International Journal for Modern Trends in Science and Technology
Volume: 03, Issue No: 09, September 2017
ISSN: 2455-3778
http://www.ijmtst.com

Analysis of Physico-Chemical Parameters of Sitakund Hot Water Spring at Munger District Bihar

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To Cite this Article
Prasoon Prakash and B.K.Gupta, "Analysis of Physico-Chemical Parameters of Sitakund Hot Water Spring at Munger District Bihar", *International Journal for Modern Trends in Science and Technology*, Vol. 03, Issue 09, September 2017, pp.-63-69.

ABSTRACT

The Sitakund hot springs situated in a region of Munger district Bihar, India are a natural geothermal springs or discharge of ground water with elevated temperature with respect to surrounding and supposed to cure off many bone related diseases like arthritis, and are also equivalently used in treatment of skin infections and gastrointestinal diseases. Hence a complete detailed study of the Physico-Chemical properties of these hot spring water of Sitakund region is required. For this purpose twelve different Physico-Chemical parameters of the water samples collected from three selected sites were analyzed by UV-visible spectroscopic methods, Titrimetric methods and Potable kit methods. Physical parameters like Temperature, Electrical Conductivity, Total Dissolved Solid, Chemical parameters like pH, Calcium Hardness, Magnesium Hardness, Total Hardness, Total Alkalinity and Ionic parameters like Sodium, Potassium, Calcium, Magnesium, Chloride, Sulphate of water samples of Sitakund main site, Hand pump site and Bardah village hot water reservoir site were analyzed. A comparison with W.H.O. standards showed that the water samples of Sitakund region Munger are suitable for drinking and bathing purposes. However Bardah village hot water spring reservoir site near Sitakund region has higher concentrations of Total Dissolved Solid than main site Sitakund as well as Hand pump site of Sitakund region.

Key words: *Hot Spring, Physico- Chemical parameters, Total Dissolved Solid, Total Hardness, Total Alkalinity.*

I. INTRODUCTION

The one place which puts Munger district of Bihar state as one of the most visited place is known as Sitakund hot spring site . Sitakund site is situated 4 miles east of Munger town. Besides this there is a Hindu temple and to the north a reservoir of cold water known as Ram Kund, while to the west there were three more Kund namely Lakshman kund, Bharat kund and Shatrughan kund. Another important hot spring reservoir site near Sitakund is known as Bardah village hot spring reservoir situated around 200 meter north to Sitakund main hot spring site. Earlier it was also called Philips Sitakund during British period (Stated by old person of the village during interview). It is mostly Muslim populated village. So, the people living nearby areas also uses water for bathing purposes. . Hot water comes out from

almost all the hand pump in the vicinity of two square kilometer area in Sitakund region. The hot spring site of Sitakund are medically as well as sociologically important [1]- [2]. They are ancient and have a lot of aesthetic value since ages [3]. It is belived that the waters from these hot springs can cure several diseases [4]- [5].

Therefore these hot springs play an important role in social medicine, religious customs and Practices. Every year patients suffering from various arthritis problems, gastrointestinal and bowel associated diseases and skin diseases visit these areas to cure themselves [6].

The present study involves the physical and chemical analysis of water samples collected from three hot spring sites of Sitakund Munger namely Sitakund main kund, Hand Pump hot spring site situated at west side in premises of Sitakund at a distance of 100 meter . Bardah village hot spring reservoir site were selected for Physico -Chemical analysis. These hot springs sites are located near the river Ganga. These hot springs sites are mainly used as a source of bathing and drinking purpose to cure gastrointestinal and general skin infections. Recently hot springs are getting polluted due to influx of tourists in and around the hot spring ponds. Water from Sitakund main site and Bardah village hot springs site after travelling 500 meter through channel and its temperature attains just above the normal

atmospheric water temperature is used to irrigate the nearby agricultural land. The Physico-Chemical parameters of these hot springs water of Sitakund region were studied and analyzed during an interval of four months during October 2014 to June 2016.

II. Study area and Sampling sites.

The dimension of Sitakund main hot spring site reservoir about 21 × 28 feet. The altitude of Sitakund hot spring site is 46 meters above sea level. It is 10 km away from Jamalpur railway station (Eastern Zone) and 4 km away from Munger railway station. Geographical location of Munger is latitude 25^{0}38" North and longitude 86^{0}47" East. There are three sampling sites named Sitakund main kund, Hot water Hand pump site situated around 50 meter west from sitakund main hot spring site and third selected sampling sites are Bardah village hot spring water reservoir site situated around 200 meter north to Sitakund main site.

Map of Sitakund hot spring sites and Munger district Bihar.

Fig. 1 Munger district Bihar

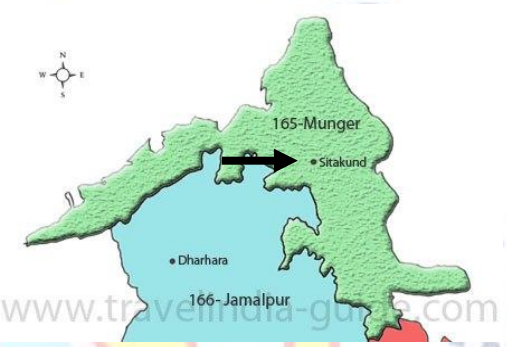

Fig. 2 Sitakund hot spring site Munger

Photograph of Selected sites

Fig. 3 Main Site Sitakund.

Fig. 4 Hand pump Site Sitakund.

Fig. 5 Bardah village hot spring site Sitakund

III. Materials and Methods

The water samples of hot springs were collected from three selected sites in pre-cleaned reagent bottle during two years from October 2014 to June 2016 at an interval of four months and were immediately brought to the laboratory in sterile conditions.

The collected samples were stored in Refrigerator and preserved till the completion of their analysis. The pH, Temperature of the water samples were measured in the field by using the potable kit method and other Physico-Chemical parameters like EC, Total Hardness, Total Alkalinity, Calcium Hardness, Magnesium Hardness, Calcium ion, Magnesium ion, Chloride, Sulphate, Sodium, Potassium, Total Dissolved Solid were analyzed in the laboratory using as per standard methods. **Sodium Adsorption Ratio** (SAR) value were also estimated for suitability of water of Sitakund main site and Bardah village hot water spring for irrigation of agricultural land by using the concentration of Sodium , Calcium and Magnesium.

IV. Results and Discussion

Results of analyzed Physico-Chemical parameters have been shown in Table 1 to Table 3 and their seasonal variations for all the three sites have been represented in Figure 6 to Figure 11 and their variations in different period have been discussed below.

A. **Temperature –** The observed Temperature of Sitakund main site, Handpump site and Bardah village reservoir hot spring site during period October 2014 to June 2016 varies from 33^{0}C to56^{0}C, 38^{0}C to 49^{0}C and 36^{0}C to 55^{0}C respectively. The temperature in post monsoon period is more than the pre monsoon period.

B. **pH –** Due to the various dissolved chemical constituents, pH acts as an important indicator of water. pH relates to the acidity or basicity of the test substances which is the measure of free hydrogen ion and hydroxyl ions in the water .

The observed pH of Sitakund main site, Hand pump site and Bardah village hot water spring reservoir site varies from 7.1 to 8.4, 6.9 to 8.0, and 7.40 to 8.34, respectively, which is within permissible limit as per APHA and WHO standard of drinking water (6.5-8.5).

C. **Electrical Conductivity –** It is used to measure the concentration of dissolve solids which have been ionized in a polar solution such as water.

The observed Electrical Conductivity of all three sites during period October 2014 to June 2016 varies from 242 µs/cm to 394 µs/cm, 214 µs/cm to 390 µs/cm and 264 µs/cm to 418 µs/cm respectively.

The Electrical Conductivity is higher than permissible limit in pre monsoon period (In the month of February) and monsoon period (in the month of June) whereas concentrations are below or within the permissible limit during post monsoon period (in the month of october). Due to presence of high amount of minerals in water, the hot springs showed higher conductivity values .

D. **Total Hardness as $CaCO_3$** – It is due to the presence of Calcium and Magnesium present as bicarbonate salt.

The observed Total Hardness concentration of three selected hot springs sites during period from October 2014 to June 2016 varies from 104 mg/l to168 mg/l, 76 mg/l to156 mg/l, 128 mg/l to 172 mg/ l respectively, All concentration lies within permissible limit as per WHO standard (300 mg/l).

E. **Calcium Hardness** – The observed Calcium hardness concentration of three selected hot springs sampling sites varies from 32 mg/l to 96 mg/l, 24 mg/l to 104 mg/l and 36.02 mg/l to 116 mg/l respectively. The Calcium Hardness concentration of Sitakund main site, Hand pump site, and Bardah village hot water spring reservoir site lies within permissible range as per WHO standard.

F. **Magnesium Hardness** – Magnesium hardness concentration of three selected hot springs sites varies from 47.93 mg/l to 87.98 mg/l, 52 mg/l to 90 mg/l and 56 mg/l to 95.6 mg/l

respectively, Which lies within permissible range as per WHO standard.

G. **Total Alkalinity as Calcium Carbonate**- This is a measure of the capacity of water to neutralize acid. The predominant chemicals present in hot water springs are Carbonates. Bicarbonates and Hydroxide of Calcium, Sodium and Potassium .

Total alkalinity value for main site Sitakund, Hand pump hot spring site as well as Bardah village hot springs reservoir site during period October 2014 to June 2016 varies from 64 mg/l to128 mg/l ,52 mg/l to 136 mg/l and 68 mg/l to144 mg/l respectively. Total Alkalinity as Calcium Carbonate concentrations recorded in all above three sites lies within permissible limit as per WHO standard (200 mg/l).

H. **Calcium ion** –The observed Calcium ion concentration of three selected hot springs sampling sites varies from 12.80 mg/l to 38.40 mg/l, 9.60 mg/l to 41.63 mg/l and 14.40 mg/l to 46.42 mg/l respectively. All concentration lies within permissible limit as per WHO standard (75 mg/l). However the concentration of Calcium ion is more in pre monsoon period than post monsoon period due to dilution either by rain water or ground water or both.

I. **Magnesium ion**- Magnesium ion concentrations observed of three selected hot springs sampling sites during period from October 2014 to June 2016 varies from 11.47 mg/l to 21.46 mg/l, 12.68 mg/l to 21.96 mg/l and 13.66 mg/l to 23.41 mg/l respectively. All concentration lies within permissible range as per WHO standard (30 mg/l). Rylander *et al.*, 1991 have shown an Inverse correlation between magnesium in drinking water and mortality from ischemic heart diseases [7]. When magnesium levels are lower owing to an increased tendency to vasoconstriction [8].

J. **Chloride**- The chloride ion concentration of the water indicates possible pollution or contamination of water from human sewage, animal manure or industrial wastes. The Sitakund hot springs region are very sacred and religious place, So possible biological fecal contamination is neglected.

Observed chloride ion concentration of three selected hot springs sampling sites of Sitakund region varies from period October 2014 to June 2016 are 42 mg/l to 72 mg/l , 36 mg/l to 50 mg/l and 48 mg/l to 56 mg/l respectively. All concentration lies within permissible limit [9]- [10] .

K. **Sulphate-** High concentration of Sulphate imparts bitter taste to water. Chemically Sulphate plays an important role in forming salt of Calcium and Magnesium to give permanent hardness of water.

The observed Sulphate ion concentration of main site Sitakund, Hand pump site as well as Bardah village hot water spring reservoir site during period October 2014 to June 2016 varies from 1mg/l to 10 mg/l, 1.28 mg/l to 6.72 mg/l and 1.48 mg/l to 8.30 mg/l respectively. All concentration lies within permissible limit as per WHO standard (200 mg/l) [11].

L. **Sodium-** High concentration of Sodium ion causes cardiovascular disease and kidney related problems.

The observed sodium ion concentration of three selected hot springs sampling sites varies from 10 mg/l to 19.80 mg/l, 10.20 mg/l to 25.1 mg/l and 10.28 mg/l to 29.60 mg/l respectively. All concentrations are well and within desirable limit as per WHO standard (200 mg/l).

M. **Potassium-** The major role of potassium ion in stimulation of nerve, muscle contractions, blood pressure regulation and protein dissolution. It prevent the body from several cardio-vascular diseases, it does not spread rapidly because of its high mobility.

The observed Potassium ion concentration of all three selected sampling sites of Sitakund region varies from 1.80 mg/l to 5.80 mg/l, 3.30 mg/l to 6.20 mg/l and 2.82 mg/l to 8.80 mg/l respectively. The resultant concentration of potassium ion lies within desirable limit as per WHO standards (10 mg/l).

Table 1-Result of Physico-Chemical analysis of sample of Sitakund Site (Main).

Parameter	Temp.	pH	EC µs/cm)	TH	TA (mg/l)	Ca^{++} (mg/l)
Oct-14	56°C	7.10	242	104	64	12.80
Feb-15	39°C	7.85	370	136	108	28.81
June-15	36°C	8.15	388	156	128	27.21
Oct-15	52°C	7.42	288	128	72	16.01
Feb-16	37°C	8.40	394	104	128	22.45
June-16	33°C	8.02	368	168	128	38.40

Table 1. Cont….

Parameter	Mg^{++} (mg/l)	Cl^{-} (mg/l)	Sulphate (mg/l)	Na (mg/l)	K (mg/l)	Ca-H	Mg-H
Oct-14	17.56	42	4.8	10	5.08	32	72
Feb-15	15.60	48	8.2	19.80	4.97	72.04	63.96
June-15	21.46	52	3.14	19.46	5.51	68.04	87.96
Oct-15	21.46	56	4.20	10.68	5.80	40.02	87.98
Feb-16	11.47	72	10	11.30	1.8	56.07	47.93
June-16	17.56	46	1	12.00	2.20	96	72

Table 2 -Result of Physico-Chemical analysis of sample of Hand pump Site, Sitakund.

Parameter	Tempe-rature	pH	EC µs/cm)	TH	TA (mg/l)	Ca^{++} (mg/l)
Oct-14	48°C	6.90	214	76	52	9.60
Feb-15	41°C	7.90	356	124	100	20.81
June-15	38°C	8	372	136	116	22.41
Oct-15	49°C	7.20	254	112	68	12.80
Feb-16	43°C	7.80	390	128	120	26.88
June-16	40°C	7.95	384	156	136	41.63

Table 2. cont…

Parameter	Mg^{++} (mg/l)	Cl^- (mg/l)	Sulphate (mg/l)	Na (mg/l)	K (mg/l)	Ca-H	Mg-H
Oct-14	1268	36	3.70	11.30	6.04	24	52
Feb-15	17.56	42	6.72	19.60	4.19	52.02	71.98
June-15	19.51	44	2.86	17.58	5.09	56.02	79.98
Oct-15	21.96	48	3.84	10.20	5.94	32	90
Feb-16	14.83	45	2.40	23.8	6.20	67.20	60.8
June-16	12.69	50	1.28	25.1	3.30	104	66

Table3 -Result of Physico-Chemical analysis of sample of Bardah Village hot water springs Reservoir Site, Sitakund.

Parameter	Temp.	pH	EC (µs/cm)	TH	TA (mg/l)	Ca^{++} (mg/l)	Cl^- (mg/l)
Oct-14	55°C	7.4	284	120	68	14.40	52
Feb-15	37°C	8.25	396	132	128	25.61	56
June-15	36°C	8.10	392	168	128	28.81	52
Oct-15	50°C	7.60	264	124	76	16.01	48
Feb-16	36°C	8.34	418	148	132	30.41	56
June-16	37°C	8.15	406	172	144	46.42	56

Table 3. cont.

Parameter	Mg^{++} (mg/l)	Sulphate (mg/l)	Na (mg/l)	K (mg/l)	Ca-H	Mg-H
Oct-14	20.49	4.55	10.6	6.42	36.02	83.94
Feb-15	16.58	3.62	17.5	4.80	64.02	67.98
June-15	23.41	6.14	18.46	4.36	72.04	95.96
Oct-15	20.49	8.30	10.28	6.10	40.02	83.98
Feb-16	17.58	4.60	29.60	8.80	75.95	72.05
June-16	13.66	1.48	25.11	2.82	116	56

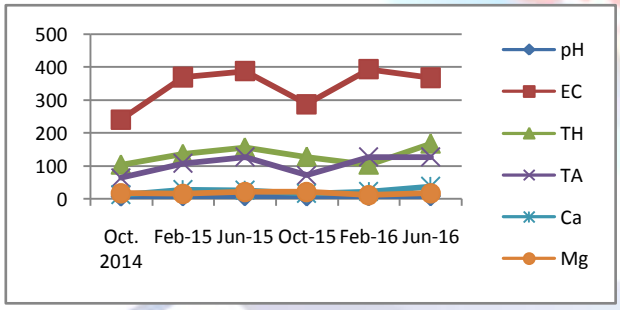

Figure 6. Seasonal variation of pH, EC, TH, TA, Ca, Mg at Sitakund main site Munger.

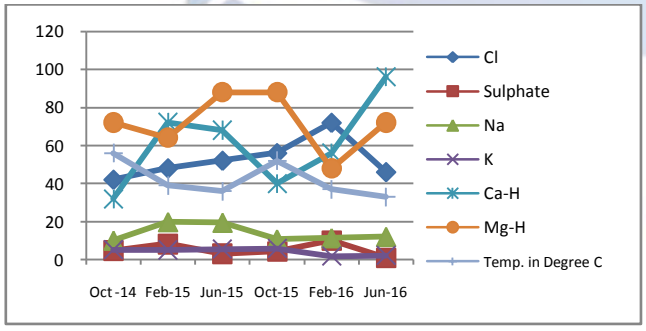

Figure 7. Seasonal variation of Temperature, Magnesium Hardness, Calcium Hardness, Potassium, Sodium, Sulphate and Chloride at Sitakund main site Munger.

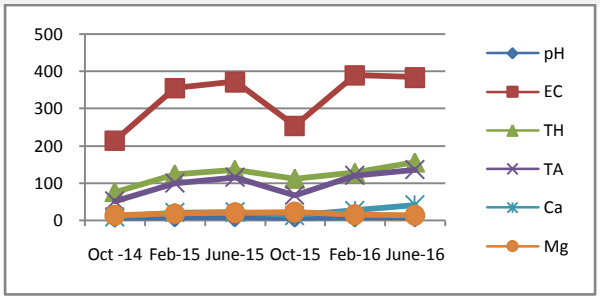

Figure 8. Seasonal variation of pH, EC, TH, TA ,Ca, Mg at Hand pump site Munger.

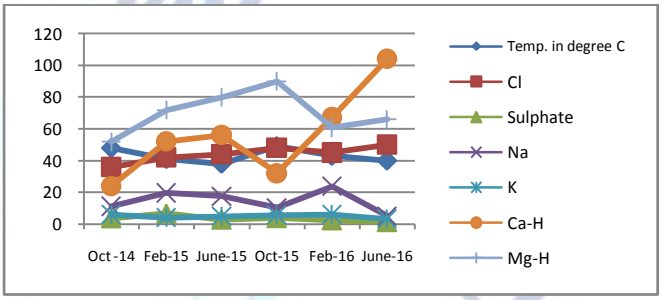

Figure 9. Seasonal variation of Temperature, Ca-H, Mg-H, Chloride, Sulphate, Na, K, at Hand pump site Sitakund, Munger.

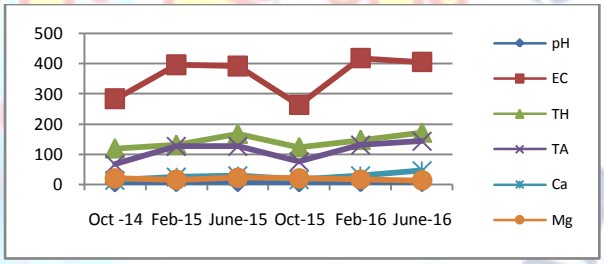

Figure 10. Seasonal variation of pH, EC, TH, TA ,Ca, Mg with respect to period at Bardah village hot water spring reservoir site, Munger.

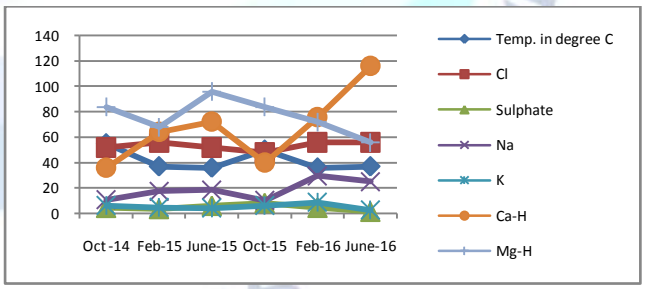

Figure 11. Seasonal variation of Temperature, Ca-H, Mg-H, Chloride, Sulphate, Na, K, at Bardah village hot water spring reservoir site, Munger.

Note-Value of EC expressed in µs/cm whereas Temperature is expressed in degree centigrade and other parameters are expressed in mg/l.

V. Sodium Adsorption Ratio (SAR)

The sodium adsorption ratio (SAR) is calculated from the ionic concentration of sodium, Calcium and Magnesium according to following relationship.

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

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 less suitable for irrigations.

In Sitakund region the people living nearby areas irrigate their crops from drainage water coming out from these two hot water spring reservoir. . Here our present aim is wheather the drainage water from these hot water reservoir is well suited for irrigation or not . For this value of SAR ratio has been calculated from different values of Sodium , Calcium ,Magnesium value and observe that drainage water from these hot reservoir is well suited for irrigation to agricultural land nearby areas.

Table 4 -SAR value of Bardah Village hot water reservoir site and Sitakund main site Munger.

	Oct-14	Feb-15	June-15	Oct-15	Feb-16	June-16
SAR value of Bardah village hot spring reservoir site.	2.54	3.81	3.61	2.40	6.05	4.58
SAR value of Sitakund main site .	2.57	4.20	3.94	2.47	2.74	2.27

Since SAR values are less than 10 of hot water spring of both the sites at Sitakund main kund and Bardah village hot water spring reservoir, which is well suited for irrigation to the agriculture field nearby adjoining areas [12].

VI. Conclusion

It is found that Electrical Conductivity parameter is higher than desired permissible limit in pre monsoon period than the post monsoon period in all three selected sampling sites of Sitakund region. This may be due to the dilution of water either by raining or increasing the ground water level. Overall study shows that water is more polluted in pre monsoon period (in February) than the post monsoon period (in month of October).

The overall conclusion is that mostly all parameter lies within potability range of WHO, So the water of Sitakund main kund , Hand Pump site may be used for drinking purposes . The water in Bardah hot water reservoir gets polluted due to the human activities like washing clothes, insert unwanted things into reservoir so it is less suitable for drinking purposes. On the basis of water quality comparison of Sitakund region hot spring in Munger district reveals that although the situation is not worst but it has to be maintained especially in Bardah village hot water springs reservoir site.

VII. Acknowledgement

We are grateful to P.G Department of chemistry and Marwari college of T.M.B.U. Bhagalpur for providing necessary facilities for this research work.

We are also thankful to and all the staff member of P.G. as well as Marwari College for their kindly support.

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