Impact Factor 2.380

UGC Approved Journal No. 64691 ISSN 2347-680X

International Journal of New Era Research Volume-IV, Issue 4, December 2017

Geography

"A Qualitative Analysis of Drinking Water in Churu District"

Ranjeet Singh Budania * *Dr. Hemant Mangal* **

Abstract

Water is an invaluable resource which is the primary need of humanity for the life, therefore pure and safe drinking water supply without any harmful element becomes most important and concerning issue for the health and well being of human beings. Water in its natural stage without any treatment is not considered safe to drink. Potable water is water that has been treated, cleared or filtered and meets established drinking water standards. Water quality is determined by comparing physical and chemical characteristics of water with a quality parameters designed by various organizations to enable the provision of clean and safe water for human consumption and health. Churu District is a place of semi arid climatic condition with low rainfall and devoid of any perennial surface water sources. So Groundwater becomes very important for the fulfillment of requirement of people for drinking, but ground water is Churu district is also affected with harmful contaminants. Increasing population and over exploitation affecting the quantity of groundwater too. In Churu district peoples are mostly using tube wells and hand pumps of varying depth, bore well, fresh water pond, Johra, govt. water supply and Kui/Kundi/Tanka for drinking purposes.Therefore drinking water is not potable in the sense as it is not free from harmful contents as directed by quality parameters. All these conditions creating adverse effect on the health of people. In main aim of the present research paper is to study the spatial-temporal variation in the quality of potable water in Churu tehsil, Churu district, Rajasthan, India and suggests some measures for the sustainability of drinking water in Churu district.

Keywords : Drinking Water, Churu district, Potable water, sustainability, Physico-chemical parameters

Introduction

Water is a crucial natural resource for life and livelihoods of mankind. Unfortunately, the craze for limitless economic growth has now made water a finite renewable natural resource and so its development and optimal utilization overtime is a major concern for planning and programming sustainable development in developing economies. And India is no exception to this global phenomenon.

* Asst. Prof. (Dept. of Geography) M.J.D Govt. P.G. College, Taranagar, Churu, (Rajasthan)

** Associate Prof., (Dept. Geography), Govt. Lohia College, Churu, (Rajasthan)

In India, along with environmental degradation and ecological instability, water crisis including water scarcity and water quality deterioration have assumed such grave dimensions that they demand top priority to recognize them as a natural resource management issues. The World Bank report on Water Economy of India envisages a turbulent future by 2025 and suggests to the reform the water sector at the earliest to squarely face water sector challenges of the 21st century. The comfortable position of water balance clearly indicates that the non-availability of water is not the basic issue for India, but to develop and manage now finite and vulnerable, but renewable water resources in an optimal manner to promote sustainable development in India, is the basic issue.

Water is essential for sustaining life, and adequate, safe and accessible supply of water must be available to all. Human and plant body consists of 60% and 90% water respectively. Access to safe drinking water is essential to health, a basic human right and a component of effective policy for health protection. The drinking water risks in developing countries are mainly associated with microbial contamination with about two dozen infectious diseases related to water quality. Millions of people all over the world particularly in the developing countries are losing their lives every year from water borne diseases (Arnal et al., 2001). Use of water containing viruses, bacteria and protozoa, for drinking and cooking as well as contact with it and its intake during bathing and washing, or even inhalation of small droplets in the form of aerosols may result in spread up diseases like cholera, typhoid, bacillary dysentery, infectious hepatitis, leptospirosis, giardiasis and gastroenteritis (Gadgil, 1998).

Chemical contamination of drinking water either naturally or by anthropogenic sources, is a matter of serious concern as the toxic chemicals do not show acute health effects unless they enter into the body in appreciable amounts, but they behave as cumulative poisons showing the adverse health effects after a long period of exposure. The use of various structurally complex synthetic compounds in the fields of industry and agriculture has added many potentially toxic chemical substances in the aquatic environment. Of these, the important ones are arsenic, barium, beryllium, cyanide, fluoride, lead, mercury, nickel, nitrate and nitrite, selenium, silver etc. amongst the inorganic constituents and pesticides, polynuclear aromatic hydrocarbons, phenols etc. amongst the organic constituents. There are other chemical constituents, which are nontoxic, but affect the asthetic and organoleptic quality of water. These include aluminium, chloride, colour, copper, hydrogen sulphide, iron, manganese, dissolved oxygen, zinc, sulphate etc.

Therefore, the need to monitor drinking water quality has been universally recognised and is a necessary safeguard against a large number of health hazards.

Review of Literature

D. Muralidharan, anitha P. Nair, V. Sathya Narayana (2002) conducted a study about high fluoride concentration in Rajgarh Tehsil, Churu.

S.Suthar, V. Chhimpa and Sushma Singh (2008) determine the bacterial contaminations in drinking water in rural areas of Northern Rajasthan.

R. K. Khanna, R.S. Rathore, C. Sharma (2009) indicated about the suitability of solar desalination techniques in Rajasthan to produce potable water from available brackish water.

Hashim committee report (1993) dealt with various issues related to integrated water resource development in the country. Vyas Committee report (2004) suggested the state (Rajasthan) water policy to advocate an integrated approach and developing additional water sources.

Rajdeep Yadav, R.N. Yadav, M.P.S. Chandrawat and Sanjay K. Sharma (2008) assessed the fluoride, Ph and TDs values in potable water of Alwar, Rajasthan.

The study is very significant as it deals with the spatial distribution of water quality which is very helpful in creating policy for the sustainable development of water resources. This will also help in detection of water born diseased and better management of health problems.

Statement of the Problem:

The study area having desertic condition where water is precious resource. Increasing population growth, dwindling natural resources that man has been consuming for centuries and deteriorations of overall environmental quality are the basic problem society is facing today. Unbalanced development activities create many problems. Increasing population has specifically increased the pressure on water and it directly affects the quality of water. So the present study ***"A Qualitative Analysis of Drinking Water in Churu District with Special Reference to Sustainability"*** has been taken for research study and analysis.

A brief critique of literature pertaining to the contamination of the drinking water in different parts of District Churu, Rajasthan, India and its source and also its extent has been presented.

The work presented in the thesis deals with the statistical analysis of drinking water quality parameters in the selected drinking water samples of Churu tehsil in Churu district of Rajasthan, India and mapping the potability of drinking water in the study area. Such an attempt would help the water authorities in taking decisions to protect the quality of water resources and to execute the suitable water treatment design.

Hypothesis of the Study

For the research study the following hypothesis has been formulated:

* There is spatial-temporal variation in the quality of potable water.
* There is increasing pressure on water resources due to increasing population.
* Increasing pressures on water resources adversely affects its quality and simultaneously human health.
* The measures of water conservation trends to increase the availability of potable water.

Objectives of the Study

The present research has been formulated the following objectives for the study on the quality of drinking water in the study area:-

- To determine the present status of water resources in Churu district.
- To determine availability of Potable water in the study area.
- To determine the spatial variation in quality of potable water.
- To establish relationship between population and availability of potable water.
- To suggest measures for sustainable availability of potable water.

Study Area

Churu district is the part of 'Thar Desert' located in the western part of Rajasthan State extending between $27^0$24' to $29^0$00' N latitude and $73^0$40' to $75^0$41' E longitudes. It is bounded by Hanumangarh district in the north, Sikar and Jhunjhunu disricts of Rajasthan and Hissar district of Haaryana in the east, Nagure district in the south and Bikaner district in the west. It has a vasy area of 13792.95 Sq. Km. The population of study area is 2,041,172 according to 2011 census. Agriculture is the principal occupation of the people of Churu providing employment to 76 percent of working population. The district comprises of six tehsils viz. Rajgarh, Taranagar, Churu, Sardarshahar, Ratangarh and Sujangarh. It is linked by roads and railways with Delhi, Jaipur, Bikaner, Jodhpur, Hissar ect. It is also connected with national highway No. 65.

Churu is characterized by shifting sand dunes. Churu experiences harsh and dry desert climate conditions with extremes of temperature (reach 50^0C in summer and 0^0C in winter) with irregular erratic low rain fall about 32mm. per annum. The area has scanty vegetation.

There is no perennial surface water source in the study area. Therefore ground water becomes very important for fulfilling the requirements of drinking water. Rapid growth of population and increasing water demand are key factors for the over exploitation of water which also affects the quality of water.

Groundwater in the study area is affected with high range of fluoride, chloride and nitrate contaminants. Few blocks in the study area are highly brackish and saline, facing the problem of unavailability of safe drinking water. Therefore Govt. planned a project name 'Apani Yojana' to ensure the supply of potable drinking water in these blocks. This project supplies canal water in few blocks of the study area like-Rajgarh, Taranagar, Churu etc.

Irregular, erratic low rainfall, extreme temperature, arid climatic conditions are unfavourable for the development of water resources in the study area.

Data Collection and Research Methodology

Primary and secondary data has been used in the present study.

First hand information has been collected through questionnaire. The source of secondary data has been collected from topographical sheets, gazetteer, census hand book and statistical book.

Experimental and descriptive research methodology has been used for the study.

Statistical Tools and Techniques

The data from PHED has been based on sources to determine the spatial quality of potable water in the study area. The chemical analysis or 20 randomly selected water sample collected from the study area. Different quality parameters graphs make

to show the quality of water in the study area. The graphs has been showed the spatial and seasonal temporal variation of quality of potable water.

Different statistical techniques has been used to present different socio economic data in proper manner. Percentile analysis has been used for socio economic data analysis. Statistical diagram like Bar and graphs has been useful to represent data analysis properly. For Experimental analysis correlation and regression analysis has been used and WQI index has been find out.

Sampling

To evaluate contamination of potable drinking water, water samples were collected during 2016. The samples were collected into acid pre-cleaned high-density polystyrene bottle of 1.5 L capacity. Two sets of water samples were collected at each of the sampling points. One was for the measurement of anions. The other, for analysis of cations and trace elements was acidified with 1% nitric acid to discourage the formation of precipitates and to keep the metal ions in the dissolved state. Temperature, pH, electrical conductivity, redox potential (eh), salinity and total dissolved solids measurements were conducted on site with a portable HACH conductivity meter which was calibrated prior to taking of readings. The samples were kept over ice in an ice chest and transported to the inorganic laboratory of the Rajasthan PHED, District Laboratory, Churu, Rajasthan for analysis.

Sample Size and Period of the Study

Drinking water samples from a total of 20 sampling sites of 20 villages of Churu Tehsil were collected. The total water collection in the year of 2016 is divided in to two seasons, one is pre monsoon and another one is post monsoon. The sampling is carried out, during April 2016 for pre monsoon season and in September- October 2016 for post monsoon season from manually operated tube wells and hand pumps of varying depth, bore well, fresh water pond, Johra, govt. water supply, water cooler and Kui/Kundi/Tanka.

Physico-chemical Analysis

All the samples were analyzed for the following Physico-chemical parameters; pH, Total Alkalinity (TA), Total Hardness (TH), Calcium hardness (CaH), Magnesium hardness (Mg H), Chloride, Nitrate, Fluoride, Total Dissolved Solid (TDS) and Electrical Conductivity (EC). The analysis of water samples were carried out in accordance to standard analytical methods.

The present study deals with the systematic investigation of physico-chemical parameters of drinking water samples of Churu Tehsil, district Churu, Rajasthan. For this drinking water samples from the study area were collected in pre and post monsoon seasons and analyzed for required water quality parameters like pH, Total alkalinity, Total Hardness, Calcium, Magnesium, Chloride, Nitrate, Fluoride, TDS and EC. The observed data were compared with the standard values given by BIS, ICMR and WHO. Seasonal temporal and spatial variation of water quality parameters were also studied by graphical analysis.

Results and Discussions

The Spatial variations of physico-chemical characteristics of the drinking water in the study area of Churu District in 2016 are discussed below.

H ; There is spatial -temporal variation in the quality of potable water in Churu tehsil, Churu district, Rajasthan

Table 1.1
Physico-chemical parameters of Drinking Water of Churu Tehsil of Churu District in Rajasthan (2016)

Description		As per I.S. Specification10500 {Drinking Water}					
		Colorless liquid					
S. No.	Sample Station	Water Sample	Odour	Colour	Taste	Water Temp.	Air Temp.
1.	Thailasar	Fresh Water Pond	Unobjectionable	Nil	Agreeable	24.5	37.4
2.	Asloo Station	Johra	Unobjectionable	Nil	Agreeable	24.5	37.6
3.	Asalkheri	Bore Well	Unobjectionable	Nil	Agreeable	23.9	37.5
4.	Bas Dhakan	Bore Well	Unobjectionable	Nil	Agreeable	23.7	36.7
5.	Boontiya	Hand Pump	Unobjectionable	Nil	Agreeable	24	37.5
6.	Kotwad Tal	Hand Pump	Unobjectionable	Nil	Agreeable	23.9	36.8
7.	Hunatpura	Tube Well	Unobjectionable	Nil	Agreeable	23.8	36.8
8.	Gajsar	Tube Well	Unobjectionable	Nil	Agreeable	23.8	36.8
9.	Kunsisar	Kui/Kundi/Tanka	Unobjectionable	Nil	Agreeable	24.5	37.5
10.	Dhadhar	Kui/Kundi/Tanka	Unobjectionable	Nil	Agreeable	23.9	36.8
11.	Dhameri	Water Cooler	Unobjectionable	Nil	Agreeable	24.5	37.8
12.	Satra	Water Cooler	Unobjectionable	Nil	Agreeable	23.8	36.8
13.	Churu (Rural)	Hand Pump	Unobjectionable	Nil	Agreeable	23.5	37.5
14.	Churu (M Cl + OG)	Govt. Water Supply	Unobjectionable	Nil	Agreeable	23.5	36.9
15.	Indrapura	Govt. Water Supply	Unobjectionable	Nil	Agreeable	24.5	37.5
16.	Jhariya	Hand Pump	Unobjectionable	Nil	Agreeable	25.9	36.8
17.	Sirsali	Tube Well	Unobjectionable	Nil	Agreeable	24.5	38.8
18.	Ranasar	Tube Well	Unobjectionable	Nil	Agreeable	25.8	36.8
19.	Suratpura	Bore Well	Unobjectionable	Nil	Agreeable	26.5	37.5
20.	Motisar	Bore Well	Unobjectionable	Nil	Agreeable	23.5	35.9

Source : Primary Data Collected by Research Scholar

Table No. 1.2 Physico-Chemical Characteristics of Drinking Water Samples of Churu Tehsil of Churu District in Rajasthan

Pre Monsoon Season (2016)

S. No.	Sample Station	Sample Source	Turbidity	pH	Total alkalinity	Total Hardness	CaH	Ca^{+2} ions	MgH	Mg^{+2} ions	Chloride as Cl^-	Nitrate as NO_3^-	Fluoride as F^-	TDS	EC	B.O.D	Dissolved Oxygen (DO)	Sulphate as SO_4^{2-}	Iron as Fe^{2+}	Sodium as $Na+$	Pesticides	Total Coliform	E coli
1.	Thanasar	Fresh Water Pond	0.09	8.6	411	529	237	94.8	292	70.95	1120	108	0.71	2216	3165	0	6.5	BDL	BDL	3.6	Absent	1	0
2.	Asloo Station	Johra	0.09	8.4	305	115	43	17.2	72	17.49	1140	15	1.44	778	1111	0	6.1	1.1	BDL	6.8	Absent	1	Absent
3.	Asalkheri	Bore Well	0.1	7.9	748	360	151	60.4	209	50.78	278	22	0.37	2100	3000	0	6	1.1	0.01	8	Absent	<1	Absent
4.	Bas Dhukan	Bore Well	0.03	8.3	462	161	67	26.8	94	22.84	176	131	1.8	1470	2100	0	6.1	BDL	BDL	7.6	Absent	1	Absent
5.	Boontiya	Hand Pump	0.1	7.5	651	516	172	68.8	344	83.59	137	28	2.12	1696	2422	0	6.4	BDL	0.01	7.2	Absent	<1	Absent
6.	Kotwad Tal	Hand Pump	0.12	8.4	396	105	40	16	65	15.79	123	27	1.99	1298	1855	0	7	1.2	0.04	8	Absent	1	Absent
7.	Hunatpura	Tube Well	0.16	7.5	586	192	78	31.2	114	27.7	333	11	2.05	2146	3065	0	6.9	0.6	BDL	9.6	Absent	<1	Absent
8.	Gajsar	Tube Well	0.35	8.4	258	158	64	25.6	94	22.84	202	86	1.14	1590	2271	0	6.1	BDL	BDL	9.2	Absent	<1	Absent
9.	Kunsisar	Kui/Kundi/Tanka	0.41	7.8	333	156	67	26.8	89	21.62	163	8	0.79	1191	1701	0	6.6	1.3	BDL	7.6	Absent	<1	Absent
10.	Dhadhar	Kui/Kundi/Tanka	0.4	7.6	435	732	336	134.4	396	96.22	315	18	0.93	1740	2486	0	6.6	5.11	BDL	11.2	Absent	<1	Absent
11.	Dhameri	Water Cooler	0.24	7.0	368	188	78	31.2	110	26.73	176	20	0.42	920	1314	0	7	2.4	BDL	11.2	Absent	<1	Absent
12.	Satra	Water Cooler	0.48	7.7	562	115	46	18.4	69	16.76	80	12	1.3	1034	1477	0	6.6	3.61	BDL	10	Absent	<1	Absent
14.	Churu (M Cl + OG)	Govt. Water Supply	0.64	7.4	243	264	121	48.4	143	34.74	33	29	0.71	792	1131	0	6.4	7.01	BDL	16	Absent	<1	Absent
15.	Indrapura	Govt. Water Supply	0.8	7.6	707	112	45	18	67	16.28	65	19	4.67	1200	1714	3	4.8	6.51	BDL	17.2	Absent	<1	Absent
16.	Jhariya	Hand Pump	0.9	8.2	582	46	22	8.8	24	5.83	20	22	1.4	1055	1507	12	4.8	12.08	BDL	17.2	Absent	<1	Absent
17.	Sirsali	Tube Well	1.30	7.7	409	568	206	82.4	362	87.96	484	8	0.9	2644	3777	4	4.8	26.07	BDL	32.4	Absent	<1	Absent
18.	Ranasar	Tube Well	0.63	7.0	460	317	128	51.2	189	45.92	380	16	0.88	2310	3300	0	6.5	3.61	BDL	12.5	Absent	<1	Absent
19.	Suratpura	Bore Well	0.72	7.9	595	528	238	95.2	290	70.47	259	72	1.4	1764	2520	6	5.5	5.51	BDL	13.6	Absent	<1	Absent
20.	Motisar	Bore Well	0.75	8.6	520	374	171	68.4	203	49.32	22	44	1.8	1333	1904	0	6.4	7.01	BDL	16	Absent	1	Absent
Range			0.09-0.9	7.4-8.6	243-595	46-732	22-336	8.8-134.4	24-396	5.83-96.22	20-1140	8-131	0.37-4.67	760-2644	1085-3777	0-12	4.8-7.0	0.6-26.07		3.6-32.4	Absent	1	Absent
Mean			0.044	7.86	472.85	284.95	119	47.6	155.8	40.32	278.3	37.9	1.39	1435.2	2050.05	1.55	6.11	4.48		11.92	Absent	1	Absent

Where- TA = Total Alkalinity, TH = Total Hardness, CaH = Calcium Hardness, MgH = Magnesium Hardness, Cl^- = Chloride, NO_3^- = Nitrate, F^- = Fluoride, TDS = Total Dissolved Solids, EC = Electrical Conductivity.

All parameters are expressed in mg/L except pH and EC. EC is expressed in µmhos/cm.

Ca_{+2} = Ca mg/L (as $CaCO_3$), Mg_{+2} = Mg mg/L (as $CaCO_3$).

Table No. 1.3 Physico-Chemical Characteristics of Drinking Water Samples of Churu Tehsil of Churu District in Rajasthan

Post Monsoon Season (2016)

S. No.	Sample Station	Sample Source	Turbidity	pH	Total alkalinity	Total Hardness	CaH	Ca^{+2} ions	MgH	Mg^{+2} ions	Chloride as Cl	Nitrate as NO_3	Fluoride as F	TDS	EC	B.O.D	Dissolved Oxygen (DO)	Sulphate as SO_4^{2-}	Iron as Fe^{2+}	Sodium as Na+	Pesticides	Total Coliform	E-coli
1.	Thalasar	Fresh Water Pond	1.23	8.1	410	406	180	72	226	54.91	987	102	1.36	2246	3145	ND	6.45	1.68	BDL	5.2	Absent	1	Absent
2.	Asloo Station	Johra	1.38	8.6	294	82	32	12.8	50	12.15	992	21	1.94	771	1080	ND	6.24	2.86	BDL	7.8	Absent	<1	Absent
3.	Asalkheri	Bore Well	1.37	7.7	607	284	122	48.8	162	39.36	194	15	0.85	2125	3010	ND	6.24	3.45	BDL	8.67	Absent	<1	Absent
4.	Bas Dhakan	Bore Well	1.40	7.7	517	540	245	98	295	71.68	417	129	0.73	1520	2962	ND	6.10	3.46	BDL	8.95	Absent	<1	Absent
5.	Boontiya	Hand Pump	1.41	7.8	580	478	173	69.2	305	74.11	193	31	1.92	1630	2328	ND	6.26	7.20	0.01	9.12	Absent	<1	Absent
6.	Kotwad Tal	Hand Pump	1.39	8.5	363	98	41	16.4	57	13.85	98	14	1.54	1207	1724	ND	6.98	7.45	BDL	9	Absent	<1	Absent
7.	Hunatpura	Tube Well	1.40	7.7	484	110	45	18	65	15.79	118	9	1.8	2132	2954	ND	BDL	9.15	BDL	9.48	Absent	<1	Absent
8.	Gajsar	Tube Well	1.47	7.6	459	161	68	27.2	93	22.59	171	94	0.81	1474	1820	ND	BDL	9.24	BDL	9.35	Absent	<1	Absent
9.	Kunsisar	Kui/Kundi/Tanka	1.49	7.4	255	187	80	32	107	26	113	6	0.51	1256	1937	ND	BDL	9.78	BDL	10.6	Absent	<1	Absent
10.	Dhadhar	Kui/Kundi/Tanka	1.57	8.5	838	254	111	44.4	143	34.74	107	7	0.98	1612	2303	1.20	6.54	9.21	BDL	12.9	Absent	<1	Absent
11.	Dhameri	Water Cooler	1.58	7.8	482	364	163	65.2	201	48.84	146	21	0.6	1044	1491	ND	6.87	9.45	BDL	15.2	Absent	<1	Absent
12.	Satra	Water Cooler	1.62	7.7	703	261	113	45.2	148	35.96	118	11	1	1206	1723	ND	5.87	10.20	BDL	14.7	Absent	<1	Absent
13.	Churu (Rural)	Hand Pump	1.65	7.7	282	211	88	35.2	123	29.88	28	67	0.9	724	605	6.50	5.67	11.89	BDL	19.2	Absent	1	Absent
14.	Churu (M Cl + OG)	Govt. Water Supply	1.77	7.7	168	220	92	36.8	128	31.1	40	27	0.32	780	1017	1.8	5.87	12.30	BDL	19.8	Absent	<1	Absent
15.	Indrapura	Govt. Water Supply	1.86	7.6	698	147	63	25.2	84	20.41	60	18	4.2	1225	1665	4.20	5.90	16.10	BDL	23.5	Absent	<1	Absent
16.	Jhariya	Hand Pump	1.98	7.6	454	159	66	26.4	93	22.59	34	24	1.17	999	1618	6.80	6.21	12.08	BDL	20.6	Absent	<1	Absent
17.	Sirsali	Tube Well	2.10	7.2	312	660	237	94.8	423	102.8	103	6	0.45	2652	3759	2.5	6.14	0.23	BDL	45.2	Absent	<1	Absent
18.	Ranasar	Tube Well	1.63	8.3	822	77	31	12.4	46	11.17	206	15	0.84	2286	2787	1.5	5.25	2.11	BDL	5.2	Absent	<1	Absent
19.	Suratpura	Bore Well	1.42	7.7	389	119	43	17.2	76	18.46	148	62	1.9	1755	2869	3.20	3.90	7.52	BDL	7.6	Absent	<1	Absent
20.	Motisar	Bore Well	1.15	8.5	859	53	21	8.4	32	7.77	112	36	1.6	1310	1914	4.80	6.21	5.01	BDL	12.5	Absent	1	Absent
Range			1.15-2.1	7.2-8.6	168-859	53-660	21-245	8.4-94.8	32-305	7.77-74.11	22-992	6-129	0.32-4.2	724-2652	605-3759	1.2-6.8	3.9-6.98	0.23-16.1	BDL	5.2-45.2	Absent	1	Absent
Mean			1.54	7.87	455.85	243.55	100.7	40.28	142.85	34.71	219.25	35.75	1.27	1497.7	2135.5	1.62	5.13	7.52	0	13.72			

Where- TA = Total Alkalinity, TH = Total Hardness, CaH = Calcium Hardness, MgH = Magnesium Hardness, Cl = Chloride, NO_3 = Nitrate, F = Fluoride,
TDS = Total Dissolved Solids, EC = Electrical Conductivity.
All parameters are expressed in mg/L except pH and EC. EC is expressed in µmhos/cm.
Ca_{+2} = Ca mg/L (as $CaCO_3$), Mg_{+2} = Mg mg/L (as $CaCO_3$).

pH

pH, an indicator of acidity is a measure of water's ability to neutralize base and formulate a close relationship among carbonates, bicarbonates, calcium

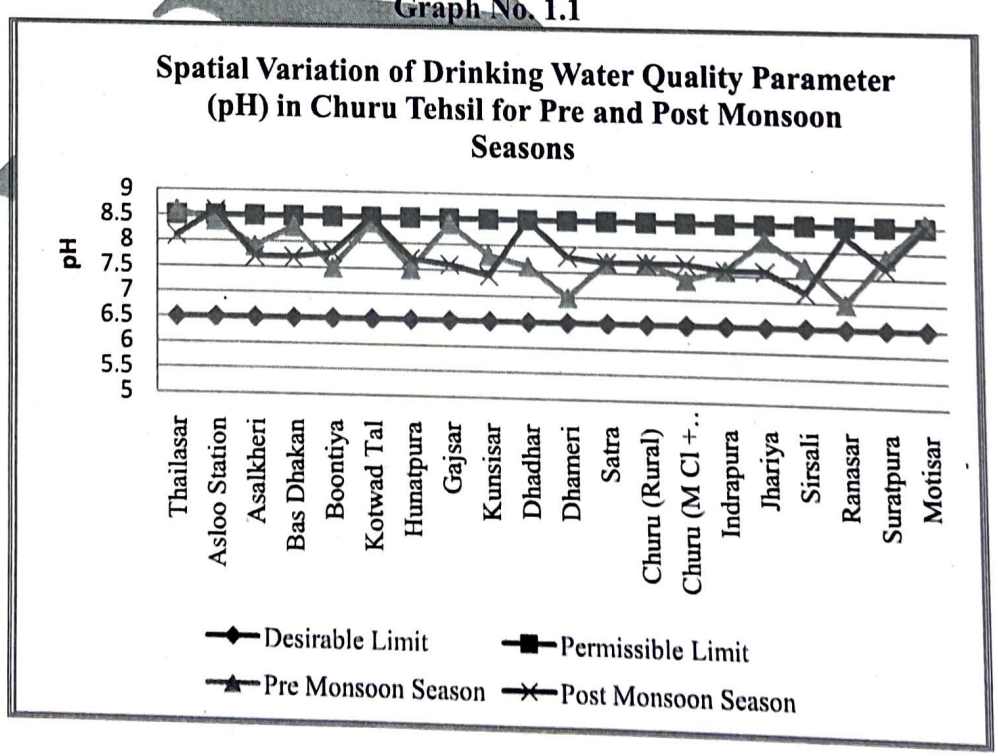
and free carbon dioxide. The hydrogen and hydroxide ions control variables in aqueous systems as they influence both physico-chemical and biological processes in the aquatic ecosystem. The equilibrium between these two ionic species is influenced by reactions with acids and bases introduced into the aqueous system.

Table 1.4
Suitability of Drinking Water Samples based on pH values (WHO, 1996)

S. No.	pH Range and Potability nature	Drinking Water Samples source Point	
		Pre-monsoon	Post-monsoon
1	Not Potable (< 6.5)	Nil	Nil
2	Potable (6.5 – 8.5) With in Permissible Limit	Asloo Station, Asalkheri, Bas Dhakan, Boontiya, Kotwad Tal, Hunatpura, Gajsar, Kunsisar, Dhadhar, Dhameri, Satra, Churu (Rural), Churu (M Cl + OG), Indrapura, Jhariya, Sirsali, Ranasar, Suratpura	Thailasar, Asalkheri, Bas Dhakan, Boontiya, Kotwad Tal, Hunatpura, Gajsar, Kunsisar, Dhadhar, Dhameri, Satra, Churu (Rural), Churu (M Cl + OG), Indrapura, Jhariya, Sirsali, Ranasar, Suratpura, Motisar
3	Not Potable (> 8.5) Above Permissible Limit	Thailasar, Motisar	Asloo Station

Source : Primary Data collected by Research Scholar

Graph No. 1.1

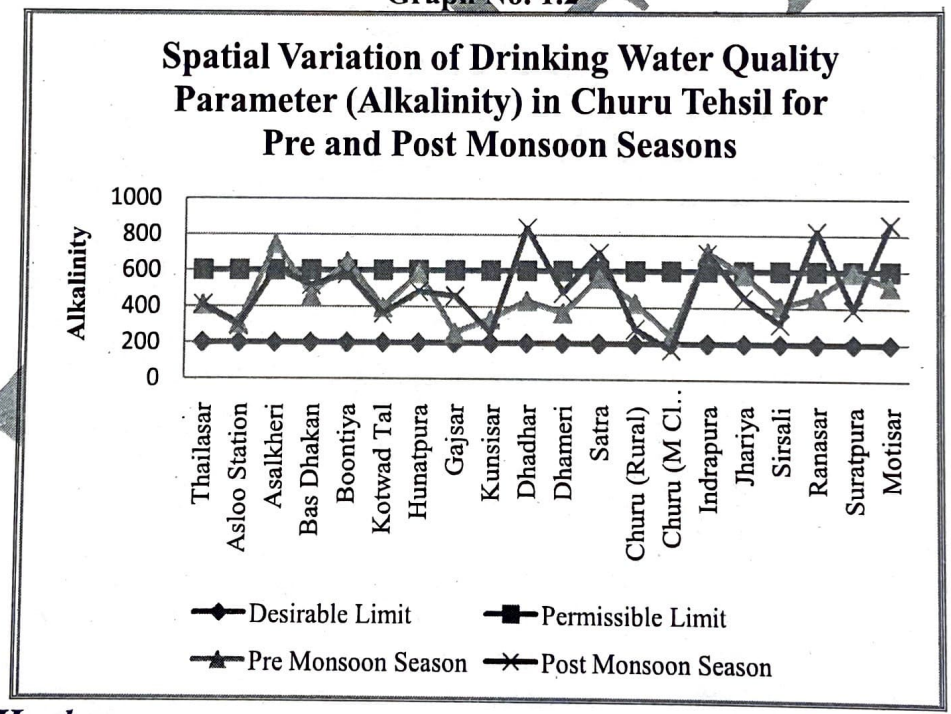


The range of pH is from 7.4 to 8.6 in pre-monsoon and 7.2 to 8.6 in post monsoon. Most of the stations in the study show alkaline tendency. In pre-monsoon there is 2 sample having Thailasar and Motisar the pH value more than the desirable level (6.5 to 8.5) mentioned by BIS and ICMR, while in post monsoon one sample (Asloo station) is exhibiting pH values more than the desirable limit. In pre-monsoon average value is 7.86 and in post- monsoon it has increased to 7.87. Higher pH may cause incrustation sediment deposit and difficulties in chlorination for disinfection of water.

Total Alkalinity

In pre-monsoon total alkalinity ranges from 243 to 595 mg/L and 168 to 859 mg/L in post-monsoon. Average value in pre-monsoon is 472.85 mg/L while it has decreased to 455.85 mg/L in post-monsoon. In pre-monsoon season 98.59% samples are found to have alkalinity values higher than the highest desirable value 120 mg/L stipulated by ICMR and WHO and in post-monsoon all samples are having alkalinity values more than the desirable limit. In ground water, most of the alkalinity is caused due to carbonates and bicarbonates.

Graph No. 1.2



Total Hardness

The determined total hardness in all stations ranges from 46 to 732 mg/L during pre-monsoon having the average value 284.95 mg/L but in post-monsoon it ranges from 53 to 660 mg/L and the average value has decreased up to 243.55 mg/L. The hardness of the many stations in pre and post monsoon seasons are well above the standard level set by BIS and ICMR as 300 mg/L. The presence of calcium or magnesium salts is the main responsible factor for the hardness of water (Singh *et al.*,

2012). Based on the amount of hardness the usability of water for domestic, drinking and industrial purpose can also be determined (Mitharwal *et al.*, 2009).

Graph No. 1.3

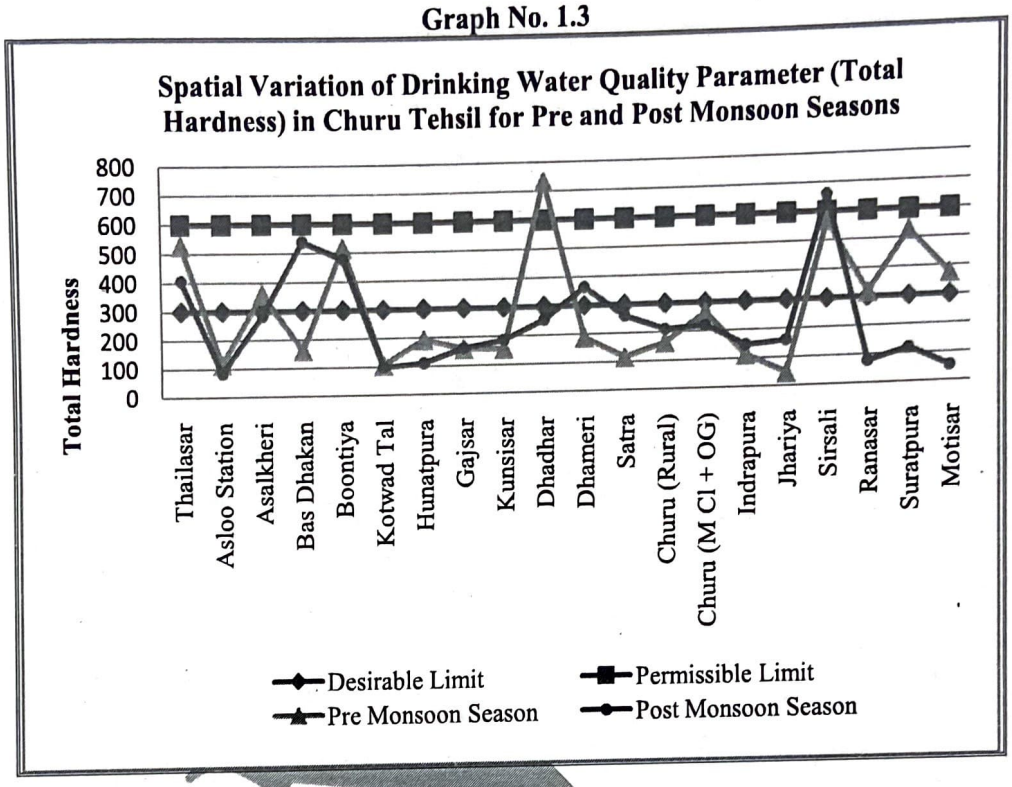


Table 1.5

Suitability of Drinking Water Samples based on Total Hardness values (WHO, 1996)

S. No.	Total Hardness Range and Potability nature	Drinking Water Samples source Point	
		Pre-monsoon	Post-monsoon
1	Acceptable (< 200)	Asloo Station, Bas Dhakan, Kotwad Tal, Hunatpura, Gajsar, Kunsisar, Dhameri, Satra, Churu (Rural), Indrapura, Jhariya,	Asloo Station, Kotwad Tal, Hunatpura, Gajsar, Kunsisar, Indrapura, Jhariya, Ranasar, Suratpura, Motisar
.2	Potable (200 – 600) With in Permissible Limit	Thailasar, Asalkheri, Boontiya, Churu (M Cl + OG), Sirsali, Ranasar, Suratpura, Motisar	Thailasar, Asalkheri, Bas Dhakan, Boontiya, Dhadhar, Dhameri, Satra, Churu (Rural), Churu (M Cl + OG),
3	Not Potable (> 600) Above Permissible Limit	Dhadhar	Sirsali

Source : Primary Data collected by Research Scholar

Calcium

Calcium in the sampling stations ranges from 8.8 to 134.4 mg/L during pre monsoon and 8.4 to 94.8 mg/L during post monsoon. The average calcium value in pre and post- monsoon season is 47.6 and 40.28 mg/L respectively. In many samples it falls above the standard value 75 mg/L depicted by BIS, ICMR and WHO. The higher value is mainly attributed due to the abundant availability of lime stone in the area. Consequently more solubility of calcium ions is present.

Graph No. 1.4

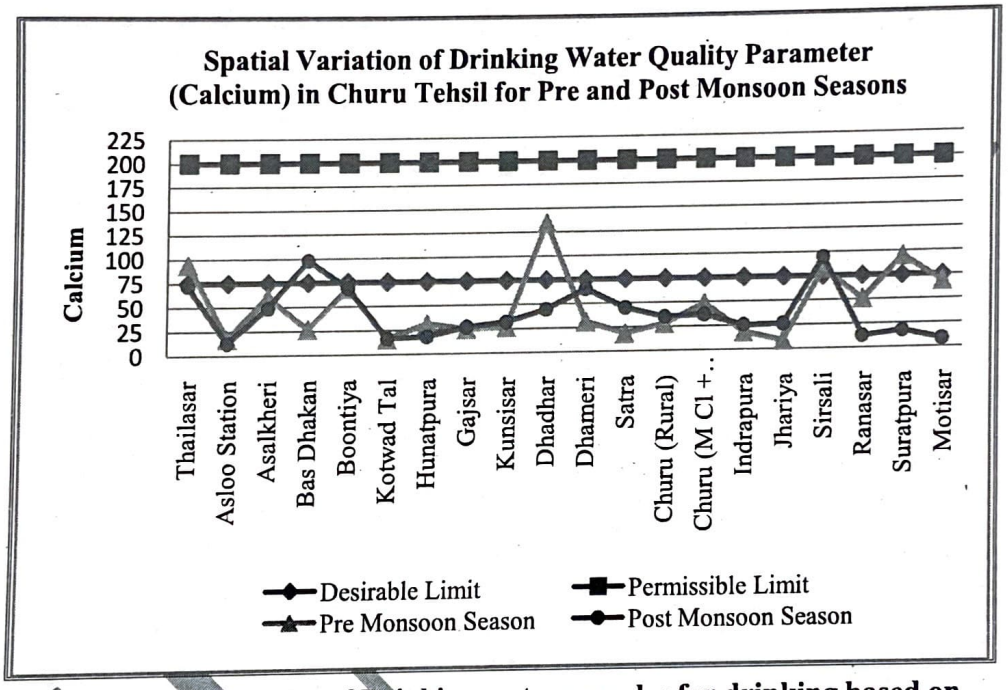


Table 1.6 Suitability of Drinking water samples for drinking based on Calcium (WHO, 1996)

S. No.	Range of Calcium (mg/l)	Potability nature	Drinking Water Samples source Point	
			Pre-monsoon	Post-monsoon
1	< 75	Acceptable	Asloo Station, Asalkheri, Bas Dhakan, Boontiya, Kotwad Tal, Hunatpura, Gajsar, Kunsisar, Dhameri, Satra, Churu (Rural), Churu (M Cl + OG), Indrapura, Jhariya, Ranasar, Motisar	Thailasar, Asloo Station, Asalkheri, Boontiya, Kotwad Tal, Hunatpura, Gajsar, Kunsisar, Dhadhar, Dhameri, Satra, Churu (Rural), Churu (M Cl + OG), Indrapura, Jhariya, Ranasar, Suratpura, Motisar
2	75 – 200	Allowable	Thailasar, Dhadhar, Sirsali, Suratpura	Bas Dhakan, Sirsali
3	>200	Not potable	Nil	Nil

Source : Primary Data collected by Research Scholar

Magnesium

Magnesium in the sampling sites ranges from 5.83 mg/L to 96.22 mg/L in the pre monsoon and 7.77 to 74.11 mg/L in the post monsoon season having the average value 40.32 and 34.71 mg/L in pre and post monsoon season respectively. In both the seasons various samples are showing magnesium values higher than the highest desirable limit 30 mg/L (BIS, ICMR and WHO). The concentration of magnesium may be very high due to dissolution of magnesium, calcite, gypsum and dolomite (Vyas, 2011).

Graph No. 1.5

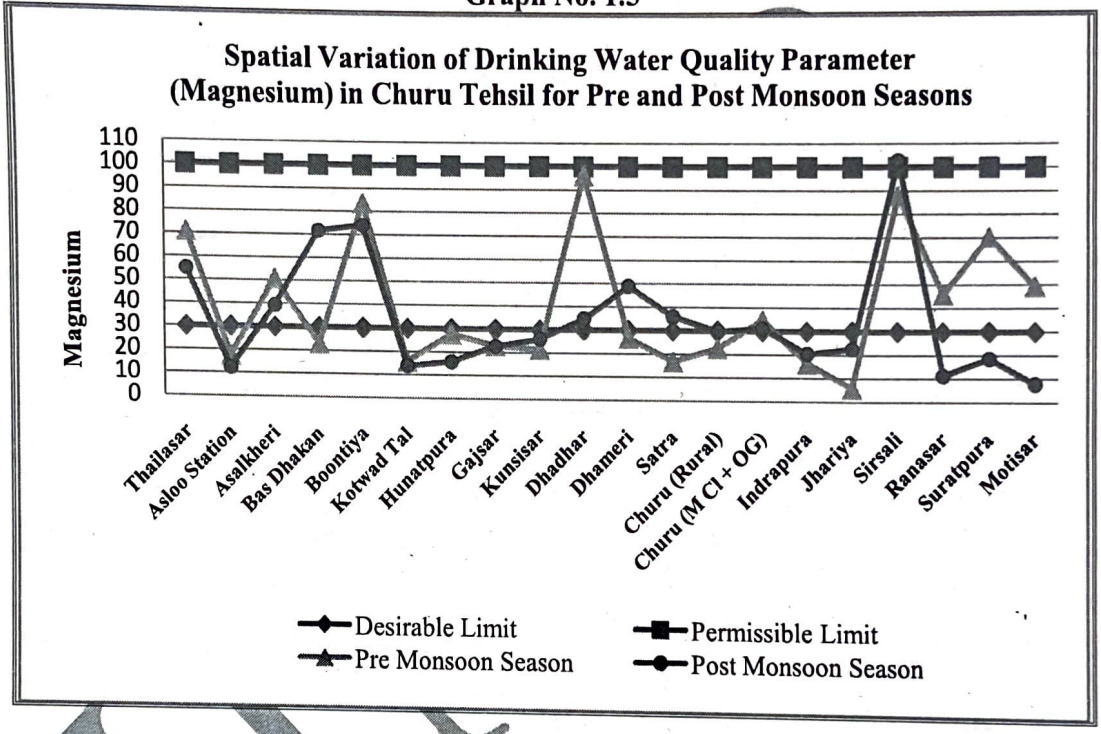


Table 1.7 Suitability of Drinking water samples for drinking based on Magnesium (WHO, 1996)

S. No.	Range of Magnesium (mg/l)	Potability nature	Drinking Water Samples source Point	
			Pre-monsoon	Post-monsoon
1	< 50	Acceptable	Asloo Station, Bas Dhakan, Kotwad Tal, Hunatpura, Gajsar, Kunsisar, Dhameri, Satra, Churu (Rural), Churu (M Cl + OG), Indrapura, Jhariya, Ranasar, Motisar	Asloo Station, Asalkheri, Kotwad Tal, Hunatpura, Gajsar, Kunsisar, Dhadhar, Dhameri, Satra, Churu (Rural), Churu (M Cl + OG), Indrapura, Jhariya, Ranasar, Suratpura, Motisar
2	50 – 100	Allowable	Thailasar, Asalkheri, Boontiya, Dhadhar, Sirsali, Suratpura	Thailasar, Bas Dhakan, Boontiya,Sirsali
3	> 150	Not potable	Nil	Nil

Source : Primary Data collected by Research Scholar

Chloride

Graph No. 1.6

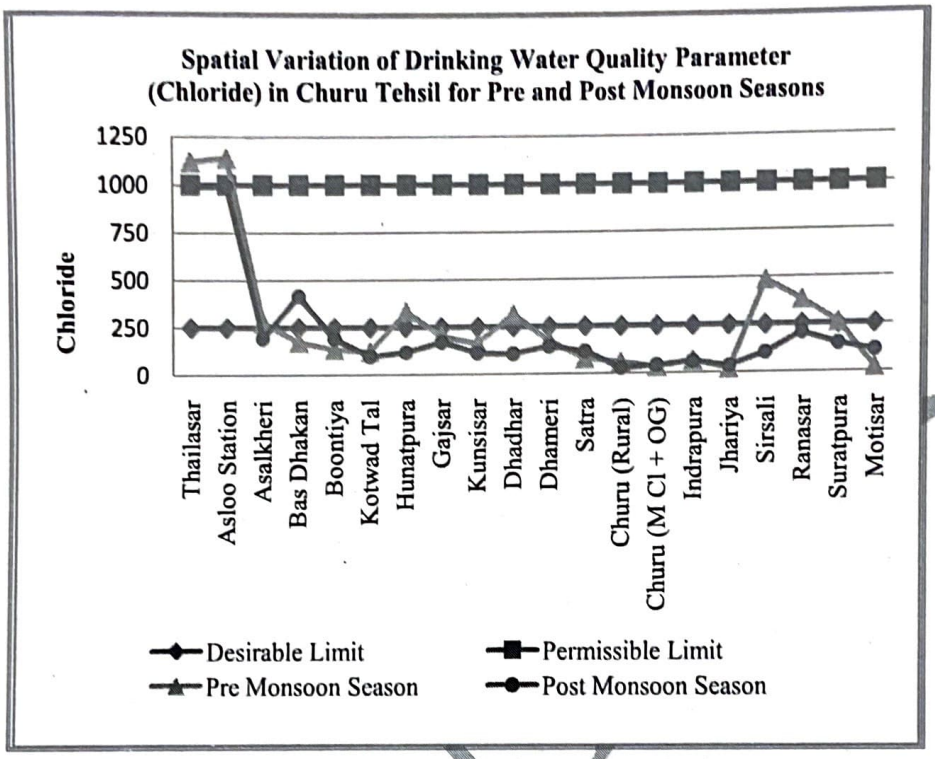


Table 1.8 Suitability of Drinking water samples for drinking based on Chloride (WHO, 1996)

S. No.	Range of Chloride (mg/l)	Potability nature	Drinking Water Samples source Point	
			Pre-monsoon	Post-monsoon
1	< 200	Acceptable	Bas Dhakan, Boontiya, Kotwad Tal, Kunsisar, Dhameri, Satra, Churu (Rural), Churu (M Cl + OG), Indrapura, Jhariya, Motisar	Asalkheri, Boontiya, Kotwad Tal, Hunatpura, Gajsar, Kunsisar, Dhadhar, Dhameri, Satra, Churu (Rural), Churu (M Cl + OG), Indrapura, Jhariya, Sirsali, Suratpura, Motisar
2	200 – 600	Allowable	Thailasar, Asloo Station, Asalkheri, Hunatpura, Gajsar, Dhadhar, Sirsali, Ranasar, Suratpura	Thailasar, Asloo Station,Bas Dhakan, Ranasar,
3	> 600	Not potable	Nil	Nil

Source : Primary Data collected by Research Scholar

The chloride values are 20 to 1140 mg/L in Pre monsoon season and 22 to 992 mg/L in Post monsoon. In pre-monsoon the average value is 278.3 mg/L while in post-monsoon it is 219.25 mg/L. Chloride concentration in most of the sample were found higher than highest desirable level (250 mg/L) stipulated by BIS and

ICMR, yet these values are well below the maximum permissible limit (1000 mg/L) but still there are some samples exhibiting the values more than the maximum permissible limit. Excess of chloride is due to anthropogenic activity like septic tanks effluents, usage of bleaching agents by people nearby bore well.

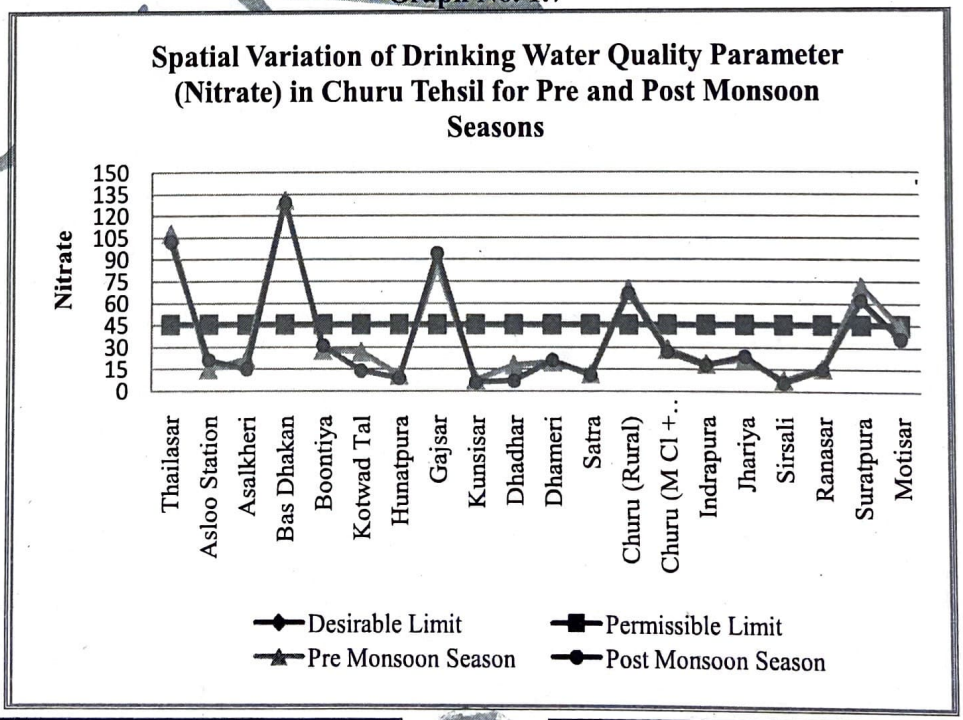
Nitrate

Table 1.9 Suitability of Drinking water samples for drinking based on Nitrate (WHO, 1996)

S. No.	Range of Nitrate (mg/l)	Potability nature	Drinking Water Samples source Point	
			Pre-monsoon	Post-monsoon
1	< 45	Potable	Asloo Station, Asalkheri, Hunatpura, Boontiya, Kotwad Tal, Kunsisar, Dhameri, Satra, Churu (M Cl + OG), Indrapura, Jhariya, Motisar Dhadhar, Sirsali, Ranasar,	Asloo Station, Asalkheri, Boontiya, Kotwad Tal, Hunatpura, Kunsisar, Dhadhar, Dhameri, Satra, Churu (M Cl + OG), Indrapura, Jhariya, Sirsali, Ranasar, Motisar
2	> 45	Not potable	Thailasar, Bas Dhakan, Gajsar, Churu (Rural), Suratpura	Thailasar, Bas Dhakan, Gajsar, Churu (Rural), Suratpura,

Source : Primary Data collected by Research Scholar

Graph No. 1.7

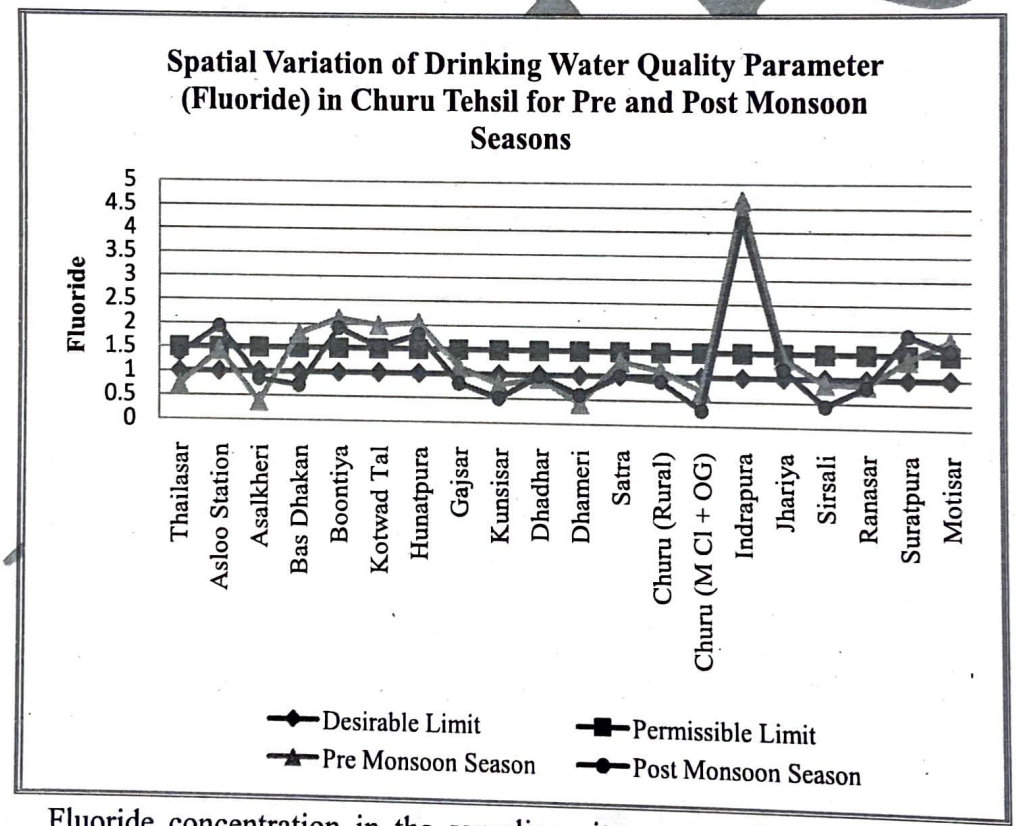


Nitrate concentrations in the study area ranged from 8.0 to 131 mg/L in the pre monsoon having the average value 37.9 mg/L and 6.0 to 129 mg/L in post monsoon season with the average value 35.75 mg/L. In both seasons various samples are found to have nitrate values more than the desirable limit of 45 mg/L (BIS, ICMR and WHO). The nitrate contamination in ground water is due to the leaching of nitrate present on the surface with percolating water and in presence of it's high concentration drinking water becomes toxic (Umavathi *et al.*, 2007).

Fluoride

The daily intake of fluoride from drinking water and food is usually less than 1ppm. Its level above 1.5 ppm causes fluorosis. Maximum tolerance limit in human body is 1.5 ppm (WHO Standard). less than 0.5mg/l Fluoride is also regarded as an essential constituent.

Graph No. 1.8



Fluoride concentration in the sampling sites ranges from 0.37 mg/L to 4.67 mg/L in pre monsoon and 0.32 to 4.2 mg/L in post monsoon seasons having the average value 1.39 and 1.27 mg/L respectively in both seasons. Most of the samples are having fluoride concentration more than the permissible limit 1.5 mg/L (BIS, ICMR and WHO) and suffering from the acute fluoride problems. Groundwater usually contains fluoride dissolved by geological formations. According to Central Ground Water Board (CGWB), the aquifers in this area are mainly composed of quartzite, schist and phyllite minerals.

Table 1.10 Suitability of Drinking water samples for drinking based on Fluoride (WHO, 1996)

S. No.	Range of Fluoride (mg/l)	Potability nature	Drinking Water Samples source Point	
			Pre-monsoon	Post-monsoon
1	< 1.5	Permissible	Asloo Station, Asalkheri, Hunatpura, Boontiya, Kotwad Tal, Kunsisar, Dhameri, Satra, Churu (M Cl + OG), Indrapura, Jhariya, Motisar Dhadhar, Sirsali, Ranasar,	Asloo Station, Asalkheri, Boontiya, Kotwad Tal, Hunatpura, Kunsisar, Dhadhar, Dhameri, Satra, Churu (M Cl + OG), Indrapura, Jhariya, Sirsali, Ranasar, Motisar
2	> 1.5	Not Permissible	Thailasar, Bas Dhakan, Gajsar, Churu (Rural), Suratpura	Thailasar, Bas Dhakan, Gajsar, Churu (Rural), Suratpura

Total Dissolved Solids

The range of total dissolved solids is from 760 to 2644 mg/L during pre monsoon and it is 724 to 2652 mg/L in the post monsoon. The average value is 1435.2 mg/L in pre monsoon and 1497.7 mg/L in post monsoon. This shows that, most of the stations fall above standard level 500 mg/L stipulated by BIS, ICMR and WHO, showing the anthropogenic impact which can be due to agricultural activity leading to local spatial and temporal variability of runoff (Siebert, 2010).

Graph No. 1.9

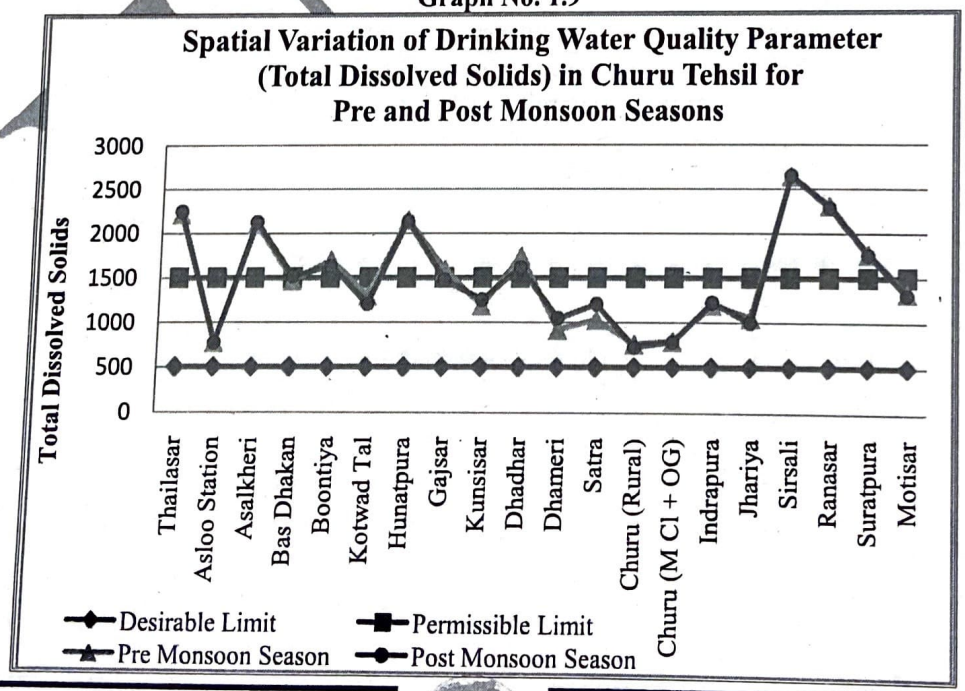


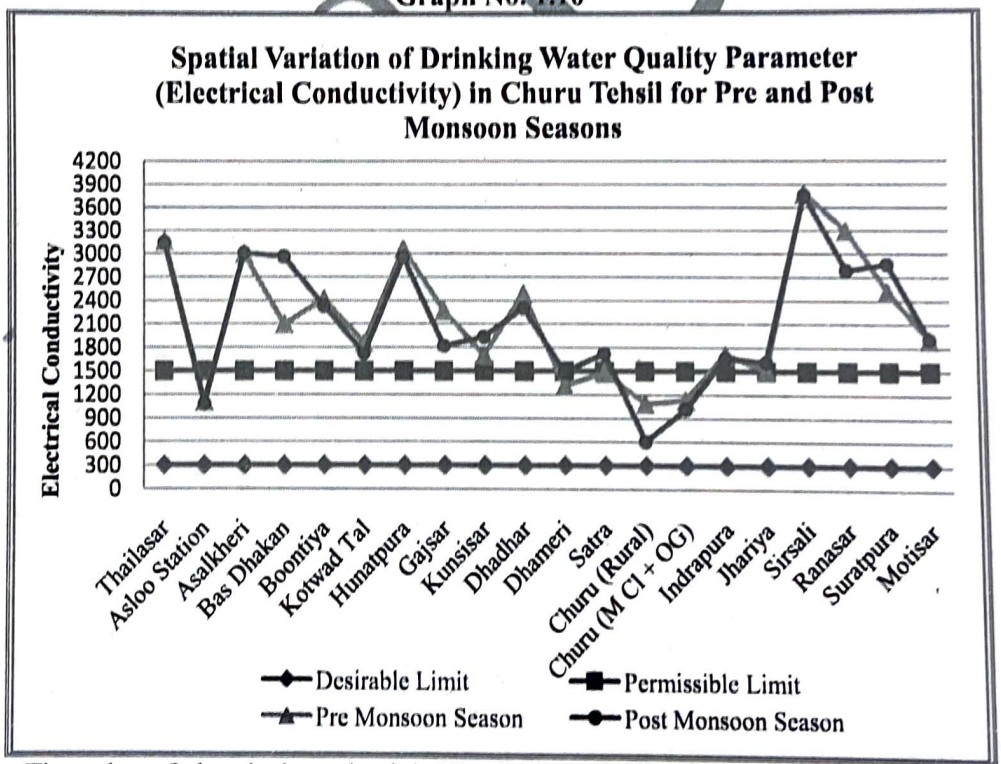
Table 1.11 Suitability of Drinking water sample based on TDS during pre- monsoon and post -monsoon based on WHO standard

Potable class Based on WHO Standard	Range of TDS (mg/l)	Pre-monsoon	Post-monsoon
Acceptable	< 500	Nil	Nil
Allowable	500 – 1500	Asloo Station, Bas Dhakan, Kotwad Tal, Kunsisar, Dhameri, Satra, Churu (Rural), Churu (M Cl + OG), Indrapura, Jhariya, Motisar	Kotwad Tal, Gajsar, Kunsisar, Dhameri, Satra, Churu (Rural), Churu (M Cl + OG), Indrapura, Jhariya, Motisar
Not potable	> 1500	Thailasar, Asalkheri, Boontiya, Hunatpura, Gajsar, Dhadhar, Sirsali, Ranasar, Suratpura	Thailasar, Asalkheri, Bas Dhakan, Boontiya, Hunatpura, Dhadhar, Sirsali, Ranasar, Suratpura,

Source : Primary Data collected by Research Scholar

Electrical Conductivity

Graph No. 1.10



The value of electrical conductivity lies between 1085-3777 µmhos/cm and 605-3759 µmhos/cm and average values are 2050.05 µmhos/cm and 2135.55 µmhos/cm in pre and post monsoon seasons respectively. The concentration of ions, nutrient status and variation

7.	Mg+2 Ions (mg/L)	5.83	96.22	40.32	27.66
8.	Chloride (mg/L)	20	1140	278.3	290.48
9.	Nitrate (mg/L)	8	131	37.9	35.64
10.	Fluoride (mg/L)	0.37	4.67	1.39	2.41
11.	TDS (mg/L)	760	2644	1435.2	899.48
12.	EC (µmhos/cm)	1085	3777	2050.05	1285.04

In the present study, from analysis of pre and post monsoon data it can be concluded that almost all parameters are exhibiting values higher than the permissible limits. At some sampling sites values are increasing in post monsoon and at some sites these are decreasing in post monsoon, but we cannot define any certain pattern in these increasing or decreasing trends. The reason can be attributed to increase in concentration as a result of greater leaching and decrease in concentration as a result of dilution.

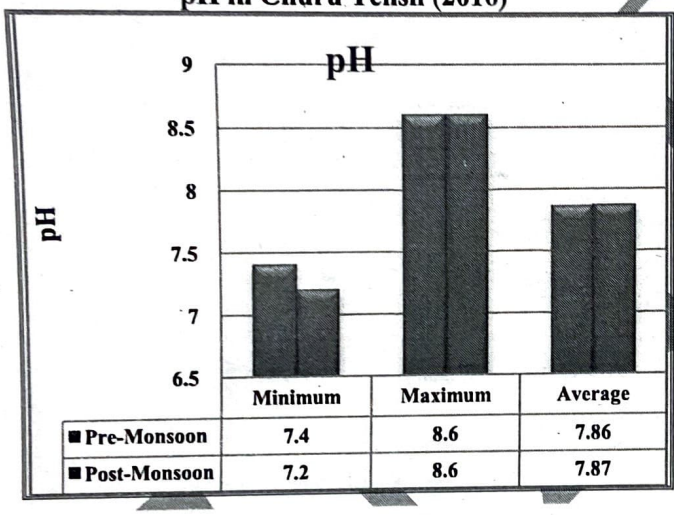
Table 1.14: Minimum, Maximum and Average Characteristics of Drinking water Sampling Sites - Post Monsoon

S. No.	Parameter	Minimum	Maximum	Average	Standard Deviation
1.	pH	7.2	8.6	7.87	0.31
2.	Total Alkalinity (mg/L)	168	859	455.85	174.15
3.	Total Harness (mg/L)	53	660	243.55	195.79
4.	Calcium Hardness (mg/L)	21	245	100.7	87.05
5.	Ca+2 Ions (mg/L)	8.4	94.8	40.28	34.82
6.	Magnesium Hardness (mg/L)	32	305	142.85	111.31
7.	Mg+2 Ions (mg/L)	7.77	74.11	34.71	27.05

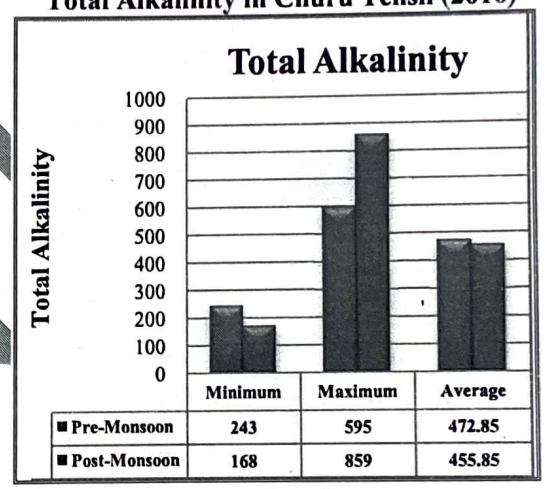
8.	Chloride (mg/L)	22	992	219.25	206.72
9.	Nitrate (mg/L)	6	129	35.75	40.60
10.	Fluoride (mg/L)	0.32	4.2	1.27	2.20
11.	TDS (mg/L)	724	2652	1497.7	746.36
12.	EC (µmhos/cm)	605	3759	2135.5	1066.23

Seasonal Temporal Variation of Drinking Water Quality Parameters in Churu Tehsil, Churu District, Rajasthan

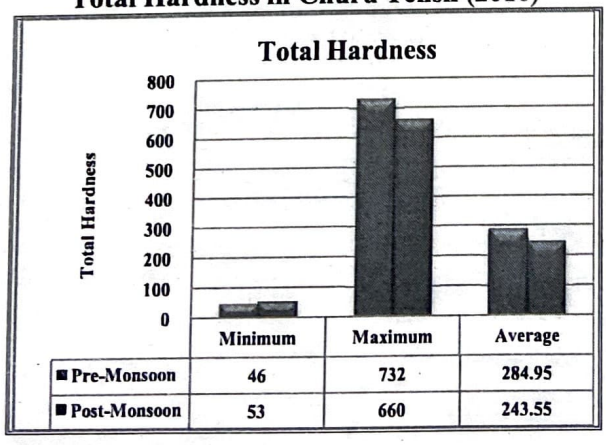
Graph No. 1.11
Seasonal Temporal variation of pH in Churu Tehsil (2016)



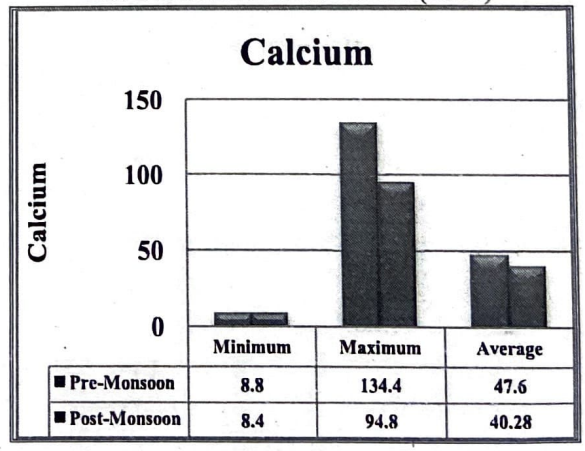
Graph No. 1.12
Seasonal Temporal variation of Total Alkalinity in Churu Tehsil (2016)



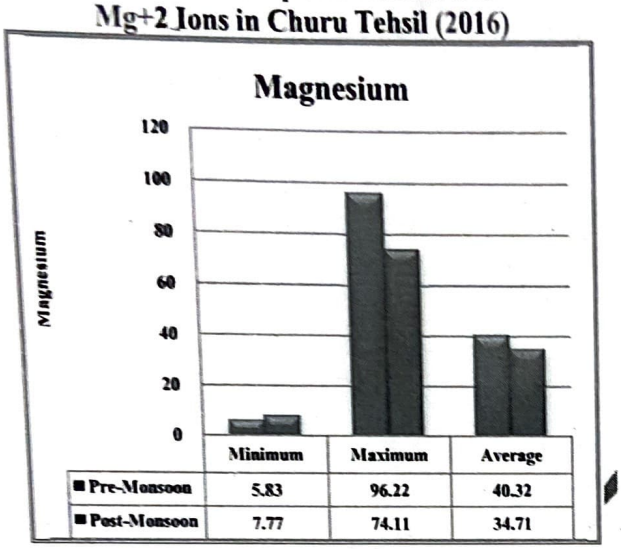
Graph No. 1.13
Seasonal Temporal variation of Total Hardness in Churu Tehsil (2016)



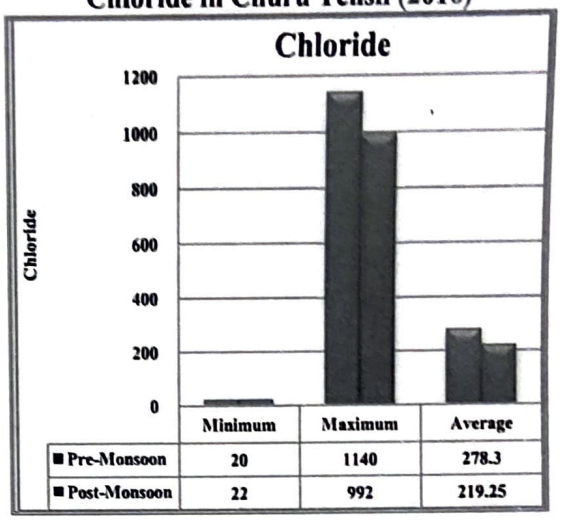
Graph No. 1.14
Seasonal Temporal variation of Ca+2 Ions in Churu Tehsil (2016)



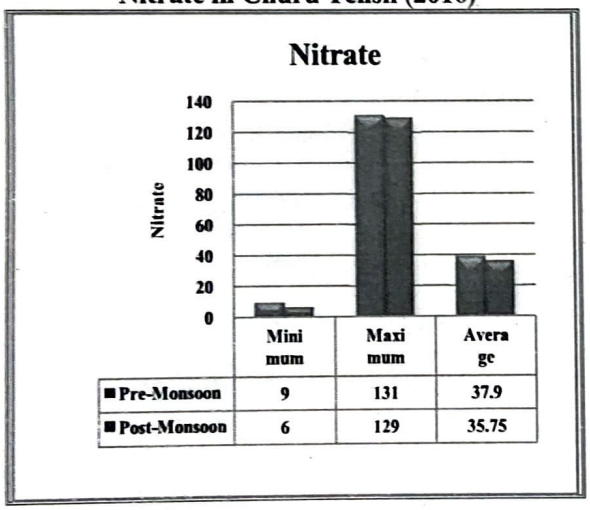
Graph No. 1.15
Seasonal Temporal variation of Mg+2 Ions in Churu Tehsil (2016)



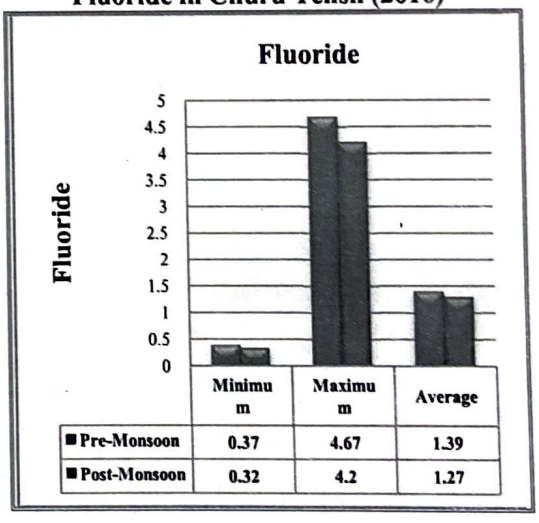
Graph No. 1.16
Seasonal Temporal variation of Chloride in Churu Tehsil (2016)



Graph No. 1.17
Seasonal Temporal variation of Nitrate in Churu Tehsil (2016)

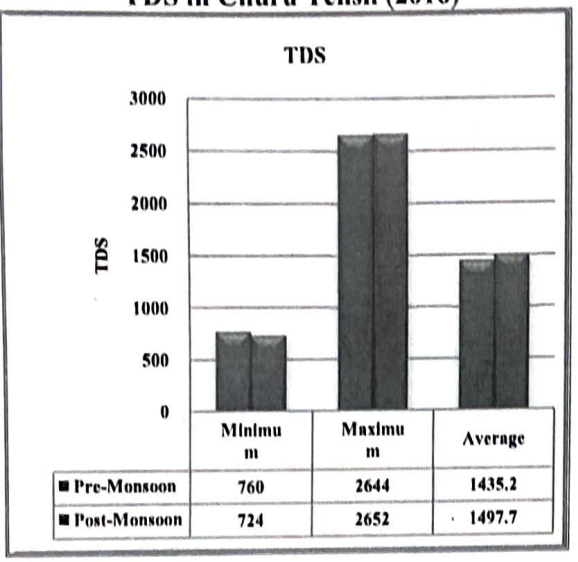


Graph No. 1.18
Seasonal Temporal variation of Fluoride in Churu Tehsil (2016)



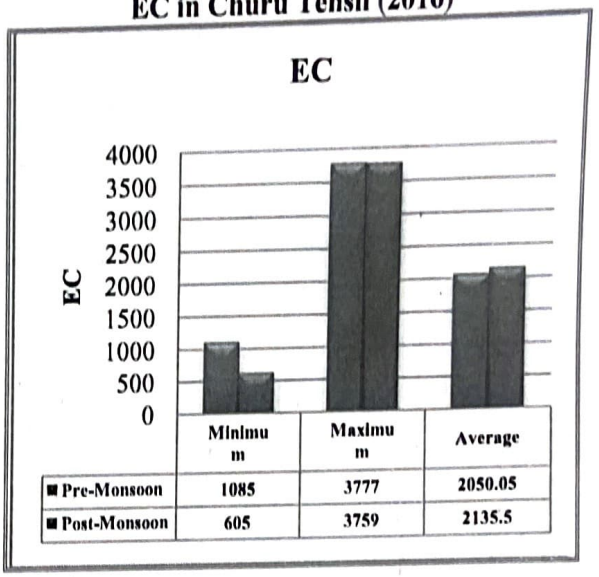
Most of the stations are having drinking water of very poor and unsuitable categories with water quality ranging from 75 to 100 and >100 respectively. From the field survey it can be concluded that the supply of pure and safe drinking water was inadequate in the town areas and was almost non-existent in the rural areas in the district. Piped water is available only in limited locations and only a small segment of the total population was benefited by the public water supply scheme. Tube wells, bore wells and hand pumps are the most common source of drinking water. Some of these may be safe for use while others may not be safe for drinking purposes. As a result scarcity as well as bacteriological contamination of water affects a large number of people.

Graph No. 1.19
Seasonal Temporal variation of TDS in Churu Tehsil (2016)



	Minimum	Maximum	Average
Pre-Monsoon	760	2644	1435.2
Post-Monsoon	724	2652	1497.7

Graph No. 1.20
Seasonal Temporal variation of EC in Churu Tehsil (2016)



	Minimum	Maximum	Average
Pre-Monsoon	1085	3777	2050.05
Post-Monsoon	605	3759	2135.5

Conclusion

In the present study, from analysis of pre and post monsoon data it can be inferred that almost all parameters are exhibiting values higher than the permissible limits. At some sampling sites values are increasing in post monsoon and at some sites these are decreasing in post monsoon, but we cannot define any certain pattern in these increasing or decreasing trends. TDS and EC mostly exhibits decrease in values while in some samples they also found to have increased values. The reason can be attributed to increase in concentration as a result of greater leaching and decrease in concentration as a result of dilution. In pre monsoon season all drinking water samples have pH value under the permissible limit whereas in post monsoon season two samples have higher pH value. Total alkalinity, Total dissolved solids and Electrical conductivity values are higher than the permissible limits in almost all drinking water samples in both seasons. The final output given in the spatial representation graphs of drinking water quality in the study area indicates that the drinking water of the study area necessarily needs some treatment before consumption. The study also helps to understand the quality of water as well as to develop suitable management practices to protect the drinking water sources.

Suggestions

1. The governments should concentrate on education, producing more fresh water and reducing the waste!:
2. **Water desalination** by using renewable energy sources (solar energy can used but might be expensive at the moment and cheaper technologies should be developed).
3. Appropriate price water policy should be adopted. **Reduce the water waste** in industries and homes by setting a realistic price on water.

4. Improve irrigation and agricultural practices. **Reduce the water use for farming and agriculture** by using modern techniques such as **drip irrigation**. Traditional methods used in some countries are not efficient and there is too much waste.
5. Farmers to be educated against excessive use of pesticides and chemical fertilizers.
6. **Renovation and Upgrading the water supply infrastructure** and networks to reduce water losses from the storage, transmission, and distribution system
7. **Educating the public** about this important issue and encouraging to contribute to the solutions of the water scarcity problem. Educate people to change consumption and lifestyles. Creating awareness regarding drinking water quality aspects.
8. Invent new water conservation technologies and used Remedial measures to remove pollutants from contaminated acquifer
9. Recycle wastewater
10. Artificial recharge of groundwater and rain water harvesting to be encouraged.
11. Develop energy efficient desalination plants
12. Improve water catchment and harvesting and use integrated water resource management techniques for water conservation.
13. Look to community-based governance and partnerships
14. Develop and enact better policies and regulations. Legislative measures needed to check over exploitation and contamination of groundwater.
15. Holistically manage ecosystems
16. Improve distribution infrastructure
17. Shrink corporate water footprints
18. Build international frameworks and institutional cooperation
19. Control and prevant pollution and Prevention of further contamination of the polluted areas
20. Public common resources/equitable access
21. R&D/Innovation and Water projects in developing countries/transfer of technology
22. Climate change mitigation
23. Population growth control

References

[1] P. B. Vyas, "Assessment of Drinking water quality in Gandhi nagar Town, Gujarat, India", J. Poll. Res., vol. 30(2), pp. 61-163, 2011.

[2] Bhalme SP, Nagarnaik PB, Analysis of drinking water of different places – A review. *International Journal of Engineering Research*, **2012**, 2: 3155.

[3] WHO, guidelines for drinking water quality. Vol.1, Geneva, World Health Organisation. 1999

[4] BIS IS 10500 (**1991**),standard parameters given by Government of India

[5] BIS IS 13428 (**2005**), Standard parameters of drinking water given by Government of India.

[6] Rossiter, H.; Owusu, P.A.; Awuah, E.; MacDonald, A.M.; Schäfer, A.I. Chemical drinking water quality in Ghana: Water costs and scope for advanced treatment. *Sci. Total. Environ.* **2010**, *408*, 2378–2386.

❋ ❋ ❋