IJETST Open access Journal International Journal of Emerging Trends in Science and Technology
IC Value: 76.89 (Index Copernicus) Impact Factor: 4.219 **DOI:** https://dx.doi.org/10.18535/ijetst/v4i8.09

Water Quality of Rajgir Hot Spring, Nalanda Bihar

Authors
Dr. B.K. Gupta[1], Prasoon Prakash[1*], Dr. Md. Faiz Ahmad[2]
[1]Marwari College, T.M.B.U. Bhagalpur-812007
[2]P.G. Department of Chemistry, T.M.B.U. Bhagalpur-812007

Abstract
The Rajgir hot spring sites located in Nalanda district of Bihar State. This spring is sulphur containing hot spring. The various parameters analyzed were Temperature, pH, Electrical Conductivity, Total Hardness, Total Alkalinity, Calcium Hardness, Magnesium Hardness, Calcium, Magnesium, Chloride, Sulphate and TDS (Total Dissolved Solid). The water samples were collected from three different springs sites (kund) during a period from October 2014 to June 2016 (Within a difference of four month). Physico-Chemical results were compared with WHO potability parameters and it was found that water is potable.

Keywords – Springs, TDS, WHO

1. Introduction

Water is the most widely distributed and abundant substance found in nature. It is essential constituent of all animals and plant materials and forms about 75% of matter of earth crust. Rainfall is an important and largest source of water, other sources are surface water and ground water (Sharma B.K, 2001). In total there are 1400 million billion liters of water, but most of these water is not used for drinking purpose, because 97% is sea water and only 3% is fresh water, out of which 2% is trapped in the polar ice caps and glaciers, only 1% water is available for potable use; whereas more water goes for irrigation then to drinking purposes and other uses (WHO 2004).

Hot springs are the sites that discharge hot ground waters, the temperature of which is notably higher than the ground water. The high temperature of hot spring water is because of the geothermal energy, exothermic reactions and disintegration of radioactive elements . Usually hot spring water contains a wide range of minerals like alkali metals, alkaline earth metals, sulphates, carbonates and trace elements (Reddy. *et. al.* 2013) and due to the presence of these mineral water of hot springs have medicinal properties. It also contains gases like Hydrogen Sulphide (H_2S), Carbon dioxide (CO_2) and low amount of Oxygen (Mahala. *et. al.* 2012) and the sulphurous odour of the hot spring water may be due to the presence of such type of gases.

Rajgir hot water spring is situated in Nalanda district of Bihar. Rajgir has so many tourist attraction apart from aerial rope way and

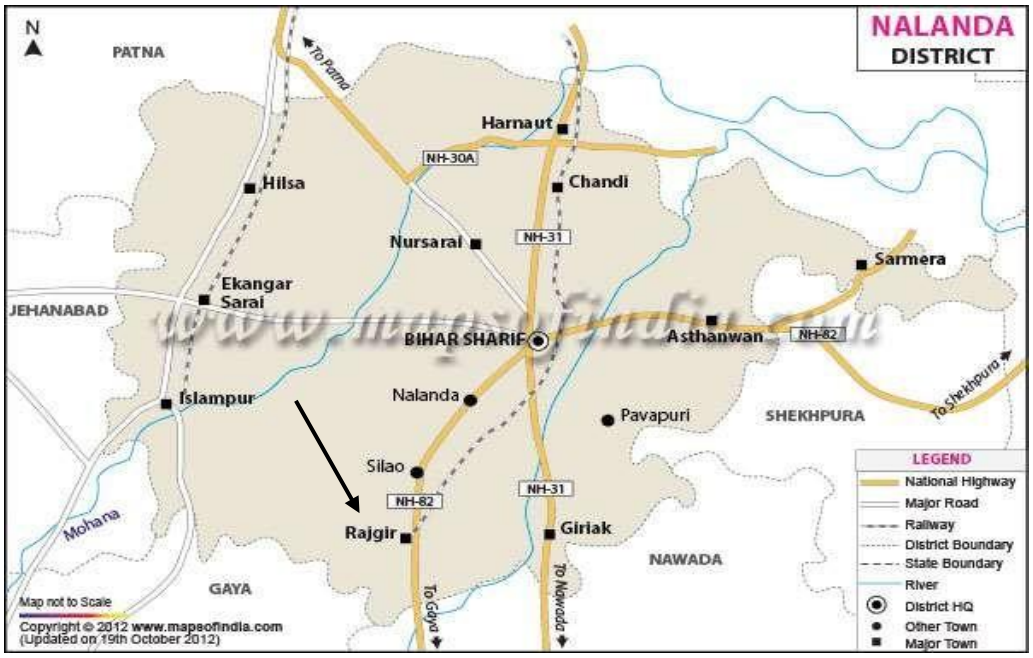
world peace pagoda it is also famous for numerous hot water spring, these hot spring water have curative property likely due to the presence of Sulphur. Today Rajgir is noted for its numerous hot water spring at the base of Vaibhava hill, attracting not only pilgrims and tourist but the sick and the infirm as well. The hot water is supposed to come from Saptaparni cave, situated on top of the hills. On the foot of Vaibhava hills different hot springs namely Vishwamitra kund, Bhratdwaj-muni kund, Vyas-muni Kund, Anant- muni kund, Vashishtha-muni kund, Gautam-muni kund ,Kapil-muni kund etc merge to form Saptadhara .Brahm kund is also situated inside premises of saptadhara Rajgir,which is hottest in comparision to all seven kund of saptadhara. The source of Brahm kund is situated below hot water spring reservoir . Another important kund named as Makhdum kund is situated few meter distance from saptadhara Rajgir. Makhdum kund is located on the foot of Vipula hills.

Many of the springs are the result of long cracks or joint in Sedimentary rock (Young M.C. Aqua). 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 (Clay Thompson. *et. al.2003*). Rajgir hot spring water is known to have minerals like Calcium, Magnesium, Sulphate, Fluoride and Chloride. (Das *et. al.*, 2013).

So, the Physico–Chemical parameter of three selected hot spring sites of Rajgir namely Vishwamitra kund ,Brahm kund ,Makhdum kund were studied and analyzed during period from October 2014 to June 2016. The objective of the present work is to analyze and discuss the suitability of water for drinking and sanitation purposes.

The Rajgir hot spring is considered as Euthermal spring and provided stable environment to ecosystem which may have remained unchanged (Brock 1967)

2 .Map of Rajgir hot spring site of Nalanda district Bihar.



3. Photograph of selected sites

Figure 3.1 a

Figure 3.1 b

Figure 3.1. a and 3.1 b Brahm Kund Rajgir Nalanda

Fig. 3.2 a

Fig 3.2 b

Figure3.2.Makdhum Kund Rajgir Nalanda

Fig. 3.3 a

Figure 3.3 Saptadhara Showing all seven Kund at Rajgir Nalnada

Fig. 3.3 b

Vishwamitra Kund, Rajgir Nalnada

4. Study area .

Geographical location of Rajgir is 25^0 02" N latitude and 85^0 25" E longitude. It is situated at a distance of 12 km from Nalanda, 25 km from Biharsharif , headquater of Nalanda district , 38 km from Pawapuri, 78 km from Gaya and lastly 110 km from capital city Patna by road. Average rainfall occur around 1860 millimeter (June-September).

5. Materials and methods.

The present study was carried out on the spring water quality of three hot springs of the Rajgir hills in district Nalanda, Bihar namely Vishwamitra Kund, Brahm kund and Makhdum Kund. Water samples from the various locations of Rajgir hot spring were collected in clean litre polythene bottles in the period from October 2014 to June 2016 (within a difference of four month). Material required for sampling and analysis of water are sample containers, chemicals and glassware, thermometer, tissue papers, other field measurement are field note book, Pen, marker Pencil, soap and towel, match box, *etc*. All analysis were carried out as per APHA, ISI and BIS standard method for drinking water. The method of analysis has been mentioned below.

1. Temperature is measured by the Mercury Thermometer.
2. pH :- pH value in water is determined by Digital pH meter.
3. Electrical Conductivity in water is determined by using Conductivity meter.
4. Total Hardness in water is determined by EDTA complexometric titration using EDTA solution.
5. Total Alkalinity in water is determined by Acid titration.
6. Calcium Hardness in water is determined by using EDTA complexometric titration.
7. Megnesium Hardness in water is determined by using EDTA complexometric titration.
8. Calcium and Magnesium ion in water is determined by using EDTA complexometric titration.
9. Chloride in water sample is determined by using Argentometric titration.
10. Sulphate in water sample is determined by UV Spectrophotometric method using Spectrophotometer.
11. Total Dissolved Solid in water is determined by using Evaporation method.

All parameters analyzed with using standard procedures (Trivedy and Goel 1986, APHA, 2005) in laboratory.

6.Results & Discussion.

1. **Temperature :-** The water from Rajgir thermal spring seeps out as transparent, colourless and odourless. The water temperature observed during period from October 2014 to June 2016 within a interval of four month in Vishwamitra kund ,Brahm kund & Makhdum Kund of Rajgir varies from 31^0C to 41^0 C, 33^0C to 42^0C & 29^0C to 38^0C respectively.
2. **pH :-** The pH observed during period October 2014 to June 2016 of

Vishwamitra kund, Brahm kund and Makhdum kund of Rajgir varies from 7.05 to 7.58, 7.00 to 7.60 and 6.95 to 7.95 respectively. The experimental value for pH of water samples was found within the WHO standard (6.50-8.50). So, this water is potable.

3.Electrical Conductivity (EC) :- Electrical Conductivity observed in Vishwamitra kund, Brahm kund and Makhdum kund of rajgir hot spring during period October 2014 to June 2016 varies from 60.6 µs/cm to 97.75µs/cm, 98µs/cm to 200.25 µs/cm and 60 µs/cm to 82.5 µs/cm respectively. which are within permissible limit as per WHO recommended standard (250 µs/cm) .

4.Total Hardness : – The observed Total Hardness concentration of all three kund namely Vishwamitra kund, Brahm kund as well as Makhdum kund of Rajgir hot spring during period October 2014 to June 2016 varies from 16mg/l to 32 mg/l, 36 mg/l to 52 mg/l and 10 mg/l to 28 mg/l respectively. Which are less than the permissible limit as per WHO recommendation (300mg/l). So it is potable.

5.Total Alkalinity – Total alkalinity of Vishwamitra kund, Brahm kund and Makhdum Kund of Rajgir hot spring observed during period October 2014 to June 2016 varies from 6 mg/l to 16 mg/l, 16 mg/l to 28 mg/l and 8 mg/l to 18 mg/l respectively, which are less as per WHO recommendation (200mg/l). Hence it is potable.

8. Calcium Hardness – The observed calcium hardness of hot springs water sample at Vishwamitra kund , Brahm kund and Makhdum kund varies from 4mg/l to 12 mg/l, 10 mg/l to 20 mg/l and 4 mg/l to 12 mg/l respectively. The Calcium Hardness found less in post monsoon period than pre monsoon period. Calcium Hardness in all sample found within desirable limit as per WHO standard .

9. Magnesium Hardness – The observed Magnesium Hardness of Vishwamitra kund, Brahm kund & Makhdum kund of Rajgir hot spring varies from 10 mg/l to 20 mg/l, 24 mg/l to 32 mg/l and 6 mg/l to 16 mg/l respectively. Magnesium Hardness observed more than Calcium Hardness in all three kund.

10. Calcium ion – The observed Calcium ion conecntraion of Vishwamitra kund, Brahm kund and Makhdum kund of Rajgir hot spring varies from 1.60 mg/l to 4.85 mg/l ,4.00 mg/l to 8 mg/l and 1.60 mg/l to 4.80 mg/l respectively. All ranges are within desirable limit as per WHO recommended (75 mg/l).

11. Magnesium – The observed magnesium concentration of Vishwamitra kund , Brahm kund and Makdum kund of Rajgir hot water spring varies from 2.44 mg/l to 4.88 mg/l, 5.85 mg/l to 7.80 mg/l and 1.46 mg/l to 3.90 mg/l respectively. The concentration of magnesium ions lies within recommended

permissible limit as per WHO standard (30 mg/l).

A major hypothesis that has emerged form studies in recent year is that magnesium together with Calcium protect against death from ischemic heart diseases (Rubenowitz *et. al.*, 1996).

6.Chloride - The concentration of Chloride ion variation was observed within the range of 8 mg/l to 12 mg/l, 16 mg/l to 30 mg/l and 6 mg/l to 10 mg/l respectively. All concentrations are within permissible range as per WHO standard (250 mg/l). So, it is potable.

7.Sulphate – Sulphates are very low in concentration and ranged from 1.22 mg/l to 3.52 mg/l, 2.44 mg/l to 2.82 mg/l and 1.28 mg/l to 1.42 mg/l respectively in Vishwamitra kund , Brahm kund and Makhdum kund of Rajgir hot spring. There is no significant variation in the concentration of Sulphate. The concentration of Sulphates found very-much lesser than the permissible limit as per WHO standard (200 mg/l).

12. Total Dissolved Solid – The observed Total Dissolved Solid in Vishwamitra kund , Brahm Kund and Makhdum kund of Rajgir hot spring varies from 26 mg/l to 40 mg/l, 54 mg/l to 68 mg/l and 22 mg/l to 32 mg/l respectively. All concentration lies within the recommended permissible range as per WHO standard (500 mg/l). So, waters of all above Sites are potable

7. Analysis of different parameters of three selected hot spring sites of Rajgir .

Table 1 – Value of different Physico-Chemical parameter of water sample of Rajgir hot water spring of district Nalanda Bihar, Site 1st- Vishwamitra Kund (Concentration expressed in Mg/l)

Parameter	Temp.	pH	EC	TH	TA	Ca-H	Mg-H	Ca^{++}	Mg^{++}	Chloride	Sulphate	TDS
Oct – 14	41^0C	7.05	97.75	16	8	4	12	1.60	2.92	8	3.52	40
Feb – 15	31^0C	7.58	62.60	20	16	10	10	4.00	2.44	8	1.22	36
June – 15	41^0C	7.15	94.00	24	12	8	16	3.20	3.90	10	1.83	30
Oct – 15	36^0C	7.05	70.00	16	6	6	10	2.40	2.44	8	1.56	26
Feb – 16	32^0C	7.50	60.60	32	16	12	20	4.80	4.88	12	1.36	36
June – 16	37^0C	7.20	88.00	26	16	12	14	4.85	3.41	10	1.86	34

Table 2 -Value of diffrent Physico-Chemical parameter of sample of Rajgir hot spring of district Nalanda Bihar , Site 2nd - Brahm kund (Concentration expressed in Mg/l)

Parameter	Temp.	pH	EC	TH	TA	Ca-H	Mg-H	Ca^{++}	Mg^{++}	Chloride	Sulphate	TDS
Oct – 14	40^0C	7.05	200.25	40	16	10	10	4.00	7.32	24	2.82	66
Feb – 15	33^0C	7.60	138.60	44	24	16	16	6.40	6.83	20	2.72	58
June – 15	42^0C	7.00	128	36	16	12	12	4.80	5.85	16	2.56	54
Oct – 15	38^0C	7.15	186	52	28	32	28	8.00	7.80	24	2.74	66
Feb – 16	33^0C	7.25	148	48	20	30	32	7.20	7.32	30	2.44	68
June – 16	40^0C	7.05	98	36	22	24	24	4.80	5.58	20	2.44	60

7.3- Table 3 -Value of diffrent Physico-chemical of sample of Rajgir hot spring of district Nalanda Bihar , Site 3rd- Makhdum kund (Concentration expressed in mg/l)

Parameter	Temp.	pH	EC	TH	TA	Ca-H	Mg-H	Ca^{++}	Mg^{++}	chloride	Sulphate	TDS
Oct – 14	38^0C	7.00	81.5	10	8	4	6	1.60	1.46	6	1.42	24
Feb – 15	29^0C	7.95	60	20	12	8	12	3.20	2.93	8	1.28	26
June – 15	37^0C	7.40	68	28	18	12	16	4.80	3.90	10	1.40	32
Oct – 15	38^0C	6.95	82.5	20	12	8	12	3.20	2.92	8	1.32	26
Feb – 16	31^0C	7.45	64.8	20	12	8	12	3.20	2.93	8	1.30	22
June – 16	38^0C	7.00	64	18	8	8	10	3.20	2.44	8	1.32	22

Note –Concentration of Electrical Conductivity expressed in µs/cm.

8. Multiple correlation coefficient among following parameters of site Vishwamitra kund Munger.

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Temp.	6	218	36.33333	18.26667
pH	6	37.53	6.255	6.54475
EC	6	472.95	78.825	269.1797
TH	6	134	22.33333	39.06667
TA	6	74	12.33333	19.86667
Ca-H	6	52	8.666667	10.66667
Mg-H	6	82	13.66667	15.06667
Ca++	6	20.85	3.475	1.73375
Mg++	6	19.99	3.331667	0.897217
Chloride	6	56	9.333333	2.666667
Sulphate	6	11.35	1.891667	0.700017
TDS	6	202	33.66667	24.66667

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	31920.54	11	2901.867	85.07334	2.4E-32	1.952212
Within Groups	2046.611	60	34.11018			
Total	33967.15	71				

8.3.Correlation Coefficients(Concentration in mg/l)

	Temp.	*pH*	*EC*	*TH*	*TA*	*Ca-H*	*Mg-H*	*Ca++*	*Mg++*	*Chloride*	*Sulphate*	*TDS*
Temp.	1											
pH	-0.0404	1										
EC	0.9518	0.1860	1									
TH	-0.3494	0.5232	-0.2796	1								
TA	-0.5529	0.7386	-0.3387	0.7705	1							
Ca-H	-0.6209	0.4462	-0.4729	0.8491	0.9159	1						
Mg-H	-0.0402	0.4671	-0.0523	0.8958	0.4701	0.5259	1					
Ca++	-0.6148	0.4455	-0.4649	0.8469	0.9150	0.9999	0.5224	1				
Mg++	-0.0431	0.4657	-0.0557	0.8964	0.4707	0.5271	1.0000	0.5236	1			
Chloride	-0.1910	0.4146	-0.1807	0.9667	0.5862	0.7000	0.9676	0.6976	0.9680	1		
Sulphate	0.7431	0.1293	0.7737	-0.4591	-0.5075	-0.6914	-0.1574	-0.6863	-0.1606	-0.3386	1	
TDS	-0.0691	0.7551	0.1339	0.1332	0.3674	0.0658	0.1591	0.0658	0.1574	0.0658	0.4940	1

9. Multiple correlation coefficient among following parameters of site Brahm kund Munger.

9.1 Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Temp.	6	226	37.66667	14.66667
pH	6	43.1	7.183333	0.049667
EC	6	898.85	149.8083	1428.56
TH	6	256	42.66667	42.66667
TA	6	126	21	22
Ca-H	6	124	20.66667	87.46667
Mg-H	6	122	20.33333	80.66667
Ca++	6	35.2	5.866667	2.474667
Mg++	6	40.7	6.783333	0.786187
Chloride	6	134	22.33333	23.06667
Sulphate	6	15.72	2.62	0.02656
TDS	6	372	62	30.4

9.2 ANOVA

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	109098	11	9918.002 144.4026	68.683	9.02E-30	1.952212
Within Groups	8664.154	60				
Total	117762.2	71				

9.3 Correlation Coefficients(Concentration in mg/l)

	Temp.	*pH*	*EC*	*TH*	*TA*	*Ca-H*	*Mg-H*	*Ca++*	*Mg++*	*Chloride*	*Sulphate*	*TDS*
Temp.	1											
pH	-0.8631	1										
EC	-0.0344	-0.0431	1									
TH	-0.6289	0.4213	0.5423	1								
TA	-0.4231	0.4592	0.0300	0.6789	1							
Ca-H	-0.4058	0.0832	-0.0431	0.6984	0.7112	1						
Mg-H	-0.4845	0.1132	-0.1323	0.6364	0.5982	0.9778	1					
Ca++	-0.6462	0.4716	0.1789	0.9135	0.7806	0.8120	0.7625	1				
Mg++	-0.4702	0.2847	0.8657	0.8711	0.3607	0.3537	0.2932	0.6003	1			
Chloride	-0.5799	0.1370	0.4580	0.6800	0.1598	0.5818	0.6460	0.4941	0.7192	1		
Sulphate	0.0641	0.1872	0.7880	0.2555	0.1151	-0.3937	-0.5247	-0.0374	0.5675	-0.0715	1	
TDS	-0.3599	-0.0326	0.6321	0.6664	0.2165	0.5430	0.5493	0.4058	0.7822	0.9365	0.1424	1

10. Multiple correlation coefficient among following parameters of site Makhdum kund Rajgir.

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Temp.	6	211	35.16667	16.56667
pH	6	43.75	7.291667	0.151417
EC	6	420.8	70.13333	91.08667
TH	6	116	19.33333	33.06667
TA	6	70	11.66667	13.46667
Ca-H	6	48	8	6.4
Mg-H	6	68	11.33333	10.66667
Ca++	6	19.2	3.2	1.024
Mg++	6	16.58	2.763333	0.635067
Chloride	6	48	8	1.6
Sulphate	6	8.04	1.34	0.0032
TDS	6	152	25.33333	13.86667

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	25099.3	11	2281.755	145.2317	6.15E-39	1.952212
Within Groups	942.6684	60	15.71114			
Total	26041.97	71				

Correlation Coefficients(Concentration in mg/l)

	Temp.	*pH*	*EC*	*TH*	*TA*	*Ca-H*	*Mg-H*	*Ca++*	*Mg++*	*chloride*	*Sulphate*	*TDS*
Temp.	1											
pH	-0.9018	1										
EC	0.6727	-0.7269	1									
TH	-0.1652	0.3903	-0.4317	1								
TA	-0.1562	0.4178	-0.1926	0.8972	1							
Ca-H	-0.0777	0.3251	-0.4473	0.9899	0.8617	1						
Mg-H	-0.2307	0.4354	-0.4136	0.9939	0.9122	0.9682	1					
Ca++	-0.0777	0.3251	-0.4473	0.9899	0.8617	1	0.9682	1				
Mg++	-0.2345	0.4387	-0.4180	0.9939	0.9114	0.9682	1	0.9682	1			
chloride	-0.0777	0.3251	-0.4473	0.9899	0.8617	1	0.9682	1	0.9682	1		
Sulphate	0.6602	-0.4543	0.5475	-0.1722	0.1156	-0.1118	-0.2165	-0.1118	-0.2192	-0.1118	1	
TDS	0.1408	0.2438	0.0582	0.6849	0.8586	0.6794	0.6797	0.6794	0.6776	0.6794	0.4178	1

11. Graph of selected hot spring sites of Rajgir Nalanda district Bihar .

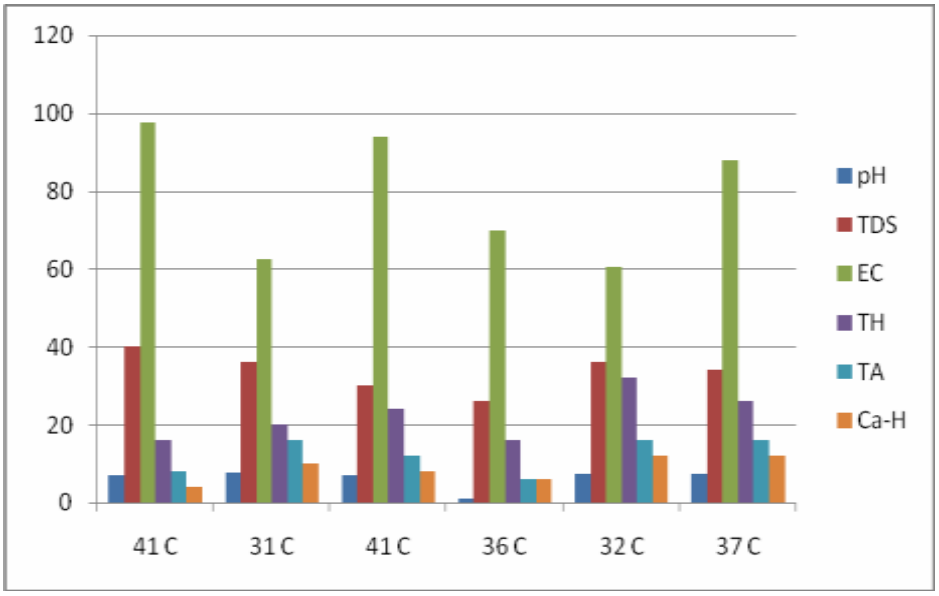


Figure 11.1- Variation of pH, TDS ,EC, TH, TA, Ca-H with respect to temperature at Vishwamitra kund Rajgir.

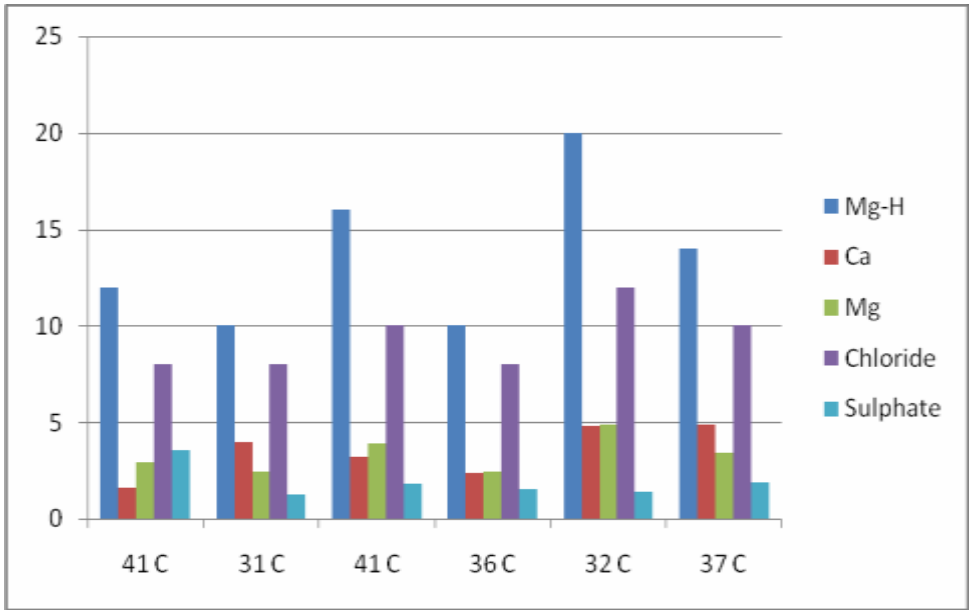


Figure 11.2- Variation of Mg-H, Ca, Mg, Chloride, Sulphate, with respect to temperature at Vishwamitra kund Rajgir

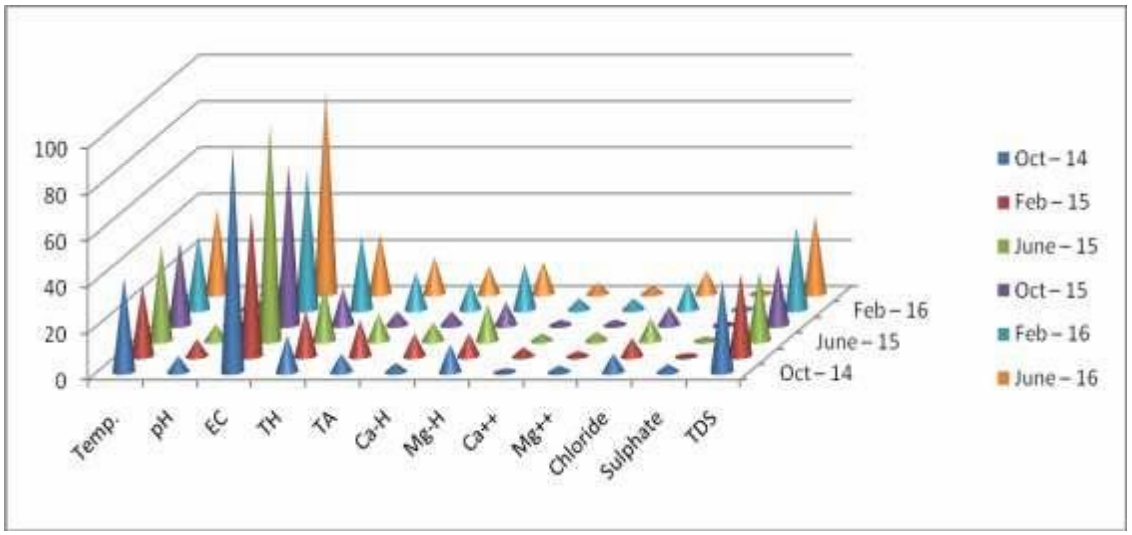


Figure 11.3 – showing variation of different parameters with respect to period at Vishwamitra kund.

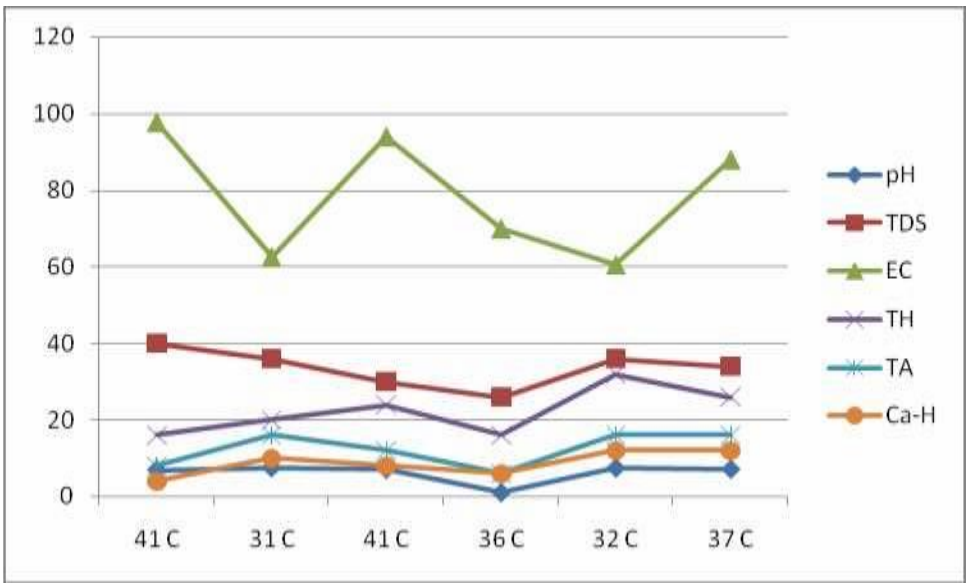


Figure 11.4 -Line graph showing variation of parameters like pH,EC,TH,TA,Ca-H,TDS with respect to temperature in Vishwamitra kund Nalanda district Bihar.

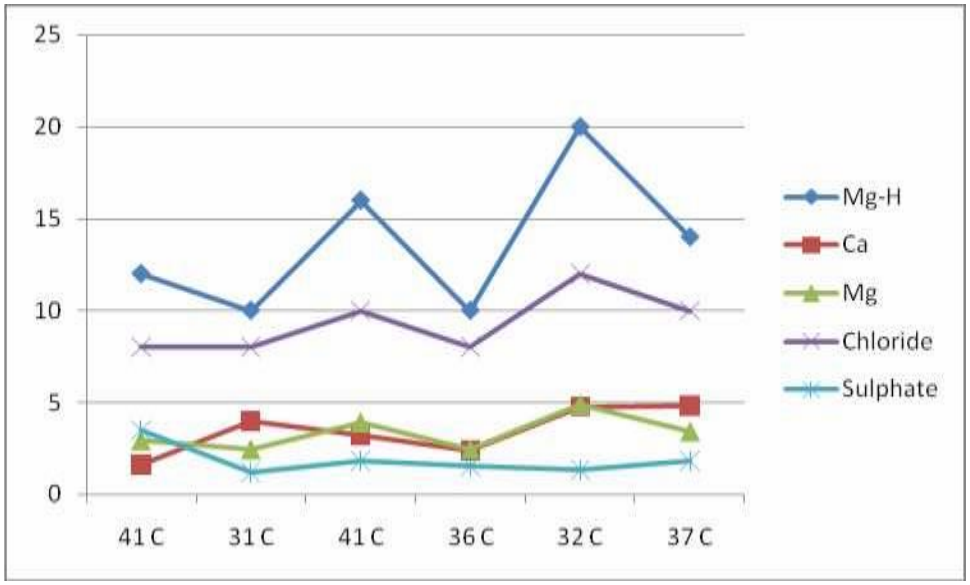


Figure11.5-Line graph showing variation of parameters like Mg-H, Ca , Mg, Chloride, Sulphate with respect to temperature at Vishwamitra kund .

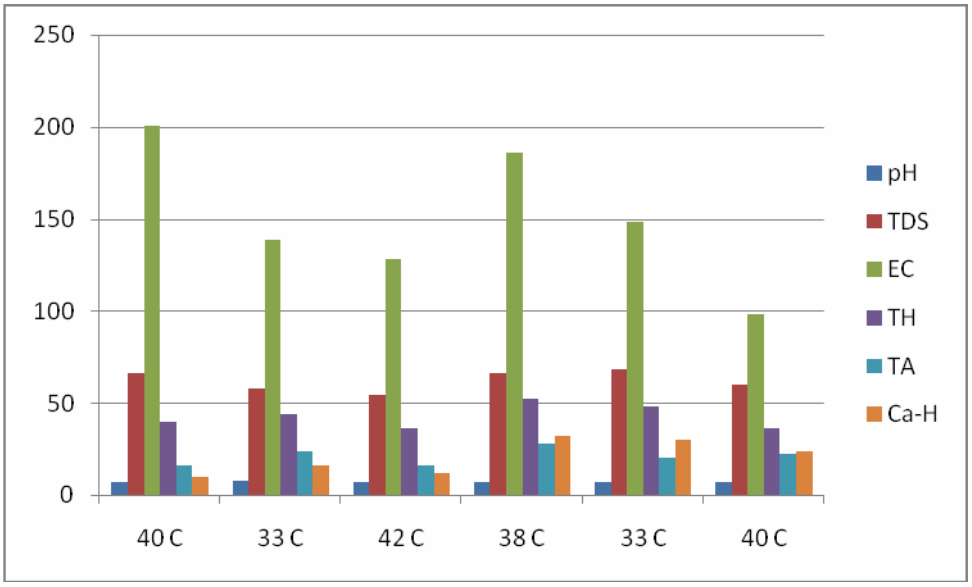


Figure11.6-Variation of pH, TDS,EC, TH, TA, Ca-H with respect to temperature at Brahm kund .

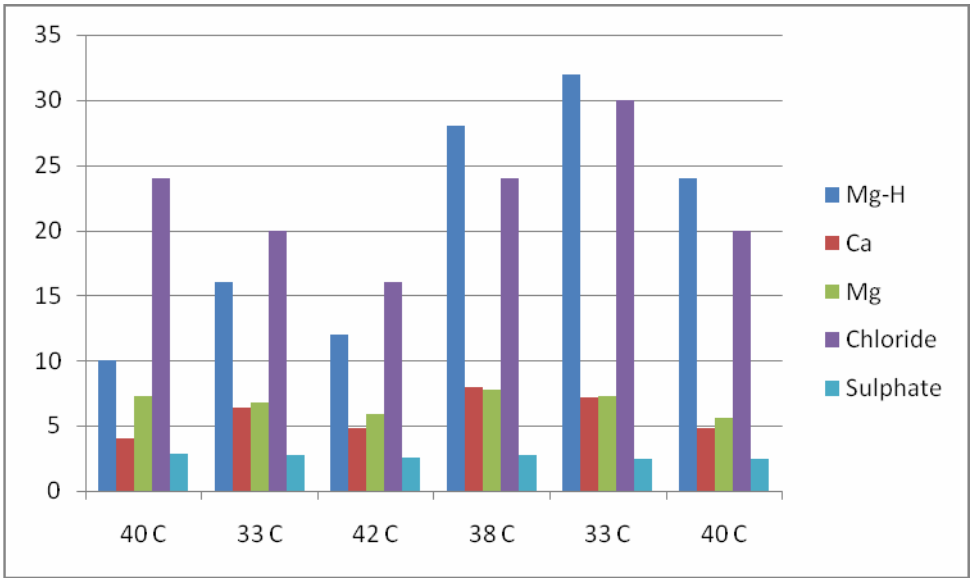


Figure 11.7-Variation of Mg-H, Ca , Mg, Chloride, Sulphate with respect to temperature at Brahm kund Rajgir.

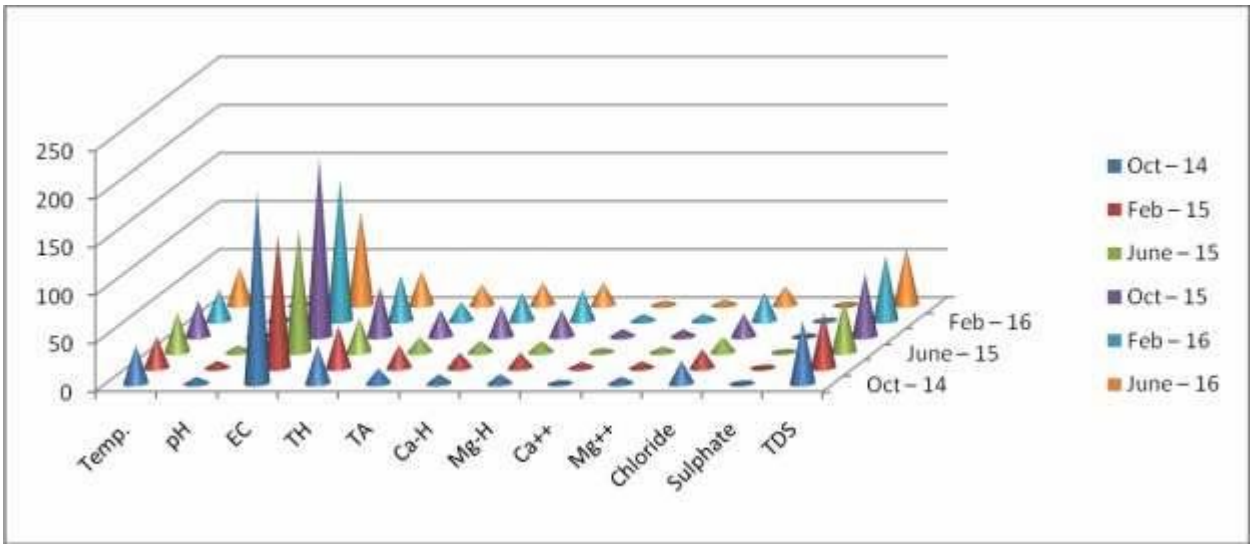


Figure 11.8- Variation of different parameters with respect to period at Brahm kund Nalanda district of Bihar State.

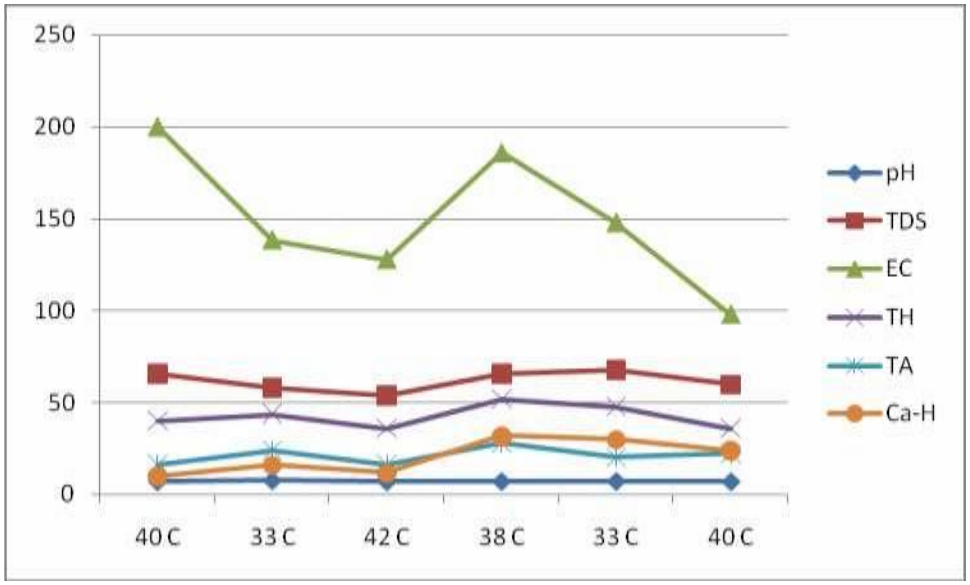


Figure 11.9 - Line graph showing variation of pH, EC,TH, TA,Ca-H, TDS with respect to temperature at Brahm kund Rajgir.

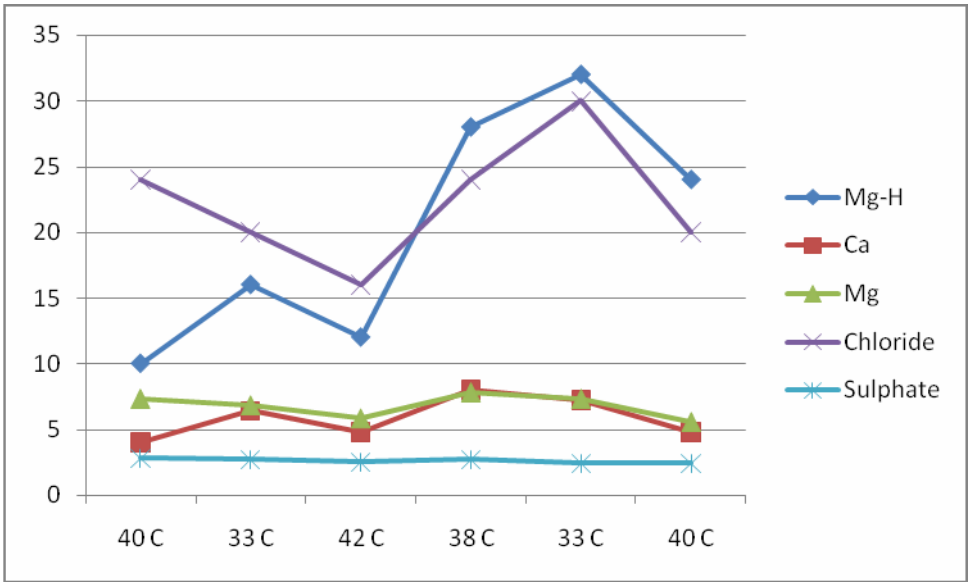


Figure 11.10-Line graph showing variation of Mg-H, Ca , Mg, Chloride, Sulphate with respect to temperature at Brahm kund Rajgir.

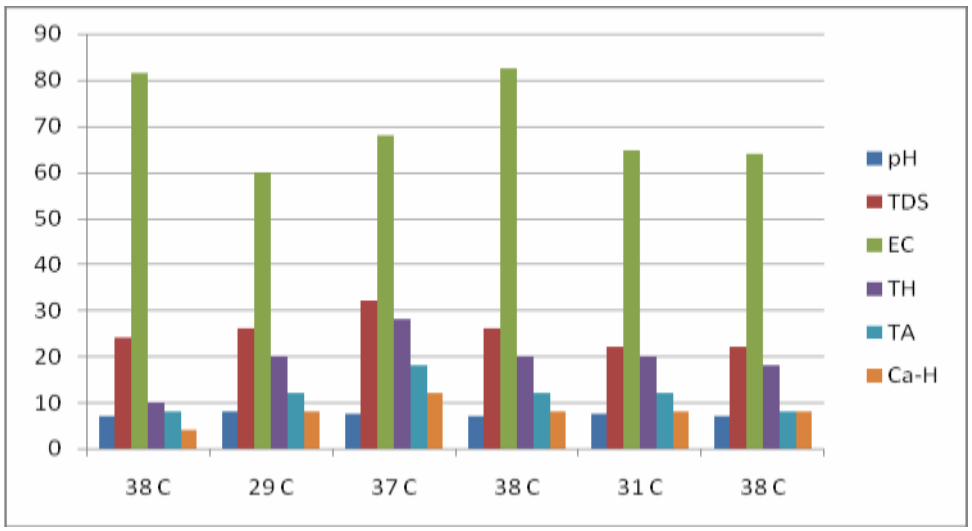


Figure 11.11- Variation of pH, EC,TH,TA,Ca-H,TDS with respect to temperature at Makhdum kund Rajgir.

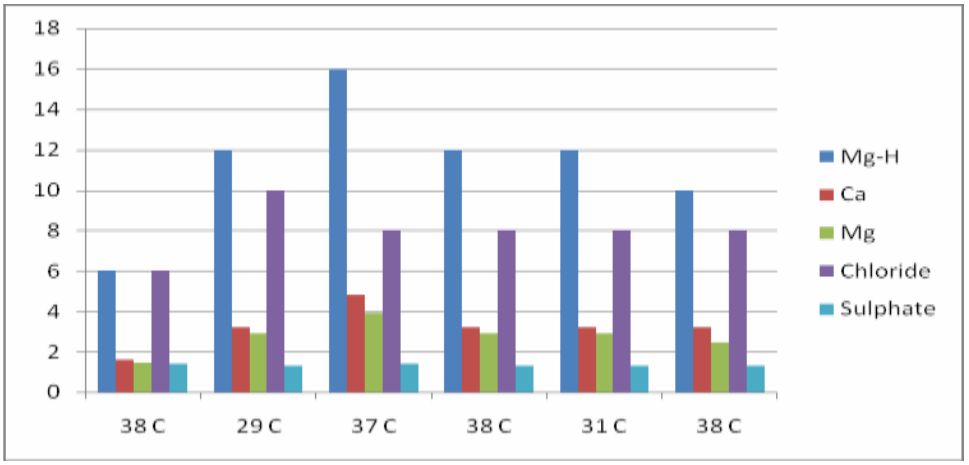


Figure 11.12-Variation of Mg-H, Ca , Mg, Chloride, Sulphate with respect to temperature at Makhdum kund Rajgir.

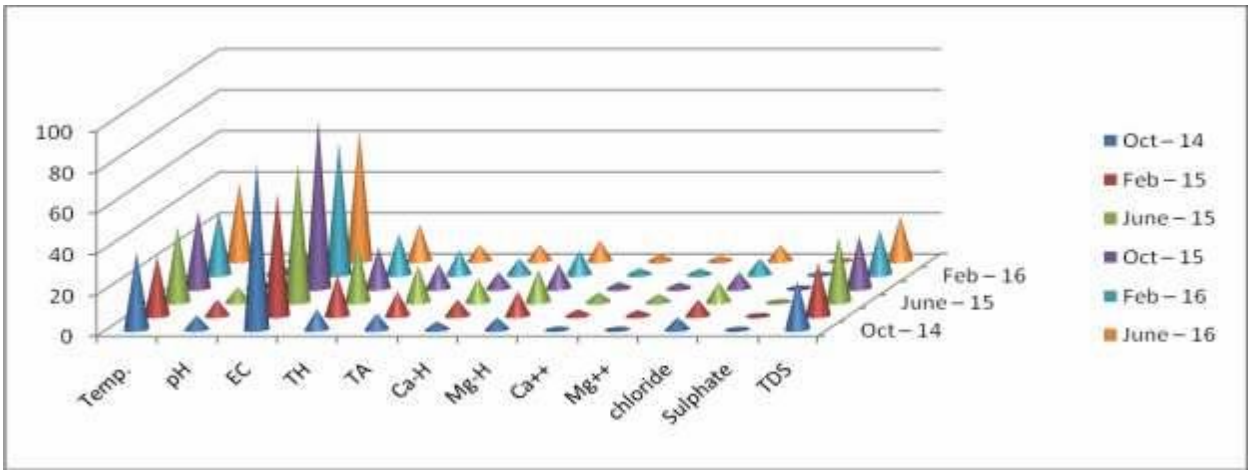


Figure 11.13- Variation of different parameters with respect to period from October 2014 to June 2016 at Makhdum kund Rajgir.

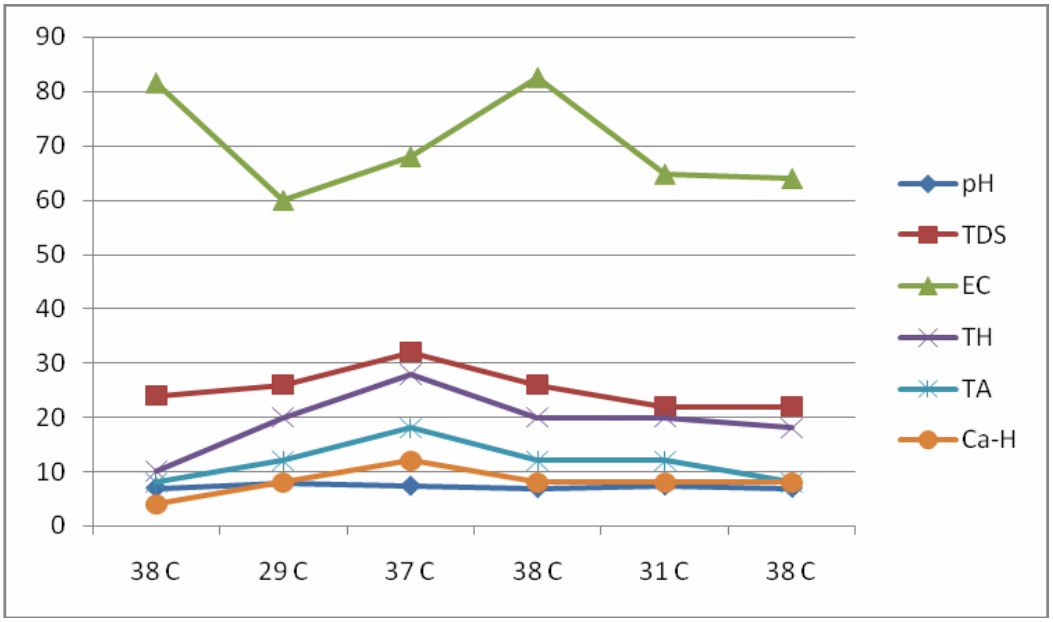


Figure 11.14-Line graph showing variation of like pH ,EC, TH, TA, Ca-H, TDS with respect to temperature at Makhdum kund Rajgir.

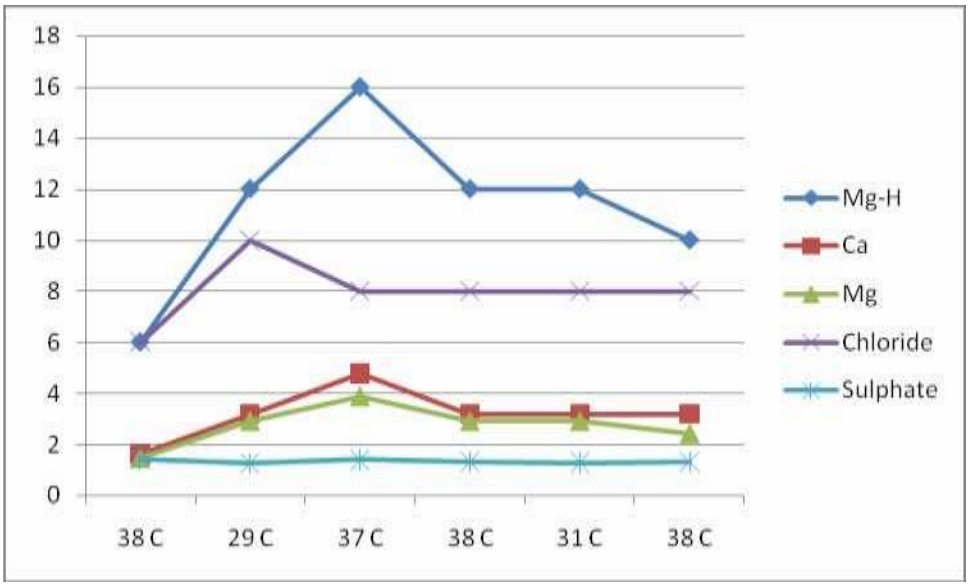


Figure 11.15 -Line graph showing variation of Ca, Mg, Chloride, Sulphate, Mg-H, with respect to temperature at Makhdum kund Rajgir .

12. Conclusion :- From the result of Physico-Chemical analysis of this study it is concluded that the water quality of Vishwamitra kund, Brahmkund as well as Makhdum kund of Rajgir hot spring sites of Nalanda District are considered to be acceptable for domestic use and the water of above spring sites of Rajgir are observed to be fit for drinking purposes.

13. Acknowledgement :-

The authors are thankful to P.G. department of chemistry TMBU Bhagalpur, Marwari College Bhagalpur, providing laboratory facilities for research work.

The authors are also extremely thankful to all staff member of both P.G. department as well as Marwari College for kindly support.

14. References :-

1. Amend J P, Shock EL, "Energetics of over all metabolic reactions of thermophilic and hyperthermophilic Archaeabacteria", *FEMS microbiology review*, Vol. **25**, pp. 175-243, 2001.
2. A.P.H.A. *Standard methods for the examinations of water and waste water*. 21 Ed., American Public health Association, Washington DC, 2005.
3. Brock TD. Life at high temperature. Sci J. 1967; 158 : 1012-1019.
4. Chatterjee B and Chatterjee SD. *The Bakreshwar thermal springs India Sci Cult.* 1958; **23**:336-341.
5. Clay Thompson, "Tonopah: It's water under the Bush", *The Arizona Republic* 1-12-03, p.B12
6. Das A, Palita S K and Patra HK (2013). Physico – Chemical analysis of thermal springs of Atri in the district of Khurda, Odisha, India. *International journal of chemical sciences and Applications* **4** (2) 97-104.
7. Das A, Palita S K and Patra H K (2012). Diversity of zooplanktons in hot water spring of Atri, Odisha, India. *International journal of environmental science and Technology* **1** (2) 111-119.
8. Mahala SC, Singh P, Das M and Acharya S (2012). Genesis of thermal springs of Odisha, India. *International journal of Earth sciences and Engineering* **5** (6) 1572-1577.
9. Reddy DV, Nagbhusanam P and Ramesh G (2013), Turnover time of rural and Rajvadi hot spring water, Maharashtra, India. *Current Science* **104** (10) 1419-1424.
10. Rubenowitz Eva, Gosta Axelsson, Ragnar Rylander. Magnesium in drinking water and death from acute myocardial infarction, *American Journal of epidemiology*, 1996, **143** (5) : 456-62.
11. Sharma B.K., "*Environmental chemistry*", IV edition, Goel publication House, Meerut, 2001.
12. Trivedy RK and Goel PK . *Chemical and biological method for water pollution studies*, Environmental publications, Karad, India, 1986.
13. Young M.C., Aqua Thermal Access, ISBN 1-890880-7, vol. 4,pp. 8, 2007.
14. World Health organization WHO *Guidelines for drinking water quality* 3rd edition Geneva PP.3 – 6 (2004).