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IMPACT OF SEASONAL VARIATION ON UNDERGROUND WATER QUALITY IN BBN AREA, HIMACHAL PRADESH, INDIA

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ABSTRACT

The present investigation was carried out in BBN (Baddi-Baroutiwala-Nalagharh) area of Solan district of Himachal Pradesh. The sources, Hand pumps and bore wells taken for the sampling of underground water in this study area. This study of underground water is focused on seasonal variation of the quality of groundwater and level of pollution in underground water sources in BBN area. The analysis of physico-chemical parameters of six sampling stations during April, 2018 to December, (2018). Parameters such as Temperature, pH, turbidity, Total alkalinity, Total Dissolved Solids (TDS), sodium, cadmium, copper, iron, lead etc. The analysis results were carried out according to APHA, 2012 procedures. The results obtained have been compared with BIS standards for drinking water (BIS: IS: 10500, 2012). The result revealed that the concentration of mostly physico-chemical parameters found higher in monsoon season as compared to summer and winter seasons. The assessment shows that underground water of this area is not suitable for drinking purpose without purification. Domestic sewage and Chemicals or industrial effluents are the main responsible factors for quality degradation of underground water in the BBN area.

KEY WORDS : Seasonal variation, BBN (Baddi-Baroutiwala-Nalagharh), Assessment, Pollution, Underground water.

INTRODUCTION

The 70 % of our body weight is water and it is so valuable element for surviving living beings on this planet (Buchholz, 1998). About 20 % is ground water out of fresh water availability in the world, which is used by domestic and industrial level mostly (Usha *et al.,* 2011). Mostly ground water is used for drinking purpose. In rural areas about 85% requirement of the water for domestic use is fulfilled by ground water sources. At urban and industrial level, 55% requirement of water is completed by ground water sources. Water is so much precious gift given by nature for living beings but presently natural sources of water contaminated by industrialization and urbanization. Potable water is important element for survival and suitability of life (Kumar, 1997). It was reported by some studies that globally the quality of water deteriorated day by day (Mahanada *et al.*, 2005). Presently contamination is not the issue of surface water but also of ground water due to leaching of toxic materials from waste materials dumping and from industries.

Maximum municipal and industrial wastages containing high concentration of heavy metals, which further merges into water sources through the pores of soil (Moore *et al.,* 1998). These waste materials further increase the impurity level by unfavorable conditions of physico-chemical and biological properties of water. Further these impurities change the taste, odor and color of water, which causes staining, hardness and corrosiveness (Vollenwinder, 1968). Generally the possibility of ground water contamination is less as compared to the surface water. In our country mostly ground water sources used for irrigation and industrial purposes but due to industrialization these precious resources of water are getting polluted very fast. The use of fertilizers in agriculture activities is the major reason for the threat of ground water ecosystem

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beside this major issue municipal and industrial effluents are also responsible factors. The discharge of waste materials and chemicals from industries are the major sources for pollution of water. The surface runoff is the seasonal factor for water pollution, which further mainly affected by the change in climate (Singh *et al.*, 2004; Kumar *et al.*, 2015; Bhutiani *et al.*, 2016).

Effluent and solid waste discharged from industries causing water pollution, which further leads to serious health issues (Raja *et al.*, 2002; Mishra and Bhatt, 2008). Growing population of world put stress on water sources. The unavalibity of clean water sources further causes water borne diseases. In the present time contamination of surface water and decreasing natural water resources are the serious issues for society. By decreasing the surface water sources great stress on ground water sources to fulfill the clean water demand of society. Society knows the importance of ground water even though the management of water resources is so poor at the level of world scenario (Fakayode, 2005). Increasing rapidly industrialization in current time by developing countries like India has a serious problem about groundwater pollution. The study of water quality is the major and valuable work in the field of water sector. In last few years groundwater exploitation increases because mostly surface water sources polluted due to industries and population growth. The effluent discharged from industries percolated into sources of ground water, which further

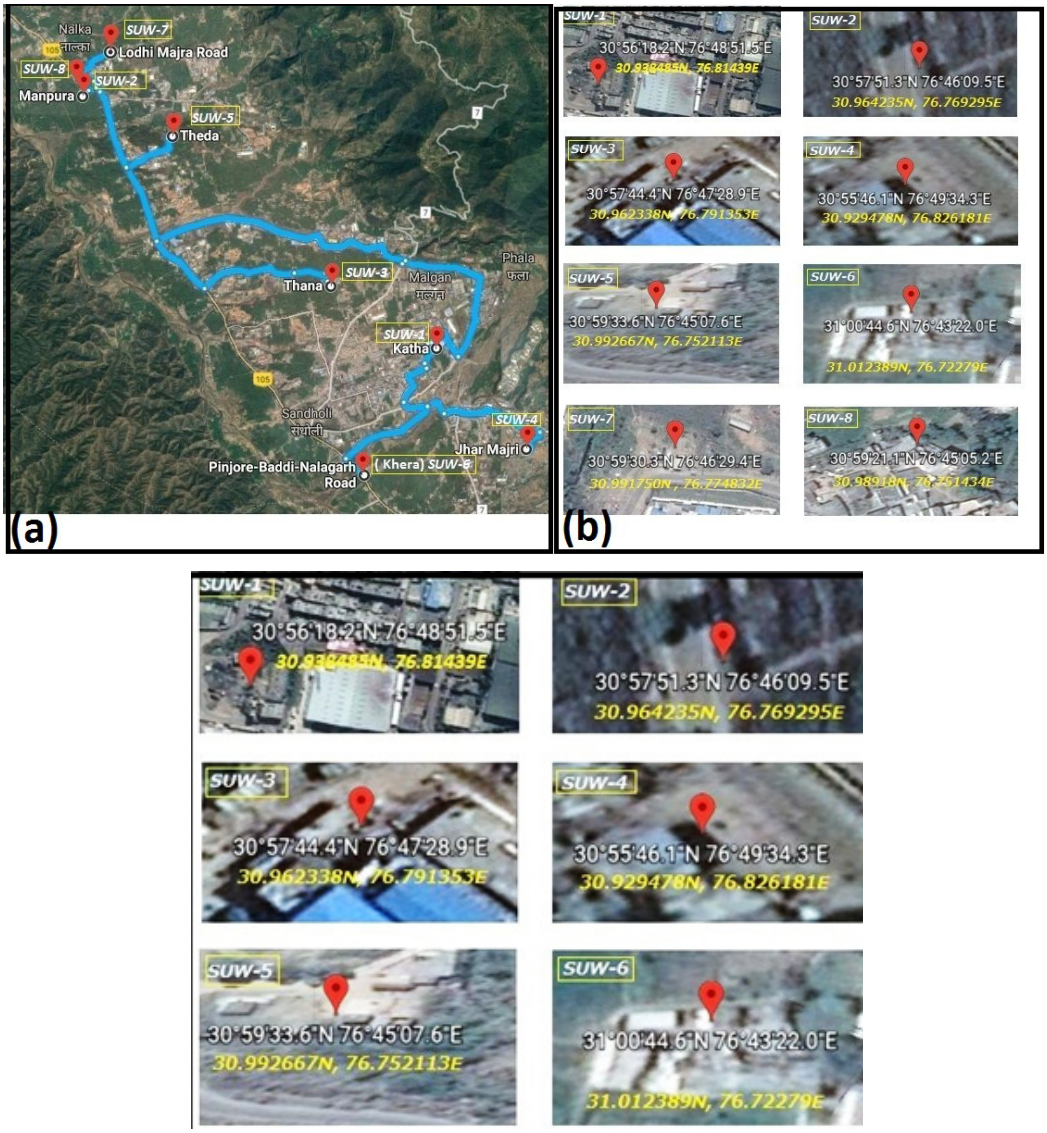

Figure: 1 Map and location of sampling sites

increases the level of chemicals in water. Once the aquifer system of groundwater is polluted, it remains polluted for many years. Over the world to check and assess the water quality is the prime and challenging issue in present time. Testing of various parameters aware us that water is usable or not, which conclude by comparing the data with standard guidelines. Therefore the study on quality checkup of water never declined in present era of time. Rapidly industrialization and urbanization in BBN area of Solan district of Himachal Pradesh has adversely affect on underground water quality. Therefore water quality assessment is very important in this area.

MATERIALS AND METHODS

Study Area Description

This study was carried out in BBN area, Solan district of Himachal Pradesh, which is located at 46 kilometers away from south of the state capital, Shimla. Its elevation average 1600 meters. This area is located in Shivalik range of the Himalayas with Longitude 77° 5' 48.2388'' E and Latitude 30° 54' 16.1496'' N. Mostly the underground water in BBN area used for domestic, drinking and industries purposes.

Sampling Stations and Sources

Underground water samples were collected from different six sampling stations of BBN area in Solan district during April, 2018 to December, 2018. This BBN area is famous due to industries, which provide employment for local people and for outsiders also.

Further industrialization put great stress on the sources of underground water in BBN area. Samples of underground water were collected from hand pumps and bore wells from the selected sites in sterile plastic bottles by using standard procedure of APHA, 2012. Disposable gloves used for the sampling of underground water. After collection samples were transported to lab for the further analysis of various parameters. A pollution sources near ground water sources was the criteria for choosing the sampling sites. Therefore the detail of six sampling sites with source of water is given below in Table 1.

Table 1. Sampling sites description with source of water

Sampling Station	Source
Katha (SUW-1)	Bore well
Manpura (SUW-2)	Hand pump
Thana (SUW-3)	Bore well
Jharmagri (SUW-4)	Hand pump
Theda (SUW-5)	Bore well
Khera (SUW-6)	Bore well

METHODOLOGY

The analysis of Physico-chemical parameters required for the assessment of seasonal variation of ground water quality in BBN area of Solan district in Himachal Pradesh. The data of all three season (monsoon, winter and summer) analyzed from April, 2018 to December, 2018. Samples were collected and preserved as per standard methods of APHA, (2012).

A.R grade chemicals were used for the assessment of water quality. For identification of physico-chemical parameters- BOD Incubator, UV Spectroscopy, conductivity meter, Turbidity meter, mercury thermometer, digital pH meter and Titrations were used. For the identification of heavy metals, Atomic Absorption Spectroscopy (AAS, Perkin Elmer-A Analyst 400) were also used.

The data obtained by the analysis of physico-chemical parameters of underground water sources in study area, further compared with the limits prescribed by Bureau of Indian Standards(BIS: IS: 10500,2012). The acceptable and permissible limits of Indian standard are shown in Table 2.

RESULTS AND DISCUSSION

In the present study, underground water from six different sampling stations in study area has been sampled and analyzed for a period of one year in monsoon, winter and summer seasons. Twenty six different physico-chemical parameters of underground water (Total alkalinity, BOD, Magnesium hardness, Total hardness, Sodium, Ammonia, Sulfate, Fluorides, Calcium, Chlorides, COD, Copper, Iron, Lead, Nitrate, pH, Temperature, TDS, Turbidity, Colour, Odor, Calcium, Mercury, Zinc, Boron and Manganese) were analysed by prescribed standard methods.

Analyses of ground water samples including the determination of physico- chemical parameters and concentration of heavy metals, which is further shown in Tables 3, 4 and 5.

The samples of underground water were collected from six different sampling stations from

BBN area. The variation in mean values is observed during the analysis of physico-chemical parameters and heavy metals of these water samples, which is shown in Tables 3, 4 and 5. The results were analyzed comparatively for three different seasons and also with the standard limits recommended by BIS, (2012). These results can be useful in evaluating the chemical status and drinking quality of underground water of these sampling stations in the area of study.

Total alkalinity: Mean concentration of this parameter was found within range 289.125- 447.610 mg/l throughout the year in different sampling stations of underground water in the study area. The lowest mean concentration of total alkalinity was found in summer season (SUW-4), whereas its mean concentration value was found highest in monsoon season (SUW-2). A comparative result of analysis indicates that values of this parameter were found above the acceptable limit but below permissible limit, according to BIS, 2012 standard.

BOD: Mean concentration of BOD was measured in range, i.e. 2.80-4.92 mg/l. Maximum mean concentration of BOD was measured during summer and monsoon season. However the values were found below from acceptable limits, according to BIS, 2012 standard.

Magnesium Hardness: Mean concentration of Magnesium hardness was found within range 8.30-19.69 mg/l throughout all seasons. Maximum mean value for magnesium hardness was observed during winter season as compared to summer and winter. Present investigation also shows that the magnesium contents in majority of samples do not exceed the limit as prescribed by BIS, 2012.

Total Hardness: The concentration of total hardness ranges between 282.77- 348.59 mg/l. The lowest mean concentration of this parameter was measured in summer season while the concentration was highest in monsoon and winter season. The measured values were found above from acceptable limits but below from permissible limits recommended by BIS, 2012.

Sodium: Mean concentration of sodium ranges between 15.60- 37.09 mg/l. The concentration was found lowest during summer and highest during monsoon season. The values were found below from acceptable as well as permissible limits

Table 2. Limits Prescribed by BIS, 2012

Parameters	Acceptable Value	Permissible Limit
Alkalinity (as $CaCO_3$) mg/l	200	600
Biological Oxygen Demand (BOD) mg/l	30	No Relaxation
Calcium Hardness mg/l	75	200
Chemical Oxygen Demand (COD) mg/l	250	
Chloride (as Cl^-), mg/l	250	1000
Copper (as Cu) mg/l	0.05	1.5
Iron (as Fe) mg/l	0.3	1
Lead (as Pb) mg/l	0.01	No Relaxation
Mercury (as Hg) mg/l	0.001	No Relaxation
Magnesium Hardness	-	-
Nitrate (asNO_3^-) mg/l	45	No Relaxation
pH	6.5	8.5
Temperature	-	-
Total Hardness mg/l	200	600
Total Dissolved Solids mg/l	500	2000
Turbidity	1	5
Colour (Hazen)	5	15
Odour	-	-
Fluoride mg/l	1	1.50
Sodium mg/l	-	-
Cadmium mg/l	0.003	No Relaxation
Zinc mg/l	5	15
Manganese mg/l	0.1	0.3
Sulphate mg/l	200	400
Boron mg/l	0.5	1
Ammonia mg/l	0.5	No Relaxation

Table 3. Data analysis of six sampling stations in BBN area during summer season

Sr. No.	Parameters	Units	Sampling Station					
			Suw-1	Suw-2	Suw-3	Suw-4	Suw-5	Suw-6
1	Total alkalinity	mg/l	294.2	317.18	317	289.125	295.35	320.35
2	BOD	mg/l	4.925	2.8	3.9	4.35	3.2	4.4
3	Magnesium hardness	mg/l	11.48	19.17	14.49	12.4	13.92	11.475
4	Total hardness	mg/l	293.005	282.77	299.1	297.3	294.995	293.25
5	Sodium	mg/l	31.5	18.3	23.25	15.6	17.05	21.51
6	Ammonia	mg/l	0	0	0	0	0	0
7	Sulfate	mg/l	193	161.5	166.375	184.44	186	15.48
8	Flouride	mg/l	0.145	0.095	0.215	0.085	0.701	0
9	Calcium hardness	mg/l	55.28	47.01	48.81	47.795	45.325	48.19
10	Chlorides	mg/l	109.105	112.35	147.8	121.505	108.615	120.21
11	COD	mg/l	82.845	52.6	84.005	79.655	92.82	88.01
12	Copper	mg/l	0.0625	0.0175	0.25	0.027	0.0295	0.0315
13	Iron	mg/l	0.445	0.34	0.13	0.38	0.575	0.765
14	Lead	mg/l	0.0085	0.006	0.005	0	0	0
15	Nitrate	mg/l	15.68	16.31	21.95	18.82	16.525	17.45
16	pH value	-	7.7	7.6	7.895	7.765	7.8	7.95
17	Temperature	˚C	25.5	25.5	25	25.5	25	25.5
18	TDS	mg/l	463	447	425	489.5	437	448
19	Turbidity	NTU	0	0	0	0	0	0
20	Colour	Hazen	1	1	1	1	1	1
21	Odor	-	agreeable	agreeable	agreeable	agreeable	agreeable	agreeable
22	Cadmium	mg/l	0	0	0	0	0	0
23	Mercury	mg/l	0	0	0	0	0	0
24	Zinc	mg/l	0.52	0.605	0.341	0.435	0.849	0.325
25	Boron	mg/l	0	0	0	0	0	0
26	Manganese	mg/l	3.6	2.835	5.5	0.155	0.265	0.32

recommended by BIS, 2012.

Sulfate: Mean concentration of sulfate ranges between 15.48- 205.57mg/l throughout the year. The concentration was exceptionally minimum in SUW-6 in all seasons. Maximum values were observed in monsoon season as compared to summer and winter. The values of this parameter were found above from acceptable limits at SUW-4 but below from permissible limits recommended by BIS, 2012.

Fluorides: The concentration of fluoride ranges between 0.00-0.82 mg/l. The level of fluoride for SUW-6 was not detected throughout the year however the concentration of fluoride was found quite high in monsoon and winter season for rest sampling stations. The observation shows that the mean values of fluoride were found below from acceptable and permissible limits recommended by BIS, (2012).

Calcium Hardness: The mean concentration of calcium hardness was found within range 45.32-65.45 mg/l. The concentration was observed very high during winter season as compared to summer season. The concentration analysis indicates that the mean values were found below from acceptable and permissible limits recommended by BIS, 2012.

Chlorides: Mean concentration value of chlorides varied from 56.15- 149.94 mg/l. The concentration was appreciable in all seasons and there was no marked variation. However the values were found below from acceptable as well as permissible limits recommended by BIS, 2012.

COD: Mean concentration of COD varied from 52.60- 94.08 mg/l. Maximum COD value was observed during monsoon season as compared to summer and winter season. On an average, the observed values were found below from acceptable and permissible limits.

Copper: Mean concentration values of heavy metal copper varied from 0.0175- 0.4 mg/l. The highest concentration of copper was observed during monsoon as well as winter season particularly at sampling station SUW-3. While as the concentration of copper was found above from acceptable limits but below from permissible limits.

Iron: Mean concentration of heavy metal irons ranges between 0.13-0.99 mg/l. Its concentration

was found high during monsoon and winter season. The comparative analyses of observed values indicated that the concentration of iron was found above acceptable limits in all seasons and nearby permissible limits in monsoon and winter season recommended by BIS, (2012).

Lead: Mean concentration of this heavy metal varied from 0.000-0.094 mg/l in all seasons. The concentration was very low during summer season whereas it was high during monsoon and winter season. Lead was not detected in sampling station, SUW-6 throughout the year. The observed values were found below from acceptable and permissible limits in all sampling stations except SUW-2, where the values were found above from acceptable limits recommended by BIS, 2012.

Nitrates: The mean concentration of nitrates ranges between 13.215-22.795 mg/l in all seasons. Higher values were observed during monsoon and winter season. However the measured values were found below from acceptable and permissible limits, when compared with BIS, 2012 standards of drinking water.

pH: The pH value ranges between 7.12-8.00 throughout the year. Maximum pH values were observed during summer season. The values were found above from acceptable limits but below from permissible limits recommended by BIS, 2012.

Temperature: The mean temperature of underground water samples in all sampling stations throughout the year varied between 21.00-25.50. The variation in water temperature may be due to different timing of collections and influence of seasons.

TDS: TDS indicates the total amount of inorganic chemicals in solution or liquid. The mean concentration of TDS in current sampling stations was observed higher in monsoon season as compared to other seasons. The concentration was found above from acceptable limits in monsoon and winter season. But its mean value was found below from permissible limits throughout year in all sampling stations.

Table 4. Data analysis of six sampling stations in BBN area during monsoon season

Sr. No.	Parameters	Units	Sampling Station					
			Suw-1	Suw-2	Suw-3	Suw-4	Suw-5	Suw-6
1	Total alkalinity	mg/l	383.71	447.61	371.32	363.41	434.295	340.775
2	BOD	mg/l	4.2	3.16	4.4	4.65	4.9	4.6
3	Magnesium hardness	mg/l	8.385	19.34	15.79	14.63	14.5	14.24
4	Total hardness	mg/l	339.39	370.26	332.155	329.09	348.51	300.475
5	Sodium	mg/l	37.095	18.93	26.925	16.59	18.245	24.88
6	Ammonia	mg/l	0	0	0	0	0	0
7	Sulfate	mg/l	195.71	162.81	167.795	205.57	190.985	19.57
8	Flouride	mg/l	0.48	0.315	0.495	0.16	0.818	0
9	Calcium hardness	mg/l	59.9	64.81	57.9	56.875	62.165	58.48
10	Chlorides	mg/l	122.735	126.13	148.4	90.695	109.64	123.8
11	COD	mg/l	91.965	73.485	87.42	76.7	91.505	94.08
12	Copper	mg/l	0.0765	0.0245	0.36	0.026	0.0385	0.0485
13	Iron	mg/l	0.55	0.74	0.395	0.7255	0.761	0.99
14	Lead	mg/l	0.0265	0.091	0.009	0.012	0.004	0
15	Nitrate	mg/l	13.215	17.78	22.795	18.975	17.24	20.65
16	pH value	-	7.605	7.795	7.765	7.7	8.005	7.845
17	Temperature	℃	26	24.5	25.5	25	25.5	25.5
18	TDS	mg/l	517.5	1023.5	406	544	554	487
19	Turbidity	NTU	0	0	0	0	0	0
20	Colour	Hazen	1.5	1.5	1.5	2	2	2
21	Odor	-	agreeable	agreeable	agreeable	agreeable	agreeable	agreeable
22	Cadmium	mg/l	0	0	0	0	0	0
23	Mercury	mg/l	0	0	0	0	0	0
24	Zinc	mg/l	1.165	1.221	1.23	1.342	1.285	1.925
25	Boron	mg/l	0	0	0	0	0	0
26	Manganese	mg/l	4.21	2.95	6.12	0.565	0.6	0.6

Table 5. Data analysis of six sampling stations in BBN area during winter season

Sr. No.	Parameters	Units	Sampling Station					
			Suw-1	Suw-2	Suw-3	Suw-4	Suw-5	Suw-6
1	Total alkalinity	mg/l	362.675	412.27	327.91	316.185	422.645	313.635
2	BOD	mg/l	3.15	3.45	3.4	3.95	4.15	3.8
3	Magnesium hardness	mg/l	14.84	19.695	15.82	16.61	15.255	14.66
4	Total hardness	mg/l	332.445	343.36	310.535	318.975	332.71	291.57
5	Sodium	mg/l	32.91	17.74	26.24	16.015	18.1	22.79
6	Ammonia	mg/l	0	0	0	0	0	0
7	Sulfate	mg/l	198.18	160.07	164.09	101.82	185.11	19.14
8	Flouride	mg/l	0.81	0.42	0.73	0.32	0.8205	0
9	Calcium hardness	mg/l	65.45	65.35	62.23	62.21	63.825	62.375
10	Chlorides	mg/l	115.1	121.31	149.945	56.15	107.32	119.48
11	COD	mg/l	91.39	76.27	76.04	73.16	79.58	84.735
12	Copper	mg/l	0.083	0.0375	0.4	0.027	0.047	0.0525
13	Iron	mg/l	0.61	0.815	0.505	0.915	0.7855	0.985
14	Lead	mg/l	0.0365	0.094	0.0155	0.0175	0.0085	0
15	Nitrate	mg/l	13.52	14.74	19.4	19.07	14.29	19.775
16	pH value	-	7.355	7.245	7.12	7.195	7.145	7.125
17	Temperature	˚C	21.5	23	22	21	21	22.5
18	TDS	mg/l	511	929	399	489.5	487.5	515
19	Turbidity	NTU	0	0	0	0	0	0
20	Colour	Hazen	1.5	1.5	1.5	1.5	1.5	1.5
21	Odor	-	agreeable	agreeable	agreeable	agreeable	agreeable	agreeable
22	Cadmium	mg/l	0	0	0	0	0	0
23	Mercury	mg/l	0	0	0	0	0	0
24	Zinc	mg/l	1.1395	1.1755	1.2555	1.324	1.375	2.15
25	Boron	mg/l	0	0	0	0	0	0
26	Manganese	mg/l	2.985	3.05	6.01	0.685	0.615	0.64

Zinc: Mean concentration of this heavy metal varied between 0.15- 6.12 mg/l throughout all seasons in all sampling stations. Maximum concentration of zinc was observed during winter season. On an average the measured values were found below from acceptable and permissible limits recommended by BIS, (2012).

Manganese: Mean concentration of manganese ranges between 0.15- 6.12 mg/l in all seasons across the year. Higher concentration of manganese was found during winter season. Comparative analysis indicates that the observed values were found above from acceptable as well as permissible limits in all seasons.

The Concentrations of Cadmium, mercury (Hg) and ammonia were detected nil at all underground water sampling stations in BBN area throughout year, whereas physical parameters like turbidity, colour and odor were found agreeable according to BIS, (2012).

CONCLUSION

A marked variation was observed in the physico-chemical parameters of underground water samples during different seasons. Various physico chemical parameters like total alkalinity, BOD, Sodium, Sulphate, Fluorides, COD, Copper, Iron, Lead, TDS and nitrate were found high in monsoon season as compared to summer and winter seasons but Total hardness and pH were found high during summer season.

The concentration of Magnesium hardness, Calcium hardness, Zinc and Manganese were found high during winter season. From these data, it is evident that the physico-chemical parameters as well as the concentration of most of the heavy metals in summer season were found low. However, all these parameters exhibit increasing trends in monsoon and winter seasons, which can be due to rise the level of water table. This study concluded that the underground water sources in study area were not much fit for drinking purposes without further treatment.

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