg/l).

5. *Total Solid (T.S.)* - The mean value of Total Solid present in hot spring water samples of three sites are 284.5, 252 and 299.66 mg/l respectively.
6. *Total Suspended Solid (T.S.S.)* - The mean value of TSS concentration of water samples at Sitakund central site, Hand pump hot water site and Bardah village hot water spring site during selected study period are 83.5, 59 and 77.33 mg/l respectively. All concentrations lie within desirable limit as per E.P.A. (1986) standard (100 mg/l).
7. *Total Hardness as  $\text{CaCO}_3$*  - The mean value of Total Hardness concentration of all above three sites during selective period from October 2014 to June 2016 are 132.66 mg/l, 122 mg/l and 144 mg/l respectively, all these concentration lie within permissible limit as per WHO standard (500 mg/l).
8. *Total Alkalinity as Calcium Carbonate* - The mean value of Total alkalinity for all three selected sites of Sitakund during study period are 104.66 mg/l, 98.66 mg/l and 77.33 mg/l respectively.  
Prasoon *et al.*, observed total alkalinity concentration of two hot spring sites of Rishikund during a period from October 2014 to June 2016 varies from 12 mg/l to 24 mg/l and 10 mg/l to 14 mg/l respectively.
9. *Calcium ion* - The mean value of Calcium ion concentration of water samples of these three hot springs are 24.28 mg/l, 22.35 mg/l and 26.94 mg/l respectively. All concentration lies within desirable limit as per BIS (2012) drinking water quality standard 75 mg/l.
10. *Magnesium ion* - The mean value of Magnesium ion concentrations of water samples of these sites observed during study period from October 2014 to June 2016 are 17.51 mg/l, 16.53 mg/l and 18.70 mg/l respectively.
11. *Chloride* - The mean value of chloride ion concentration of three selected sampling sites of Sitakund region during study period is 52.66 mg/l, 44.16 mg/l and 53.33 mg/l respectively. All concentration lies within desirable limit, as per WHO, 2011 and BIS, 2012 (250 mg/l) Standard.
12. *Sulphate* - The mean value of Sulphate ion concentration of three selected site of Sitakund region during study period are 5.22 mg/l, 3.46 mg/l and 4.78 mg/l respectively. All concentration lies within desirable limit as per WHO -2011 (250 mg/l).
13. *Sodium* - The mean value of sodium ion concentration of three sites during study period are 13.87 mg/l, 17.93 mg/l and 18.59 mg/l respectively. All concentrations are well and within permissible limit as per WHO standard 2011 (200 mg/l).

14. *Potassium* - The mean value of Potassium ion concentration of selected sampling sites of Sitakund region during study period are 4.22 mg/l, 5.12 mg/l and 5.55 mg/l respectively. All concentrations are well and within permissible limit as per C.W.Q.G., 2008 (8 mg/l).
15. *S.P.C. (Standard Plate Count)* - S.P.C. of water samples at three selected hot spring sites of Sitakund i.e. Sitakund central site, Hand pump hot water site and Bardah village hot spring site during study period between October 2014 to June 2016 varied from 90 cfu/ml to 140 cfu/ml, 40 cfu/ml to 50 cfu/ml and 480 cfu/ml to 730 cfu/ml respectively. All selected sampling sites lies within permissible range according to U.S.E.P.A. (2012) - 500 cfu/ml.
16. *M.P.N. (Most Probable Number)* - M.P.N. count of water samples at selected hot spring sites of Sitakund region namely Sitakund central site, Hand pump hot water site and Bardah village hot spring site during study period between October 2014 to June 2016 varied from  $\leq 2$  MPN /100 ml to 7 MPN /100 ml,  $\leq 2$  MPN /100 ml to 2 MPN /100 ml,  $\leq 2$  MPN /100 ml to 12 MPN /100 ml respectively. All concentration lies well within permissible limit as per W.H.O. 2011, B.I.S. 2012, C.P.C.B., 1978 (50 M.P.N./100 ml).except few samples of Bardah village hot water spring reservoir site.

TABLE I: RESULT OF PHYSICO-CHEMICAL AND BACTERIOLOGICAL ANALYSIS OF SAMPLE OF SITAKUND HOT SPRING WATER OF DISTRICT MUNGER BIHAR, SITE 1<sup>ST</sup> - SITAKUND CENTRAL SITE (S<sub>1</sub>)

| Parameter | Temp. (°C) | pH        | EC (μs/cm)   | TH mg/l       | TA mg/l       | Ca mg/l     | Mg mg/l     | Cl mg/l     | Sulphate mg/l | Na mg/l     | K mg/l     |
|-----------|------------|-----------|--------------|---------------|---------------|-------------|-------------|-------------|---------------|-------------|------------|
| Oct-14    | 56         | 7.10      | 242          | 104           | 64            | 12.80       | 17.56       | 42          | 4.8           | 10          | 5.08       |
| Feb-15    | 39         | 7.85      | 370          | 136           | 108           | 28.81       | 15.60       | 48          | 8.2           | 19.80       | 4.97       |
| June-15   | 36         | 8.15      | 388          | 156           | 128           | 27.21       | 21.46       | 52          | 3.14          | 19.46       | 5.51       |
| Oct-15    | 52         | 7.42      | 288          | 128           | 72            | 16.01       | 21.46       | 56          | 4.20          | 10.68       | 5.80       |
| Feb-16    | 37         | 8.40      | 394          | 104           | 128           | 22.45       | 11.47       | 72          | 10            | 11.30       | 1.8        |
| June-16   | 33         | 8.02      | 368          | 168           | 128           | 38.40       | 17.56       | 46          | 1             | 12.00       | 2.20       |
| Mean ±S.D | 42.1 ±9.4  | 7.8 ±0.48 | 341.66 ±61.9 | 132.66 ±26.34 | 104.66 ±29.54 | 24.28 ±9.29 | 17.51 ±3.77 | 52.66 ±1063 | 5.22 ±3.31    | 13.87 ±4.50 | 4.22 ±1.75 |

TABLE II: RESULT OF PHYSICO-CHEMICAL AND BACTERIOLOGICAL ANALYSIS OF SAMPLE OF SITAKUND HOT SPRING WATER OF DISTRICT MUNGER BIHAR, SITE 1<sup>ST</sup> - SITAKUND CENTRAL SITE (S<sub>1</sub>)

| Parameter | T.S           | T.S.S        | S.P.C      | M.P.N         | T.D.S.      |
|-----------|---------------|--------------|------------|---------------|-------------|
| Oct – 14  | 276 mg/l      | 114 mg/l     | Nil        | ≤2 MPN/100 ml | 162 mg/l    |
| Feb – 15  | 246 mg/l      | 34 mg/l      | 100 cfu/ml | 4 MPN/100ml   | 212 mg/l    |
| June – 15 | 282 mg/l      | 58 mg/l      | 140 cfu/ml | 7 MPN/100ml   | 224 mg/l    |
| Oct – 15  | 302 mg/l      | 122 mg/l     | Nil        | ≤ 2 MPN/100ml | 180 mg/l    |
| Feb – 16  | 267 mg/l      | 43 mg/l      | 130 cfu/ml | 4 MPN/100ml   | 224 mg/l    |
| June – 16 | 334 mg/l      | 130 mg/l     | 90 cfu/ml  | 6 MPN/100ml   | 204 mg/l    |
| Mean ±S.D | 284.5 ± 30.40 | 83.5 ± 43.16 |            |               | 201 ± 22.91 |

TABLE III: RESULT OF PHYSICO-CHEMICAL AND BACTERIOLOGICAL ANALYSIS OF SAMPLE OF SITAKUND HOT SPRING WATER OF DISTRICT MUNGER BIHAR, SITE 2<sup>ND</sup> - HAND PUMP SITE (S<sub>2</sub>)

| Parameter | Temp. (°C) | pH         | EC (μs/cm)    | TH mg/l    | TA mg/l      | Ca mg/l      | Mg mg/l     | Cl mg/l     | Sulphate mg/l | Na mg/l    | K mg/l     |
|-----------|------------|------------|---------------|------------|--------------|--------------|-------------|-------------|---------------|------------|------------|
| Oct-14    | 48         | 6.90       | 214           | 76         | 52           | 9.60         | 12.68       | 36          | 3.70          | 11.30      | 6.04       |
| Feb-15    | 41         | 7.90       | 356           | 124        | 100          | 20.81        | 17.56       | 42          | 6.72          | 19.60      | 4.19       |
| June-15   | 38         | 8          | 372           | 136        | 116          | 22.41        | 19.51       | 44          | 2.86          | 17.58      | 5.09       |
| Oct-15    | 49         | 7.20       | 254           | 112        | 68           | 12.80        | 21.96       | 48          | 3.84          | 10.20      | 5.94       |
| Feb-16    | 43         | 7.80       | 390           | 128        | 120          | 26.88        | 14.83       | 45          | 2.40          | 23.8       | 6.20       |
| June-16   | 40         | 7.95       | 384           | 156        | 136          | 41.63        | 12.69       | 50          | 1.28          | 25.1       | 3.30       |
| Mean ±S.D | 43.16 ±4.4 | 7.62 ±0.45 | 328.33 ±75.06 | 122 ±26.86 | 98.66 ±32.46 | 22.35 ±11.38 | 16.53 ±3.46 | 44.16 ±4.91 | 3.46 ±1.8     | 17.93 ±6.2 | 5.12 ±1.17 |

TABLE IV: RESULT OF PHYSICO-CHEMICAL AND BACTERIOLOGICAL ANALYSIS OF SAMPLE OF SITAKUND HOT SPRING WATER OF DISTRICT MUNGER BIHAR, SITE 2<sup>ND</sup> - HAND PUMP SITE (S<sub>2</sub>)

| Parameter  | S.P.C.    | M.P.N.          | T.S.        | T.S.S.     | T.D.S.      |
|------------|-----------|-----------------|-------------|------------|-------------|
| Oct – 14   | Nil       | ≤ 2 MPN/100 ml, | 206 mg/l    | 64 mg/l    | 142 mg/l    |
| Feb – 15   | 50 cfu/ml | 2 MPN/100ml,    | 226 mg/l    | 28 mg/l    | 198 mg/l    |
| June – 15  | 40 cfu/ml | ≤ 2 MPN/100 ml  | 252 mg/l    | 46 mg/l    | 206 mg/l    |
| Oct – 15   | Nil       | ≤ 2 MPN/100ml,  | 264 mg/l    | 96 mg/l    | 168 mg/l    |
| Feb – 16   | Nil       | ≤ 2 MPN/100 ml  | 242 mg/l    | 28 mg/l    | 214 mg/l    |
| June – 16  | Nil       | ≤ 2 MPN/100 ml  | 322 mg/l    | 92 mg/l    | 230 mg/l    |
| Mean ± S.D |           |                 | 252 ± 39.83 | 59 ± 30.24 | 193 ± 29.52 |

TABLE V: RESULT OF PHYSICO-CHEMICAL AND BACTERIOLOGICAL ANALYSIS OF SAMPLE OF SITAKUND HOT SPRING WATER OF DISTRICT MUNGER BIHAR, SITE 3<sup>RD</sup> - BARDAH VILLAGE HOT SPRING SITE (S<sub>3</sub>)

| Parameter  | Temp. (°C)  | pH          | EC (μs/cm)  | TH mg/l     | TA (mg/l)      | Ca <sup>++</sup> (mg/l) | Mg <sup>++</sup> (mg/l) | Cl <sup>-</sup> (mg/l) | Sulphate (mg/l) | Na (mg/l)    | K (mg/l)    |
|------------|-------------|-------------|-------------|-------------|----------------|-------------------------|-------------------------|------------------------|-----------------|--------------|-------------|
| Oct-14     | 55          | 7.4         | 284         | 120         | 68             | 14.40                   | 20.49                   | 52                     | 4.55            | 10.6         | 6.42        |
| Feb-15     | 37          | 8.25        | 396         | 132         | 128            | 25.61                   | 16.58                   | 56                     | 3.62            | 17.5         | 4.80        |
| June-15    | 36          | 8.10        | 392         | 168         | 128            | 28.81                   | 23.41                   | 52                     | 6.14            | 18.46        | 4.36        |
| Oct-15     | 50          | 7.60        | 264         | 124         | 76             | 16.01                   | 20.49                   | 48                     | 8.30            | 10.28        | 6.10        |
| Feb-16     | 36          | 8.34        | 418         | 148         | 132            | 30.41                   | 17.58                   | 56                     | 4.60            | 29.60        | 8.80        |
| June-16    | 37          | 8.15        | 406         | 172         | 144            | 46.42                   | 13.66                   | 56                     | 1.48            | 25.11        | 2.82        |
| Mean ± S.D | 41.83 ± 8.4 | 7.97 ± 0.38 | 360 ± 67.51 | 144 ± 22.34 | 112.66 ± 32.14 | 26.94 ± 11.60           | 18.70 ± 3.45            | 53.33 ± 3.26           | 4.78 ± 2.30     | 18.59 ± 7.71 | 5.55 ± 2.05 |

TABLE VI: RESULT OF PHYSICO-CHEMICAL AND BACTERIOLOGICAL ANALYSIS OF SAMPLE OF SITAKUND HOT SPRING WATER OF DISTRICT MUNGER, BIHAR, SITE 3<sup>RD</sup> - BARDAH VILLAGE HOT SPRING SITE (S<sub>3</sub>)

| Parameter  | S.P.C.      | M.P.N.         | T.S.           | T.S.S.        | T.D.S.   |
|------------|-------------|----------------|----------------|---------------|----------|
| Oct – 14   | Nil         | ≤ 2 MPN/100 ml | 292 mg/l       | 112 mg/l      | 180 mg/l |
| Feb – 15   | 480 cfu/ml  | 4 MPN/100ml,   | 272 mg/l       | 42 mg/l       | 230 mg/l |
| June – 15  | 660 cfu/ml, | 9 MPN/100ml,   | 278 mg/l       | 46 mg/l       | 232 mg/l |
| Oct – 15   | Nil         | ≤ 2 MPN/100ml, | 312 mg/l       | 124 mg/l      | 188 mg/l |
| Feb – 16   | 620 cfu/ml, | 11MPN/100ml,   | 278 mg/l       | 32 mg/l       | 246 mg/l |
| June – 16  | 730 cfu/ml  | 12 MPN/100ml   | 366 mg/l       | 108 mg/l      | 258 mg/l |
| Mean ± S.D |             |                | 299.66 ± 35.53 | 77.33 ± 41.48 | 28.73    |

#### IV. CONCLUSION

All the Physico-chemical parameters of three selected hot spring sites estimated are well within desirable and permissible potability range of water compared with WHO 2011, BIS 2012, CPCB, 1978 and USEPA, 2012. The Bacteriological parameters SPC and MPN of Sitakund main site and Hand pump site are well within permissible range while in Bardah village the value of SPC and MPN exceeds the permissible limits in some season, which are due to human and animal activity nearby site. So its water is less suitable for drinking purposes.

#### ACKNOWLEDGEMENT

We are grateful to P. G. Department of Chemistry and Marwari college of T. M. Bhagalpur University, Bhagalpur for providing necessary facilities for our research work.

#### REFERENCE

- [1] American Public Health Association. "Standard method for the examination of water and waste water," (21<sup>st</sup> ed.), Washington DC, pp. 2-90, 2005.



- [2] Bureau of Indian Standard. "Indian standard for drinking water specification I.S.10500," *Indian Standard Institute New Delhi, India*, 1991.
- [3] B. K. Gupta, P. Prakash, and F. Ahmad, "Water quality of Rajgir hot spring Nalanda Bihar," *International Journal of Emerging Trends in Science and Technology*, vol. 4, no. 8, pp. 5447-5464, 2017.
- [4] Central Board for the Prevention and Control of Water Pollution (C.P.C.B). "Scheme for zoning and classification of Indian rivers, estuaries and coastal waters (Part one: Sweet water) New Delhi, ADSORBS/3/1978-79, pp. 1-19, 1978.
- [5] Canadian Water Quality Guidelines (C.W.Q.G) Health Canada. "Guidance for potassium from water softeners. Ottawa, Ontario, Health Canada, Healthy Environments and Consumer Safety Branch, Water, Air and Climate Change Bureau," Available <http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/potassium/index-eng.php>, pp 4-5, 2008.
- [6] E.P.A. "Guidelines for recognition of environmental laboratories under the environment protection act under section 13," Central Pollution Control Board (ministry of environment and forest) Parivesh Bhawan, East Arjun Nagar Delhi, pp 545-548, 1986.
- [7] K. Mahamuni, and H. Kulkarni, "Hydrogeological action research for spring recharge and development and hill-top lake restoration in parts of Southern District, State of Sikkim, India," 2011.
- [8] P. Prakash, B. K. Gupta, and F. Ahmad, "Characteristics of hot water springs in region of Rishikund Munger district of Bihar State, India," *International Research Journal of Environmental Sciences*, vol. 6, no. 10, pp 15-21, 2017.
- [9] R. K. Trivedy, and P. K. Goel, "Chemical and biological methods for water pollution studies," *Environmental Publications, Karad, India*, vol. 6, pp. 10-12, 1986.
- [10] U.S.E.P.A. "Edition of the drinking water standards and health advisories EPA 822-S-12-001 Office of Water U.S. Environmental Protection Agency Washington, DC," pp 1-10, 2012.
- [11] World Health Organization. *Guidelines for Drinking Water Quality*, (4<sup>th</sup> ed.), Recommendations W.H.O., Geneva,