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Seasonal Variation in Ground Water Quality of Baswa Tehsil, Dausa District, Rajasthan: A Statistical Approach

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ABSTRACT

In the present study seasonal variation in ground water quality of Baswa Tehsil, Dausa were assessed with the help of statistical techniques. 18 water samples were collected in each season (May 2020, Oct.2020, May 2021 and Oct 2021) and analyzed for seven water quality parameters. Electrical conductivity, Total dissolved solids, Total hardness, Chlorides, Calcium and Fluorides all were present above the permissible limit prescribed by BIS. Although the concentration of above parameters are comparatively less in the post-monsoon, still the ground water comes in very poor quality and not fit for drinking purposes. Statistical analysis of all the collected data also indicated the poor water quality index in the study area. Fluoride content is much higher (4.9- 14.8 mg/l) than the prescribed value which results the dental and skeletal fluorosis in most of the population of this area. Total hardness is also higher than the prescribed value in all the collected samples in each season.

Keywords Water quality, Pre-monsoon, Post-monsoon, Statistical analysis, Dental fluorosis.

INTRODUCTION

Water is very important for living beings after air for their survival. Uncontaminated and clean water is a necessity for a healthy life. Less than 1% of earth's water is available for human consumption and more than 1.2 billion people still have no access to safe drinking water. Almost 50% of mega cities having population over 10 million are heavily dependent on groundwater but our ground water resources are adversely affected by many development activities like irrigation practices, industrialization, urbanization, geological processes occurring within them and reactions with aquifer minerals (Chartterjee *et al*. 2010, Nagarajan *et al*. 2010) rainfall patterns, filtration rate, leaching of pollutants from the landfills (Srivastava and Ramanathan 2008).

Studies on the seasonal variation of WQI of water quality in water treatment plants in Delhi and Hebbal Lake, Bangalore, India indicated that the quality of raw water varied from season to season and water quality index showed excellent water quality in monsoon season due to fresh recharge of rain water and very poor in winter season (Saxena *et al*. 2014, Sudarshan *et al*. 2019). Ample of research work has

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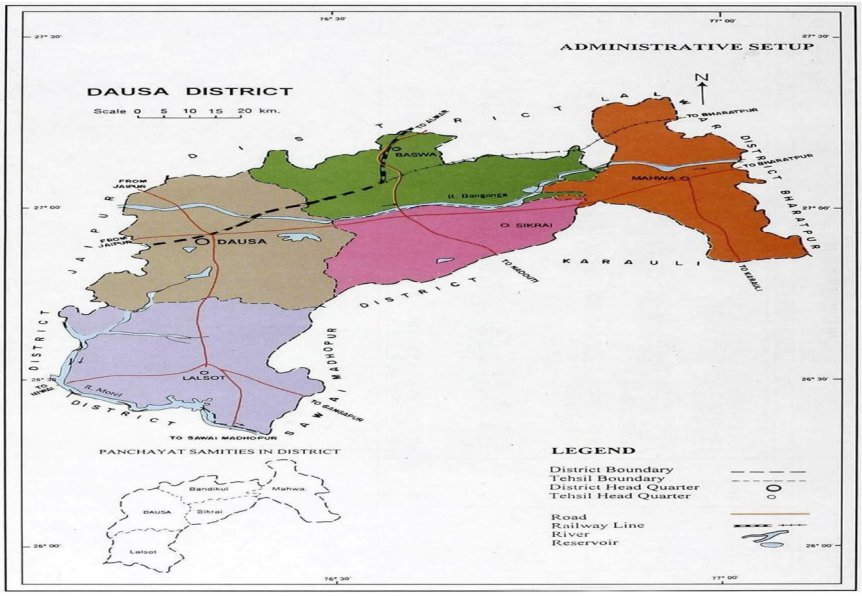

Fig.1. Dausa district.

been done on statistical analysis to access the ground water quality (Pathak *et al*. 2008, Karunakaran *et al*. 2009). Investigation of seasonal variability of groundwater quality parameters in Aligarh city, India, revealed that the groundwater of the study area is very hard and indicates deterioration in ground water quality (Anwar and Aggarwal 2016). Sharma and Chhipa (2016) evaluated the ground water quality in pre and post monsoon in north east area of Jaipur and reported that all the studied parameters were above the standard limits in most of the location during post monsoon season due to leaching of salts.

In the present research a systematic statistical analysis and interpretation of correlation coefficient both were studied to establish the seasonal variation among various parameters of ground water samples collected from Baswa Tehsil. The correlation between various quality parameters gives an idea about the usage of water in the particular area.

Study area

Baswa tehsil of dausa district is situated in Rajasthan, India. The geographical area of Baswa Tehsil is 632.64 sq km with 3,38,878 population. The weather of the study area is generally dry except in the monsoon period. The cold season is from December to February and is followed by hot season, which continues till about second week of July. The day temperature remains very high during May and June. The average maximum temperature in June is 42.73^{0}C and it drops down to 33.71^{0}C in August.

In the year 2020 and 2021 the average rainfall in this area was 570 mm and 735 mm respectively and maximum precipitation was observed in the month of August (Fig. 1).

MATERIALS AND METHODS

In this study water samples were collected from villages of Baswa Tehsil in Dausa District in the month of May 2020, Oct 2020, May 2021 and Oct 2021 representing the pre and post monsoon period. 20 samples were collected every time from various locations to access the seasonal variation in ground water quality. Seven parameters such as pH, electrical conductivity (EC), total dissolved solids (TDS), total hardness (TH), calcium (Ca^{+2}), chloride (Cl^-) and fluoride (F^-) were analyzed according to the methods suggested by APHA, AWWA, WEF (2012).

Value of pH was determined by digital pH meter

Table 1. Data analysis of pre-monsoon (May 2020).

Sample	pH	EC (mmho/c m)	Cl^-	TDS	TH	Ca^{+2}	F^-
1	7.9	1.545	302	1721	989	64	14.8
2	7.8	1.460	202	1749	982	60	9.6
3	7.6	1.785	224	2012	940	62	5.8
4	7.8	1.635	244	1839	941	63	6.1
5	7.9	1.750	202	1833	914	63	5.6
6	7.9	1.682	181	1750	972	62	5.6
7	7.6	1.436	181	1932	988	63	6.3
8	7.7	1.657	189	1782	981	63	7.2
9	7.5	1.123	281	1789	946	53	5.4
10	7.9	1.967	277	1864	948	52	7.4
11	7.2	1.635	267	1754	980	58	7.1
12	7.9	1.655	287	1863	917	56	6.3
13	7.8	1.935	186	1876	922	64	7.8
14	7.4	1.850	287	1972	945	60	6.2
15	7.5	1.524	214	2008	921	64	8.7
16	7.7	1.687	201	1940	922	63	6.7
17	7.9	1.964	208	1867	944	58	4.9
18	7.8	1.455	217	1764	943	62	6.1
19	7.6	1.154	267	1822	919	60	6.9
20	7.7	1.930	220	2008	947	58	8.1

(Model DPH500) having combined glass and calomel electrodes. EC were measured by (Model DCM900) using dip type of conductivity cell. The values of TDS were determined by water testing kit (Model NP-C362D). Total hardness, Ca^{++} and Cl^- were determined by volumetric analysis. TH and Ca^{++} were determined by EDTA method and Cl^- by titration with $AgNO_3$.

Table 2. Data analysis of post-monsoon (Oct 2020).

Sample	pH	EC (mmho/cm)	Cl^-	TDS	TH	Ca	F^-
1	7.8	0.872	225	927	631	36	14.6
2	7.8	0.912	260	1284	622	46	9.4
3	7.6	0.790	266	1189	647	42	5.1
4	7.5	0.745	299	1184	620	46	6.1
5	7.9	0.945	250	917	640	41	5.4
6	7.8	0.865	250	1292	645	36	5.1
7	7.7	0.815	223	1265	640	43	6.1
8	7.6	0.775	267	1243	617	43	6.5
9	7.8	0.805	244	1187	641	41	5.2
10	7.5	0.921	242	1260	614	37	7
11	7.9	0.825	224	1290	647	42	6.8
12	7.4	0.865	233	1130	639	41	5.5
13	7.8	0.920	243	1163	655	39	7.6
14	7.9	0.780	248	980	646	34	6.1
15	7.9	0.805	241	1211	645	39	8.1
16	7.8	0.766	257	1253	640	39	6.1
17	7.3	0.910	220	1220	650	38	4.3
18	7.4	0.810	221	1197	638	39	6
19	7.6	0.865	219	1194	614	39	6.3
20	7.9	0.876	273	1197	650	46	7.9

Table 3. Data analysis of pre-monsoon (May 2021).

Sample	pH	EC (in um)	Cl^-	TDS	TH	Ca	F^-
1	7.4	1.452	217	1632	895	53	14.8
2	7.6	1.605	220	1752	890	53	9.8
3	7.6	1.106	241	1916	841	63	5.6
4	7.4	1.825	241	1754	817	62	6.2
5	7.2	1.42	288	1678	844	63	5.7
6	7.6	1.115	280	1967	889	52	5.4
7	7.6	1.456	264	2011	818	54	6.2
8	7.2	1.426	301	2032	892	63	7.4
9	7.3	1.645	300	2012	893	64	5.4
10	7.4	1.915	289	1861	894	54	7.2
11	7.5	1.255	287	2016	844	52	7.4
12	7.9	1.108	245	2032	845	55	6.4
13	7.9	1.136	214	1610	833	53	7.9
14	7.9	1.85	210	1632	812	62	6.2
15	7.9	1.654	219	1967	868	54	8.7
16	7.9	1.926	192	1913	846	64	6.7
17	7.9	1.854	190	1836	847	64	4.9
18	7.6	1.853	166	1667	884	53	6.1
19	7.8	1.958	165	1619	811	52	6.9
20	7.2	1.905	176	1561	817	58	8.1

Fluoride contents in water samples were determined with the help Ionalyzer meter -Model 407A. Total Ionic Strength Adjustment Buffer (TISAB) was used to achieve the satisfactory results.

The descriptive statistical analysis of the data were carried out (Mean, Median, Mode, Standard deviation and Standard error) with Microsoft Excel 2007 and the results were evaluated in accordance with the standards of drinking water recommended by BIS (IS : 10500: 2012).

The data obtained from study of 20 water samples collected in the month of May 2020, 2021 and October 2020, 2021 are presented in Tables 1 - 4. The statistical analysis of collected water samples in all the four seasons are given in Tables 5 – 6.

RESULTS AND DISCUSSION

pH – The pH values in pre- monsoon (2020, 2021) varied between 7.0-7.9 and in post monsoon between 7.0-8.0. All the pH values were in the range of prescribed limit (6.5-8.5) by IS. Statistical analysis is given in Fig. 2.

Electrical conductivity (EC) – The electrical conductivity lied between 1.123-1.967 µmho/cm with

Table 4. Data analysis of post-monsoon (Oct 2021).

Sample	pH	EC (in µm)	Cl^-	TDS	TH	Ca	F^-
1	7.5	0.764	208	1282	640	37	146
2	7.4	0.82	220	1260	622	40	9.4
3	7.6	0.877	259	1198	632	37	5.1
4	7.6	0.964	258	1282	622	38	6.1
5	7.9	0.865	257	1262	613	46	5.4
6	7.2	0.847	220	1284	641	44	5.1
7	7.2	0.865	217	1260	632	42	6.1
8	7.4	0.847	244	1272	621	41	6.5
9	7.6	0.885	244	1282	614	40	5.1
10	7.2	0.863	255	1262	672	44	7
11	7.2	0.882	251	1284	618	47	6.8
12	7.6	0.847	252	1265	610	46	5.5
13	7.6	0.844	208	1240	644	43	7.6
14	7.9	0.769	204	1240	619	38	6.1
15	7.9	0.854	217	1270	612	39	8.1
16	8	0.827	204	1240	626	46	6.2
17	7.6	0.859	214	1230	639	39	4.5
18	7.6	0.811	174	1207	619	43	6
19	7.6	0.829	169	1210	628	36	6.4
20	7.2	0.864	194	1220	610	46	7.9

the mean value 1.641µmho/cm in the month of May 2020, between 1.106-1.058 µmho/cm with the mean value 1.573 µmho/cm in May 2021, between 0.745-0.945 with mean 0.843 µmho/cm in Oct 2021 and lied between 0.764-0.964 µmho/cm with mean 0.849 µmho/cm in the month of Oct 2021 (Fig. 3).

The lower values of electrical conductivity in post- monsoon clearly indicate the recharging of groundwater during monsoon season.

Chloride (Cl^-) – The chloride ion concentration in the study area varied from 181 mg/l to 301 mg/l with a mean of 231.85 (pre-monsoon, 2020), from 165 to 301 mg/l with the mean value 235.3 mg/l (pre-monsoon, 2021), from 219 to 299 mg/l with mean value 245.3 mg/l (post- monsoon 2020) and from 169 to 259 mg/l with mean value 223.5 mg/l (post-monsoon 2021). Mean values of chloride ions in all the samples collected in 2020 and 2021 lies below the acceptable limit given by IS and WHO both (200-600 mg/l). (IS: 10500. 2012), (WHO, 1996).

Total dissolved solids (TDS) - The range of total dissolved solids varied from 1721 to 2012 mg/l with mean value 1857.35 ppm (May 2020) and 1561 to 2032 mg/l with mean value 1823.4 mg/l (May 2021) in pre-monsoon season. In post- monsoon season the TDS range from 917 to 1292 with 1179 mg/l mean value (Oct 2020) and 1198 to 1284 mg/l with mean value 1253 mg/l (Oct 2021) shown in Fig. 4.

According WHO specification (500-1500 mg/l) all the samples collected in all four seasons were not fit for drinking, although value of TDS were much less in post-monsoon comparatively due to fresh recharge in ground water during monsoon. The ground water of all the locations can be used for irrigation.

Total hardness (TH) – Total hardness of ground water is mainly due to Ca^{+2} and Mg^{+2} ions and standard limit of total hardness according to WHO 100-500 mg/l. In this study the total hardness of groundwater varied between 914-989 mg/l with 948.04 mg/l mean value in May 2020, between 811-895 mg/l with mean value 854 mg/l in the month of May 2021 and in post-monsoon it varied from 614 to 655 mg/l with mean value 637.11 mg/l (Oct 2020) and 610 to 672 mg/l with mean value 626.7 mg/l (Oct 2021). Total hardness of ground water is comparatively less in post-monsoon season in both the years (Fig. 5).

Table 5. Statistical analysis of pre and post-monsoon 2020.

	Pre-monsoon (May 2020)							Post-monsoon (Oct 2020)						
Parameters	Min	Max	Mean	Medi-an	Mode	SD	SE	Min	Max	Mean	Medi-an	Mode	SD	SE
pH	7.2	7.9	7.70	7.75	7.9	0.196	0.044	7	7.9	7.69	7.8	7.8	0.19	0.043
EC (mmho/cm)	1.123	1.967	1.641	1.656	1.635	0.240	0.054	0.745	0.945	0.843	0.845	0.895	0.059	0.013
Cl^-	181	302	231.8	218.5	202	40.54	9.06	219	299	245.3	243.5	250	21.06	4.709
TDS	1721	2012	1857	1851	2008	94.35	21.09	917	1292	1179	1197	1197	111.9	25.02
TH	914	989	948	944.5	922	25.40	5.68	614	655.3	637.1	640	640	12.83	2.868
Ca^{+2}	52	64	60.4	62	63	3.575	0.799	34	46	40.35	40	39	3.407	0.762
F^-	4.9	14.8	7.13	6.5	6.1	2.151	0.481	4.3	14.6	6.76	6.1	6.1	2.204	0.493

Table 6. Statistical analysis of pre and post-monsoon 2021.

Parameters	Pre-monsoon (May 2021)							Post-monsoon (Oct 2021)						
	Min	Max	Mean	Medi-an	Mode	SD	SE	Min	Max	Mean	Medi-an	Mode	SD	SE
pH	7	7.9	7.59	7.6	7.9	0.259	0.058	7	8	7.54	7.6	7.6	0.256	0.057
EC (mmho/cm)	1.106	1.958	1.573	1.625	#N/A	0.309	0.069	0.764	0.964	0.849	0.851	0.847	0.042	0.009
Cl^-	165	301	253.3	230.5	241	45.27	10.12	169	259	223.5	218.5	208	27.82	6.221
TDS	1561	2032	1823	1848	1632	168.5	37.67	1198	1284	1253	1261	1282	27.73	6.2
TH	811	895	854	845.5	817	31.22	6.98	610	672	626.7	622	622	15.11	3.378
Ca^{+2}	52	64	57.4	54.5	53	4.988	1.115	36	47	41.6	41.5	46	3.56	0.796
F^-	4.9	14.8	7.15	6.55	6.2	2.175	0.486	4.5	14.6	6.775	6.15	5.1	2.194	0.491

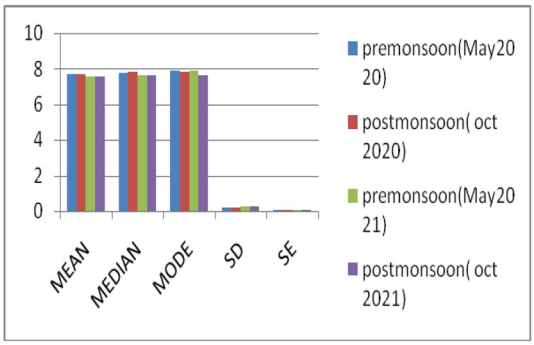

Fig. 2. Seasonal variation in pH of ground water.

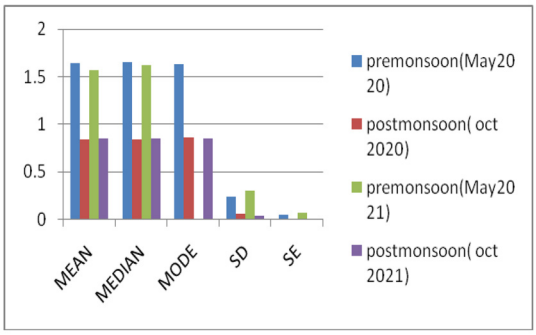

Fig. 3. Seasonal variation in EC of ground water.

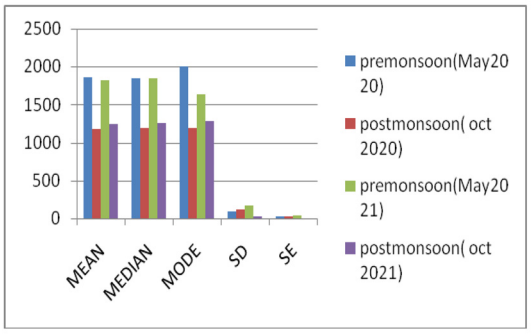

Fig. 4. Seasonal variation in TDS of ground water.

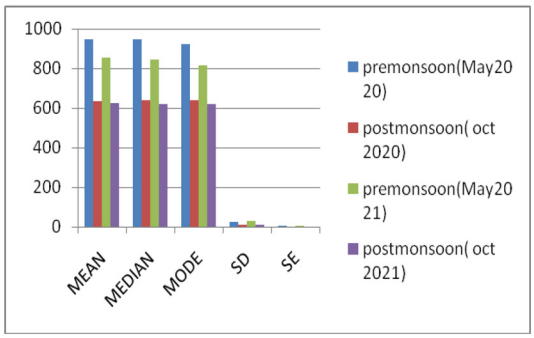

Fig. 5. Seasonal variation in TH of ground water.

Calcium (Ca^{+2}) – Calcium ions ranged from 52 to 64 mg/l in pre-monsoon season with a mean of 60.4 (May 2020) and 57.4 mg/l (May 2021) respectively. In post-monsoon it ranged between 34– 47 mg/l with a mean of 40.35 mg/l (Oct 2020) and 41.6 mg/l (Oct 2021).

Fluoride (F^-) – The value of fluoride ions in all the ground water samples are much more than the permissible limit prescribed by IS (1.5 mg/l). In pre-monsoon it ranged from 4.9 to 14.8 mg/l with the

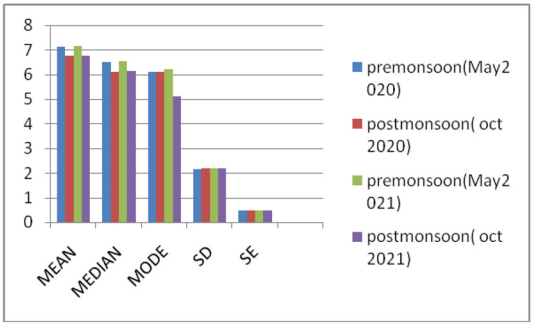

Fig. 6. Seasonal variation in Fluoride ion concentration.

mean of 7.13 mg/l (May 2020) and 7.15 mg/l (May 2021) and in post-monsoon it varied between 4.3 to 14.6 mg/l with a mean of 6.76 mg/l and 6.78 mg/l in Oct 2020 and Oct 2021 respectively (Fig. 6).

CONCLUSION

The primary problem of the study area is high value of fluoride ions in ground water throughout the year followed by high TH. After comparing the mean values of different variables analyzed from collected water samples in the month of May and October of both the year, it can be concluded that total dissolved solids, total hardness, chloride ions, calcium ions and fluoride ions are lower in post-monsoon season and clearly indicates the seasonal effect (Agrawal *et al*. 2014, Sirsat *et al*. 2015) but values of all the above variables (specially fluoride ions and total hardness) are still above the permissible value of IS.

Fluoride content is much higher than the reference value and that is highly toxic for human life (Ali *et al*. 2019). Fluoride intake through drinking water or through plants causes skeletal and dental fluorosis in most of the population. Except EC and pH, the overall quality of ground water in the study area is very poor for drinking and agricultural uses.

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