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Assessment of Groundwater Quality: A Case Study of Jammu District

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Abstract: ***The present study is regarding the assessment of the ground water quality in Jammu district. The study has indicated that concentration of various dissolved solids, specific conductance, chlorides, nitrate fluoride, iron and other water quality parameters are increasing marginally and in some isolated pockets remarkably. Ground water samples from entire district were collected with prescribed norms and analysed by adopting standard methods of analysis. The results of current study indicate that the drinking water, used by the people residing in villages of Jammu district is potable except some few pockets which are contaminated It has been evaluated that in the study area, nature of water is acidic to alkaline in nature. Some of the samples collected from shallow ground water and deep ground water of jammu district are acidic. Village Suchetgarh has been demarcated as the water challenge for J&K state because of contamination due to Sodium, magnesium and chloride and electrical conductivity. Maximum concentration of TH of 1050mg/l is found at Mulechak. In Jammu district, 32 wells are found to have Iron concentration beyond maximum permissible limit, 1.0 mg/l (Muthi 8.4 mg/l, Khour 8.3 mg/l and Nagbani 6.76mg/l). The analysis reveals that the groundwater of some areas needs some degree of treatment before consumption and it also needs to be protected from contamination. Based on these results and analysis of water samples, it is recommended to use water only after boiling and filtering or by reverse osmosis treatment for drinking purpose by the individuals to prevent adverse health effects. It is recommended that water analysis should be carried out from time to time to monitor the rate and kind of contamination.***

Keywords: ground water, parameters, contamination

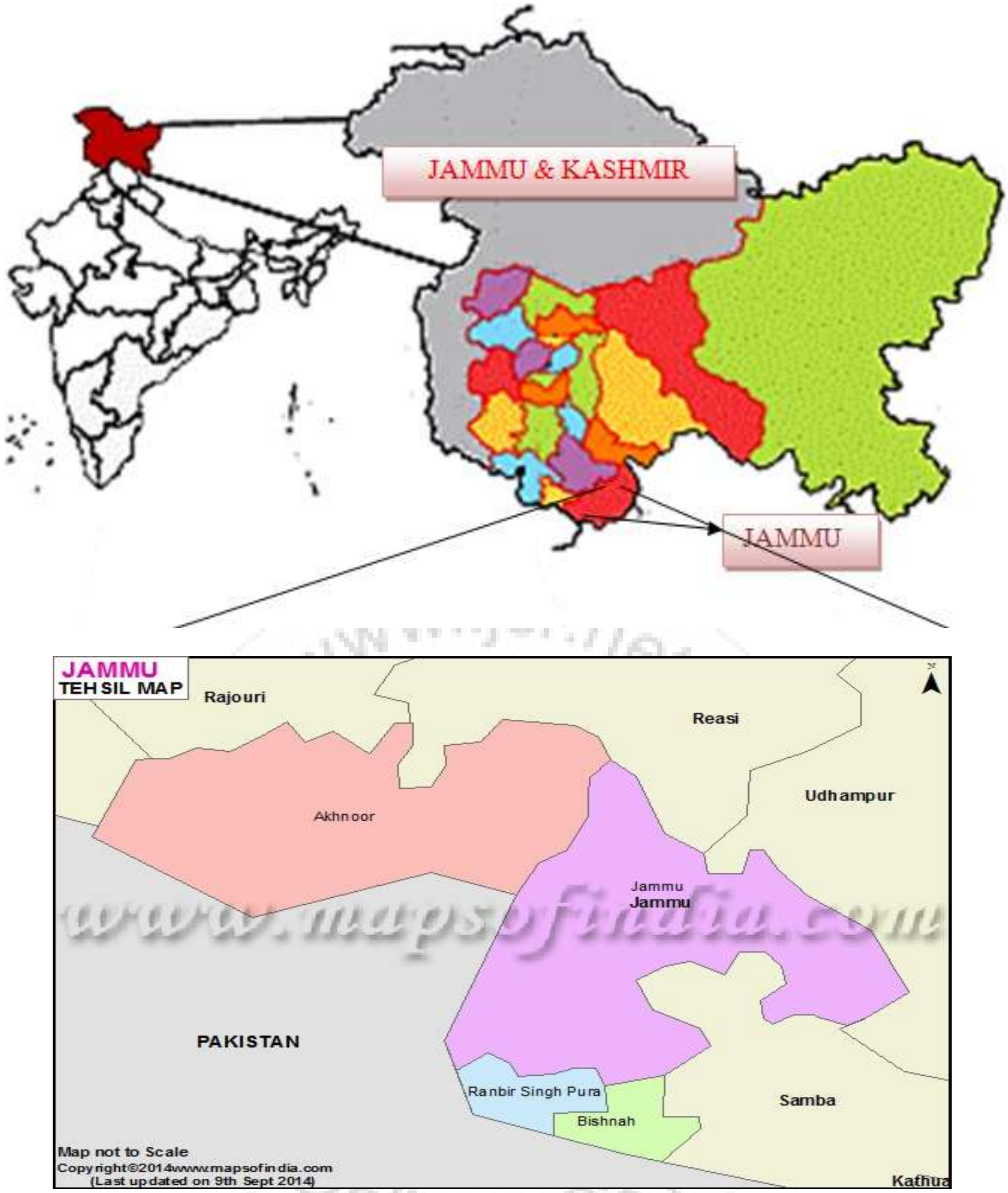
1. Introduction

Ground water is a vital natural resource that is used for myriad purposes. Unfortunately, this vital resource is vulnerable to contamination. The suitability of groundwater for different purposes depends upon its intrinsic quality which reflects inputs from the atmosphere, soil and rock weathering, as well as from anthropogenic activities. For the last decade or so deteriorating water quality has emerged as a major challenge to the sustainability of water resources and so to inclusive growth of the country. Groundwater has long been regarded as the pure form of water compared to surface water, because of purification of the former in the soil column through anaerobic decomposition, filtration and ion exchange. This is one of the reasons for the excessive consumption of groundwater in rural and semi-urban areas all over the world (WHO, 1984; Saha et al., 2008). Most of the human activities including agriculture need ample quantities of water. Increasing demands of food grain by ever increasing population has resulted in the utilization of water resources to the limit. Groundwater, an underground reservoir, being the sustainable source of municipal and irrigation supplies suffered the most. It is estimated that approximately one third of the world's population uses groundwater for drinking purposes (UNEP, 1999). This is a well-recognized fact that the groundwater, through the ages, continues to be an essential commodity for a large number of users. The chemical composition of groundwater is determined by a number of processes, which can chiefly be grouped into three - atmospheric inputs, interaction of water with soil and rock and anthropogenic activities. Precipitation, climate change and natural hazards add to the atmospheric inputs, while weathering and erosion of crustal materials result from the interaction of water with soil and rock (Babu et al., 2007). The anthropogenic disturbances through industrial and agricultural pollution, increasing consumption and urbanization degrade the groundwater and impair their use for drinking, agricultural, industrial and domestic uses (Simeonov et al., 2003; Sreedevi, 2004).

It has been suggested that it is the leading worldwide cause of deaths and diseases and that it accounts for the deaths of more than 14, 000 people daily. Water for rural supply is mainly withdrawn from underground sources. Development of the city has been accompanied by increased waste production and discharge with progressively more serious groundwater pollution (Bajpayee, 2001). The sanitary-technical conditions of water pipelines, the characteristics of withdrawal facilities as well as their sanitary-technical state considerably affect potable water quality. Water is typically referred to as polluted when it is impaired by anthropogenic contaminants and either does not support a human use, like serving as drinking water, and/or undergoes a marked shift in its ability to support its constituent biotic communities, such as fish. Water pollution has many causes and characteristics (Rao et al., 2004).

2. Study Area

Jammu is located 74 degree 24' and 75 degree 18', East longitude and 32 degree 50' and 33 degree 30' North latitude. It is approximately 600 Kms away from National Capital, New Delhi and is linked with a National Highway..



The District is bounded in the north and north east by the Tehsils of Reasi in Udhampur district in the east and south east partly by tehsil Ramnagar of Udhampur district and partly by tehsil Billawar of Kathua district, in the south and south west by Kathua district and Sialkote district of Rawalpindi (Pak) and in the north west by Tehsil Nowshara of district Rajouri and parts of the district Bhimber now under the occupation of Pakistan.

The District comprises four tehsils i.e. Jammu, R.S.Pura, Akhnoor, Bishnah.

The entire district can be divided into two distinct portions. The area forming north of Jammu-Chhamb road and Jammu-Pathankot road which is known as Kandi area is comparatively under-developed and is mostly rainfed. The area south of these roads is largely fed by canal and tubewells for irrigation purposes and is relatively more prosperous.

The national highway-1A (NH-1A) passes through the district and connects it with other parts of country. The district has a total geographical area of 3165 sq km out of which 1165 sq km is covered by hilly terrain and 2000 sq km is the outer plains, which comprises of *Kandi* and *Sirowal* belts. The total population of the district is 15.88 lakh

District Jammu falls in sub-mountainous region at the foothills of the Himalayas. Siwalik range rises gradually in the north part of the district and merges with the Indo-Gangetic plains in the south. Jammu city is at an elevation of 312m above the sea level. The entire district can be divided into two distinct portions. The area forming north of Jammu-Chhamba road and Jammu-Pathankot road which is known as *Kandi* area is comparatively under developed and is mostly rain-fed. The area south of these roads is largely fed by canal and tube wells for irrigation purposes and is relatively more prosperous.

Northern Hill Area: Out of the total 3165 sq km geographical area of district, hills constitute 1165 sq km i.e., about 37% of total area. The terrain is rugged with strike valleys and dissected ridge slopes. Altitude of the area varies roughly between 400 and 700 m. above mean sea level. Major physiographic slope is towards the southwestern direction i.e. towards the outer plain area. Hill nalas are seasonal and flesh floods immediately after the rains.

Southern Outer Plains: These are located at the foot of the outer most Siwalik hills and have an altitude varying between 280 and 400 m. above the mean seas level. In numerable seasonal nalas traverse the area. These streams are boulders laiden and have broad shallow channels, having water only for short, time after the rains. The plains can further be divided into two parts the '*Kandi'* in the north and the '*Sirowal'* in the south, towards Pakistan border.

The *Kandi* tract has got steep topographic slopes ranging between 1:90 and 1:120. General altitude of the *Kandi* ranges between 320 to 400 m. above the mean sea level. Water levels are deep, resulting into very less number of ground water structures i.e. dug wells and tube wells. The *Kandi* imperceptibly merges with the *Sirowal* southwards.

The *Sirowal* tract occupies the southern plainest tract of the district. It has altitude less than 300 m. above the mean seas level. Topographic gradient is reduced and become very gentle i.e.1:250 to 1:300. Swampy conditions prevalent at places emerge because of immense out of flow of ground water along the spring line marking the contact between the *Kandi* in north and the *Sirowal* in the south.

3. Ground Water Scenario of Jammu District

General Characteristics of Ground Water Resources

The ground water has been recognised as pure form of water, free from hazardous substances and containing minerals since ancient times. With rapid urbanization, industralialization and geological transformation, the presence of various constituents in ground water like total dissolved solids, nitrate, fluoride and heavy metals in excessive concentrations are having irreversible impact on its nature, characteristics and availability.

Rainfall is the major source of groundwater recharge apart from the influent seepage from the rivers, irrigated fields and inflow from upland areas whereas discharge from ground water mainly takes place from wells and tube wells; effluent seepages of ground water in the form of springs and base flow in streams etc

The general ground water characteristics of the ground water of jammu district has been mentioned as below:

Table 1: Ground water resources and irrigation potential for Jammu district

S. No.	Characteristics	Value	Units
1.	Annual replenishable GW resource during monsoon and non-monsoon period	85077	Ham
2.	Natural discharge during non-monsoon season	8508	Ham
3.	Net annual groundwater availability	76569	Ham
4.	Annual ground water draft	13490	Ham
5.	Demand for domestic and industrial uses(projected upto 2025)	11721	Ham
6.	Ground water availability for future irrigation	58121	Ham
7.	Stage of ground water development	18	%

Source- CGWB, Ministry of Water Resources, Govt. of India, Jammu

Table 2: General Assessment of Ground Water resources of Jammu district

Type of rock formation	Areal extent (in Hectares)			
	Total Geographical Area	Hilly Area	Groundwater Recharge worthy Area	
			Command area	Non-command Area
Alluvium	309700	109700	59271	140729

Source- CGWB, Ministry of Water Resources, Govt. of India, Jammu.

Table 3: General Characteristics of the Groundwater Command and Non command area of Jammu District

S. No.	Characteristics	Command area	Non-command area	Total
1	Rainfall (mm)	1246.0	1246.0	
2	Rainfall Infiltration Factor	20%		
3	Average Pre-monsoon Water level (mbgl)	5.32	15.64	
4	Average Post-monsoon Water level (mbgl)	4.62	15.00	
5	Pre & Post-monsoon Water level Trend	Rise		
6	Average Fluctuation (m)	0.70	0.64	
7	Recharge from rainfall during monsoon season	11806.78	28033.21	39839.99
8	Recharge from other sources during monsoon season	31478.95	600	32078.95
9	Recharge from rainfall during non-monsoon season	2963.55	7036.45	10000
10	Recharge from other sources during non-monsoon season	10789.75	423.85	11213.6
11	Total Annual Ground Water Recharge	57039.03	36093.51	93132.54
12	Provision for Natural Discharges	5703.903	3609.351	9313.254
13	Net Annual Ground Water Availability	51335.13	32484.16	83819.29

Source- CGWB, Ministry of Water Resources, Govt. of India, Jammu.

Status of Ground Water Development

Ground water development in the district on moderate scale is restricted along the major streams and rivers. In these areas, all the major irrigation and drinking water supplies depend on the tube well and dug wells in addition to various water supply schemes based on rivers / nallas.

Irrigation & Public Health Department being a nodal agency in the State concerned with water, tapped number of tube wells, dug wells yielding discharge between 3-10 lps. These State departments has also drilled hand pumps in the district with the depth ranging from 30 to 60 m depending upon the lithology of the area with a discharge varying from 0.5 to 2 lps. Few of them energized with submersible pumps fitted.

CGWB has so far constructed 89 number of exploratory wells in the district in the depth range of 65 to 320 m bgl. The discharge of these wells ranged from less than 1 lps to more than 10 lps.

Hydrogeology

Geologically, the area can be explained as the northern hilly area underlain by the Siwalik rocks and the southern outer plain area underlain by the sediments of Recent Sub-Recent times, laid down by the present day streams the area. Following geological succession occurs in the area.

Physiography	Geological Horizon	Lithology	Age
	Alluvium, fan, terrace Deposits.(kandi and Sirowals) Boulder bed stage	Heterogeneous clastic sediments Conglomerates sandstones with intercalations of red clays.	Sub-recent to recent. Lower to middle Pleistocene
Upper shiwaliks	Pinjor stage	Coarse sandstone, sandrock and massive sandstones beds	Lower Pleistocene
	Tatrot stage	Sandstone drab clays alternative beds	Upper plieocene.
Middle shiwaliks	Dhokpathan stage	Sandstone and shale with isolated sand nodules	Lower pleiocene
	Nagri stage	Sandstones and shale, hard and compact	Upper meiocene
	Chingi	Bright red shale and sandstones	Middle meiocene
Lower shiwaliks	Kamlial stage	Hard red sandstones and shale with pseudo conglomerates	Middle to lower Miocene.

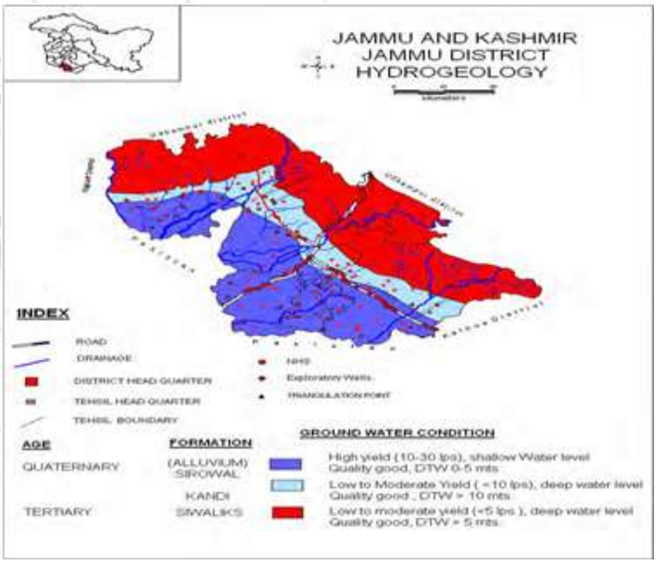
In outer plain regions groundwater occurs in the saturated parts of alluvium sediments in the pore spaces. It occurs both under water table and confined conditions in the Sirowal and under unconfined conditions in *Kandi* belt. The flow direction of groundwater is broadly form north to south and corresponds roughly with the topographic slope.

In Siwalik formation the water level ranges between ground level & 24 m bgl. Discharge is generally low and it varies from negligible to 600 lpm. In *Kandi* formation, the water level range between 5 m and 65 m bgl and yield varies from 235 to 2574 lpm while in Sirowal formation water level varies between 2 m to 12 m bgl and discharge range between 1050 and 3785 lpm.

The CGWB has so far drilled 89 exploratory boreholes in the district out of which 12 in Siwalik formation, 30 in *Kandi* belt, and 33 in *Sirowal* formation. The depth range of exploratory wells in Siwalik belt varies between 105 m bgl and 305.38 m bgl. In Kandi belt it varies between 65.0 m bgl and 320 m bgl and in Sirowal belt it varies between 26.0 m bgl and 336.0 m bgl. The values in *Kandi* formation are between 367 and 978 m^2/day and in *Sirowal* formation it is between 272 and 1197 m^2/day.

Depth to Water Levels:

Depth to water level in the district varies from less than 1 m to 28 m bgl. The Kandi belt in general has deeper water level.



Physico-Chemical Analysis of Groundwater Resources

The suitability of water lies not in quantity but it is intrinsic quality that makes water an important resource for sustainable development. The chemical quality of the groundwater largely depends on the nature of the rock formations, physiography, soil environment, recharge, and draft conditions in which it occurs. The chemical composition of water is an important factor to be considered before it's used for domestic, irrigation or industrial purposes. The physical and chemical quality of ground water is important in deciding its suitability for drinking purposes. As such the suitability of ground water for potable uses with regard to its chemical quality has to be deciphered and defined on the basis of the some vital characteristics of the water. (CGWB, 2010)The analysed chemical parameters of groundwater play an important role in classifying and assessing water quality particularly as regards its portable nature. The standard quality of drinking water has been specified by world health organization WHO and ISI. It has given the permissible and desirable limits for the presence of various elements in the groundwater.

Table 4: Water Quality Parameters of Shallow Groundwater Samples compared with ISI standard and WHO standard

	Location	Physico-Chemical Parameters														Type of Water
		pH	EC µmho s/cm	CO3	HCO3	Cl	SO4	NO3	F	Ca	Mg	Na	K	Fe	TH	
				mg/l												
1.	Trikuta Nagar	7.35	840	0	452	32	6	24	.2	112	21	31	8.9	.03	365	Ca-HC0$_3$
2.	Greater Kailash	7.4	730	0	482	21	N/D	8.7	.14	92	39	18	2.3	4.5	390	CaMg-HCO$_3$
3.	Pouni Chak	7.6	880	0	500	35	28	4.2	.22	102	32	38	25	1.19	385	CaMg-HCO$_3$
4.	Garkhal	8.2	580	0	366	7.1	12	10	0.1	50	46	5	6.1	0.36	315	MgCa-HCO3
5.	Bhalwal Bharth	7.6	1100	0	519	39	18	12	.18	74	51	27	50	1.23	395	MgCa-HCO3
6.	Deora outpost	7.65	640	0	360	7.1	39	18	.18	98	22	8	93	1.27	335	CaMg-HCO3
7.	Channi diwanu	7.4	910	0	403	46	70	7.42	0.38	96	35	41	3.4	0.65	385	CaMg-HCO3
8.	Milan Khui	7.8	470	0	238	14	25	7.42	0.14	68	13	8.4	8.8	.3	225	CaMg-HCO3
9.	Kalith	8.35	350	18	195	14	n/d	6.34	.19	50	12	6.4	2.5	.43	175	CaMg-HCO3
10.	Raipur Khairi	8.38	720	48	311	25	12	20	0.27	116	21	11	3.8	.43	375	CaMg-HCO3
11.	Gharota	8	370	0	183	7.1	25	11	.11	46	17	7.5	2.4	n/d	185	CaMg-HCO3
12.	K angar	7.9	580	0	397	7.1	5	7.77	.2	82	32	6.5	1.5	n/d	335	CaMg-HCO3
13.	Bathera	7.8	420	0	238	11	n/d	6.29	.14	22	38	3.7	1.8	1.96	210	MgCa-HCO3
14.	Sui	7.7	510	0	311	11	n/d	5.68	.14	68	17	4	25	.33	240	CaMg-HCO3
15.	Gajansu	7.55	590	0	366	14	n/d	1.74	.18	68	26	18	4.4	1.01	275	CaMg-HCO3
16.	Barsalpur	7.7	660	0	433	14	9	8.04	0.32	62	41	30	6	n/d	325	MgCa-HCO3
17.	Bhoome	8	1260	0	622	43	98	612	.63	68	55	90	80	.16	395	MgNaCa-HCO3
18.	Kahne Chak	8.4	510	24	262	11	n/d	8.56	.22	82	15	6.1	2.1	.18	265	CaMg-HCO3
19.	Bahne chak Fatwal	7.95	730	0	464	21	n/d	9.79	.32	72	43	28	43.1	1.2	355	CaMg-HCO3
20.	Laswara	7.6	550	0	220	79	48	4.72	n/d	84	17	6.5	2.7	.12	280	CaMg-HCO3
21.	Chak Ramdas	7.3	960	0	421	43	65	4.11	.63	100	29	55	1	.15	370	CaNaMg-HCO3
22.	Kotli Charkan	7.8	1210	0	561	64	110	14	.38	110	56	64	36	n/d	505	CaNaMg-HCO3
23.	Bholi Chak	8.4	1050	42	549	14	35	45	.7	164	30	23	28	2.57	535	CaMg-HCO3
24.	Marchopur	7.25	580	0	134	82	65	6.12	.07	86	15	16	11	2.06	275	CaMg-ClHCO$_3$ SO
25.	Fatehgarh	7.25	970	0	360	53	120	28	.2	120	35	32	14	n/d	445	CaMg-HCO$_3$ SO
26.	Pandhori brahmna	8	1000	0	665	28	35	20	.48	140	43	30	41	n/d	525	CaMg-HCO$_3$
27.	Ratian	8.2	600	0	378	14	8	11	.24	98	15	14	13	n/d	305	Ca-HCO$_3$
28.	Beaspur Parlah	7.6	1420	0	701	89	75	2.62	.22	112	35	110	100	n/d	425	CaNaHCO$_3$
29.	Chak Sheta	7.75	710	0	152	14	9.6	3.05	0.3	50	39	55	1.6	0.03	285	MgCa Na-HCO$_3$
30.	Mule Chak	6.95	2300	0	732	160	325	194	.24	290	79	130	6.2	n/d	1054	CaMgNa-HCO$_3$ SO
31.	Benagarh	7.95	2200	0	812	110	450	50	.12	253	63	116	160	.71	891	Ca-HCO3 SO4
32.	Kotli Raiyan	7.5	570	0	342	11	25	8.91	.68	92	17	11	3.8	n/d	300	CaMg-HCO3
33.	Changiya	7.7	510	0	287	11	32	6.42	.4	50	34	13	1.3	n/d	265	MgCa-HCO3
34.	Chatta	7.75	430	0	293	11	n/d	9.15	.31	74	13	9.6	4.5	4.01	240	CaMg-HCO3
35.	Peerkhou	8.1	290	0	189	11	n/d	7.08	.14	44	11	8	1.8	.1	155	CaMg-HCO3
36.	Hakkal	7.75	540	0	329	11	20	12	.05	88	19	9.5	3.5	.2	300	MgCa-HCO3
37.	Chathha	8	500	0	305	14	18	13	.07	68	27	11	1.7	.42	280	CaMg-HCO3
38.	Rampura	7.9	820	0	458	32	32	42	n/d	122	29	31	2	31	425	CaMg-HCO3
39.	Khairi(bishnah)	8.45	1300	42	100	28	59	324	.31	60	43	107	166	.2	340	Na K Mg Ca- HCO3
40.	Manghal	8.1	660	0	158	14	n/d	1.6	.31	62	36	45	3	n/d	305	CaMgNa-HCO3
41.	Chak Jawahar Singh	7.93	1200	0	550	57	125	4.36	.5	108	45	112	3.4	.04	455	CaMgNa-HCO3
42.	Kathar	7.55	1280	0	715	46	n/d	0	.9	152	36	50	52	.1	530	CaMg-HCO3
43.	Joian	8.45	850	66	560	25	18	25	0.39	110	17	36	48	.07	345	CaMg-HCO3
44.	Doal	8.35	1150	36	534	53	14	38	.57	64	57	114	30	.05	395	NaMgCa-HCO3
45.	Khojipur	8.25	920	0	513	35	29	13	.14	62	26	130	2.2	.08	266	NaCa-HCO3
46.	Kotla	7.75	500	0	799	11	-	2.18	.93	48	21	38	2.6	.48	205	CaMgNa-HCO3
47.	Gangyal sector6	7.95	620	0	330	32	18	20	.14	74	32	18	1.3	.07	315	CaMg-HCO3
48.	Babliana	7.8	670	0	354	25	10	23	.07	74	32	19	1.4	.69	315	CaMg-HCO3
49.	Sidra	8.35	750	18	207	46	85	50	.14	78	40	19	1	.06	360	CaMg-HCO3SO4
50.	Parkalta	8.4	500	36	282	14	20	8.72	.14	82	18	9.8	3	.14	280	CaMg-HCO3
51.	Kanna Chargal	7.9	430	0	271	11	n/d	3.27	.21	60	22	7	2	.15	240	CaMg-HCO3
52.	Sagoon	7.6	640	0	415	18	n/d	7.08	.15	66	32	35	1.9	1.24	295	CaMgNa-HCO3

53.	Gangyal Deep nagar	7.9	580	0	322	14	12	12	.18	70	28	28	1.6	1.29	290	CaMg-HCO3
54.	Tanda	7.8	470	0	279	21	n/d	11	.23	46	35	9.6	1.8	.45	260	CaNa-HCO3
55.	Pungali	7.55	630	0	336	28	18	7.08	.36	96	11	18	16	1.19	285	Ca-HCO3
56.	Dansal	7.75	670	0	312	32	n/d	14	.31	64	30	27	.8	.15	285	CaMg-HCO3
57.	Baruh	7.7	420	0	202	11	n/d	6	.31	38	28	12	.9	2.2	210	MgCa-HCO3
58.	Pohtta	8	580	0	372	14	n/d	4.36	.23	40	36	39	2	.42	250	Na-HCO3
59.	Khairi(nagrota)	8.1	680	0	305	43	50	3.82	.23	22	10	130	1.3	.08	95	Na-HCO3
60.	Dhounthly	7.95	360	0	320	11	n/d	6	.14	46	17	8.2	2	2.12	185	Na-HCO3
61.	Chak Chinna	7	1140	0	531	43	15	11	.49	82	26	52	108	.78	310	CaMg-HCO3
62.	Mule Chak	7.3	590	0	305	11	n/d	n/d	.52	54	30	5.2	2.4	n/d	260	Ca K Na-HCO3
63.	Karel Manhasan	7.6	1630	0	769	78	115	45	.36	148	52	94	95	n/d	585	CaMgNa-HCO3
64.	Shahpur nadrol	7.3	1560	0	836	78	95	2.5	.33	142	69	112	22	.33	640	CaMgNa-HCO3
65.	Kothey bamnal	7.8	620	0	293	18	38	23	.46	58	27	34	.8	.9	255	CaMgNa-HCO3
66.	Daleher	7.5	620	0	354	11	25	1.2	.77	50	34	33	2.3	1.06	265	MgCaNa-HCO3
67.	Marol	7.3	470	0	220	7.1	55	6.5	.33	52	21	5.6	26	1.88	215	CaMg-HCO3SO4
68.	Arnia	7.4	710	0	342	25	54	11	.43	98	23	20	3.5	1.11	340	CaMg-HCO3
69.	Rangpur trewa-1	7	1000	0	494	39	72	55	.3	114	24	60	58	0.12	385	CaNa-HCO3
70.	Rangpur trewa-2	7.4	950	0	561	25	48	16	.36	62	41	60	84	0.24	325	MgCaNa-HCO3
71.	Sai	7.5	850	0	555	18	35	9	.72	80	43	70	4.2	0.78	375	CaMgNa-HCO3
72.	Pindi sarochan	7.4	890	0	519	28	28	23	.52	128	38	20	2.1	.7	475	CaMg-HCO3
73.	Mule chak	7.555	760	0	537	14	n/d	n/d	.49	94	27	56	1.5	2.95	345	
74.	Shera chak	7.65	570	0	381	7.1	21	n/d	.46	98	17	18	1	.51	315	Ca-HCO3
75.	Kothey kalena	7.7	400	0	262	7.1	21	1.2	.52	62	18	11	1.2	.74	230	CaMg-HCO3
76.	Kul kalan	7.95	570	0	366	7.1	38	2	.52	90	24	14	1.6	.65	325	CaMg-HCO3
77.	Pachel	7.25	750	0	458	14	40	1	.49	130	23	11	.9	5.32	420	CaMg-HCO3
78.	Nai basti	7.27	730	0	482	11	40	n/d	.43	84	41	36	3.2	.2	380	CaMg-HCO3
79.	Abdal	7.4	1130	0	601	53	120	2	.72	144	61	46	2.1	.12	610	MgCa-HCO3
80.	Phalora	7.7	640	0	488	7.1	n/d	4	.52	68	44	26	2.8	.25	350	CaMg-HCO3
81.	Satowali	7.6	640	0	415	7.1	8	16	.64	88	26	25	.5	.57	325	CaMg-HCO3
82.	Kaloe	7.52	600	0	452	7.1	n/d	n/d	.46	70	36	25	3.2	n/d	325	CaMg-HCO3
83.	Allah	7.55	1000	0	470	43	38	33	.33	52	41	64	64	1.15	300	Mg NaCa-HCO3
84.	Kotli mian fateh	8.35	450	30	226	11	10	14	.6	84	11	9.1	.8	.25	255	Ca-HCO3
85.	Suchetgarh	7.6	610	0	470	7.1	n/d	1.2	.57	62	44	26	2.6	n/d	335	Mg Ca-HCO3
86.	Badyal bramna	7.45	640	0	354	18	12	30	.35	98	19	12	.6	.29	325	CaMg-HCO3
87.	Marh	7.85	610	0	390	14	11	16	.04	108	11	23	1.5	.15	315	Ca-HCO3
88.	Birpur	7.46	500	0	299	25	14	16	.2	100	7.2	13	.6	.14	280	Ca-HCO3
89.	BOP Old Kannachak	7.41	600	0	312	11	5	20	.15	84	19	8.7	6.4	Tr	280	CaMg-HCO3
90.	BOP Golpattan	7.14	1200	0	659	53	22	30	.15	160	33	46	22	n/d	535	CaMg-HCO3
91.	BOP Golpattan	7.29	550	0	317	11	22	9.5	.15	78	21	6.1	9.9	1.3	280	CaMg-HCO3
92.	BOP Beli Azmat	7.05	940	0	500	36	18	45	Tr	118	33	26	23	.37	430	CaMg-HCO3
93.	BOP Beli Azmat	7.43	720	0	445	14	8	15	.75	96	28	20	7.2	Tr	355	CaMg-HCO3
94.	BOP B T Forward	7.42	520	0	317	7.1	35	Tr	.35	74	22	13	6.7	.22	275	CaMg-HCO3
95.	Bishnah	8.72	1590	54	397	156	45	187	.4	16	51	75	330	.28	250	K7Mg-HCO3Cl
96.	Kaluchak	8.5	960	36	311	117	25	1.2	.1	12	51	120	73	Tr	240	NaMg-HCO3Cl
97.	Mira Sahib	8.25	530	0	159	57	27	27	.1	38	28	24	1.1	Tr	210	MgCa-HCO3Cl
98.	Majuha Lakshmi	8.5	870	48	427	43	12	18	.1	66	45	34	59	Tr	350	MgCa-HCO3Cl
99.	Nikowal	8.39	660	30	287	60	8	Tr	.64	12	55	47	18	.18	255	Mg Ca-HCO3
100.	Quadarpur	7.93	410	0	226	14	18	6.8	.25	54	17	12	1.5	.24	205	Mg Na-HCO3Cl
101.	Rehal	8.1	590	0	311	28	15	3.9	.3	86	19	21	1.4		295	Ca-HCO3
102.	Suchet garh	8.05	2800	0	732	405	430	1.9	.6	44	144	320	180	Tr	700	NaMg -HCO3ClSO4
103.	Uprela canal	8.6	800	24	421	39	16	7.3	.8	68	26	72	24	.45	275	CaNaMg-HCO3
104.	Majhu-Lakshmi	8.35	960	48	488	46	10	27	.3	82	46	46	61	n/d	395	CaMg-HCO3
105.	Chak chimanna	8.59	300	6	177	11	.1	3.9	.1	20	13	30	1.6	n/d	105	CaKMg-HCO3
106.	Akhnoor	8.7	240	6	104	18	6	2.9	.1	28	12	4	3	.13	120	CaMg-HCO3
107.	Bakore	8.5	460	12	256	28	.1	6	.15	76	11	17	4.5	.45	235	Ca-HCO3
108.	Bhagwanechak	8.25	400	0	207	18	5	17	.6	34	19	22	1.7	.24	165	CaMg Na-HCO3
109.	Devipur	9	560	18	104	71	32	94	.1	22	47	14	1	.22	250	Mg-ClHCO3 NO
110.	Dhanpur	8.05	270	0	171	3.5	.1	.97	.15	40	9.7	5	.7	.36	140	CaMg-HCO3
111.	Gura	8.13	450	0	226	25	14	17	.2	36	32	13	1.2	4.7	220	MgCa-HCO3
112.	Hazuribhag	7.92	630	0	262	53	8	29	.1	52	34	23	2	.76	270	MgCa-HCO3Cl
113.	Jhiri	8.85	260	12	116	11	8	.1	.1	20	18	6.4	4.2	.24	125	MgCa-HCO3
114.	Jourian	7.85	700	0	366	35	12	27	.1	86	15	34	31	.1	275	Ca-HCO3
115.	Kanachak	8.42	310	6	159	11	8	.97	.6	30	19	5.8	1.9	1.08	155	MgCa-HCO3

116.	Khour	7.9	360	0	128	21	25	29	.2	54	11	4	.7	8.3	180	CaMg-HCO3
117.	Lam	8.5	250	6	128	14	.1	.1	.1	22	7.2	17	8.2	.36	85	CaNa Mg-HCO3
118.	Muthi	8.62	450	6	189	32	30	.1	.15	22	30	30	2.2	8.4	180	MgNa Ca-HCO3
119.	Nagbani	8.55	290	6	153	18	.1	.1	.1	22	22	14	3.2	6.76	130	MgCa-HCO3
120.	Palanwala	8.54	260	6	116	25	.1	.1	.2	28	9.7	14	2.7	1.49	110	CaMg Na-HCO3Cl
121.	Pangli colony	8.7	210	12	73	18	.1	.1	.1	18	6	15	3.3	2.16	70	CaMg Na-HCO3Cl
122.	Pata kho	7.98	260	0	153	18	.1	4.8	.1	18	19	94	2.7	.84	125	MgCa-HCO3
123.	Purkho	8.5	390	12	159	25	.1	26	.1	18	28	21	2.5	1.3	160	MgNa Ca-HCO3
124.	Senth	8.47	790	6	256	60	80	4.8	.1	22	29	56	78	.46	175	NaMgK-HCO3
125.	Taryai	8.5	290	6	122	21	.1	18	.2	32	12	12	1.3	.35	130	CaMg-HCO3
Values as per IS 10500-1991	Desirable					250	200		1.0	75	30			0.3	300	
	Permissible	6.5-85	250 WHO	*	*	1000	400	45	1.5	200	100	*	*	1	600	

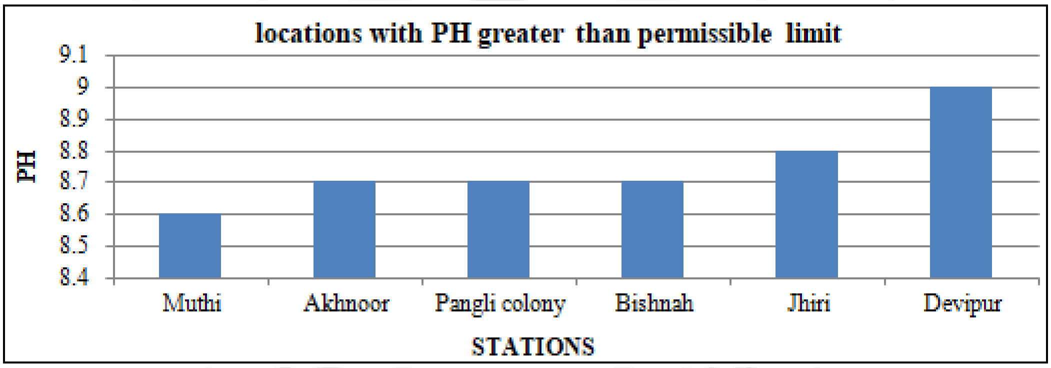
Table 3.1.5: Water Quality Parameters of Deep Groundwater Samples compared with ISI standard and WHO standard

S. No	Location	Physico-Chemical Parameters														Type of Water
		pH	EC µmho s/cm	CO3	HCO3	Cl	SO4	NO3	F	Ca	Mg	Na	K	Fe	TH	
				mg/l												
1.	Purkhoo	7.79	560	0	409	7.1	Tr	18	0	104	17	14	1.2	Tr	330	Ca-HCO$_3$
2.	Patakhu	7.62	500	0	372	7.1	20	9.5	0.2	100	19	6.7	2.2	0.11	330	CaMg-HCO3
3.	Nad	8.45	320	0	232	7.1	8	11	0.2	42	23	7.8	0.9	0.15	200	CaMg-HCO3
4.	Jourian	8.25	360	0	232	7.1	4	2.9	0.2	52	17	3.5	0.6	Tr	200	CaMg-HCO3
5.	Padli	7.87	380	0	244	7.1	5	8.9	0.3	56	15	10	0.9	0.37	200	CaMg-HCO3
6.	Garar	7.89	310	0	262	7.1	3	Tr	0.2	50	18	13	1.2	1.34	200	CaMg-HCO3
7.	Taryari	8.35	270	6	171	7.1	Tr	19	0.2	42	9.7	15	0.9	0.41	145	CaMg-HCO3
8.	Thanger pattian	7.67	530	0	366	18	10	39	Tr	98	15	29	0.7	0.11	305	Ca-HCO3
9.	Dalheri	7.34	380	0	195	7.1	12	25	0.3	64	7.3	5.9	0.5	0.89	190	Ca-HCO3
10.	Pangiari	6.97	400	0	134	7.1	Tr	11	0.2	38	6	5.2	0.6	0.6	120	Ca-HCO3
11.	Akhnoor town	7.94	450	0	354	11	12	5.9	0.2	96	15	9.1	2.8	0.18	300	Ca-HCO3
12.	Jhiri	7.83	380	0	293	7.1	8	12	0	68	21	4.9	1.9	Tr	255	CaMg-HCO3
13.	Gajansoo	7.97	400	0	306	7.1	16	7.2	0.2	70	23	5.2	2.7	0.3	270	CaMg-HCO3
14.	Pouni chak	7.89	450	0	342	11	Tr	12	0.2	76	23	9.2	1.1	Tr	285	CaMg-HCO3
15.	Ranjan	8.45	510	6	366	7.1	14	14	0	96	21	9.3	0.7	Tr	325	CaMg-HCO3
16.	Amran	8.35	340	0	262	7.1	8	4.2	0.3	68	13	4.7	2.2	0.22	225	CaMg-HCO3
17.	R S pura	7.98	510	0	372	11	15	Tr	0.2	78	23	21	1.7	0.15	290	CaMg-HCO3
18.	Diwanpur	7.8	560	0	390	7.1	10	Tr	0.3	54	34	29	2.3	0.78	275	CaMg-HCO3
19.	Deora out post	7.72	540	0	397	14	20	3.5	0.6	96	23	12	7.9	0.07	335	CaMg-HCO3
20.	Nanak nagar	7.79	870	0	397	36	14	89	0.3	112	26	35	1.9	Tr	385	CaMg-HCO3
21.	Greater kailash	8.09	340	0	268	3.6	Tr	15	0.2	60	15	14	0.9	0.41	210	CaMg-HCO3
22.	Hakkal	7.91	540	0	317	14	12	18	0.7	74	23	13	1.7	Tr	280	CaMg-HCO3
23.	Ram vihar janipur	8.19	400	0	244	7.1	12	11	Tr	64	9.7	15	1.3	Tr	200	Ca-HCO3
24.	Waziran wali gali	7.86	770	0	378	32	15	60	0.2	110	21	25	1.7	0.22	360	CaMg-HCO3
25.	Company bagh	7.96	850	0	433	39	16	60	0	116	26	34	6.4	0.26	395	CaMg-HCO3
26.	CPS boria	8.45	380	0	207	11	5	21	0	52	13	10	3.1	0.15	185	CaMg-HCO3
27.	Nakrean	8.21	500	0	244	21	8	24	Tr	68	12	16	2.7	0.26	220	Ca-HCO3
28.	Mule chak	7.3	590	0	305	18	3.8	Tr	0.5	54	30	5.2	2.4	Tr	258	CaMg-HCO3
29.	Gangyal	7.62	500	0	413	28	24	29	0.2	112	22	27	1.3	0.18	370	CaMg-HCO3
30.	Digiana	7.15	1040	0	451	50	45	77	Tr	138	34	39	2	0.07	485	CaMg-HCO3
31.	Narwal bala	7.7	870	0	421	36	22	72	0.2	112	33	27	2.1	Tr	415	Ca-HCO3
32.	Deeli	7.54	320	0	98	18	15	63	0.2	42	9.7	12	0.9	Tr	145	CaMg-HCO3NO3
33.	Trikuta nagar	7.24	340	0	134	25	5	30	Tr	38	12	14	0.9	Tr	145	CaMg-HCO3Cl
34.	Peerkho	8.35	310	0	189	11	Tr	4.1	Tr	58	2.4	7.5	1.3	Tr	155	Ca-HCO3
35.	Dhounthly	8.21	340	0	183	11	8	1.8	0.4	48	8.5	9.4	1.2	0.18	155	Ca-HCO3
36.	Paloura	7.6	850	0	356	18	100	31	Tr	90	28	50	2.6	0.07	340	CaMgNa-HCO3SO
37.	Sushil nagar talab	7.28	870	0	381	75	18	31	0	114	29	27	1.5	Tr	405	CaMg-HCO3Cl
38.	Women college, gandhi nagar	7.45	610	0	305	25	16	27	Tr	84	21	13	2.7	0.15	295	CaMg-HCO3
39.	Shastri nagar	7.5	830	0	366	43	12	92	Tr	100	33	29	1.8	0.78	385	CaMg-HCO3
40.	Barnari	7.42	610	0	348	18	30	20	0.3	82	18	38	0.7	Tr	280	CaNaMg-HCO3
41.	Bandhu rakh	7.56	550	0	348	11	5	20	0.4	88	17	18	1.7	Tr	290	CaMg-HCO3
42.	Gol gujral	7.6	670	0	397	28	22	22	0	84	30	15	2.5	0.18	335	CaMg-HCO3
43.	Gangyal TW No 28	7.85	650	0	384	28	15	26	0.2	82	28	24	1.3	0.07	320	CaMg-HCO3
44.	Gangyal (chinar TW)	7.85	620	0	397	14	Tr	19	0.2	82	29	24	1.2	0.09	325	CaMg-HCO3

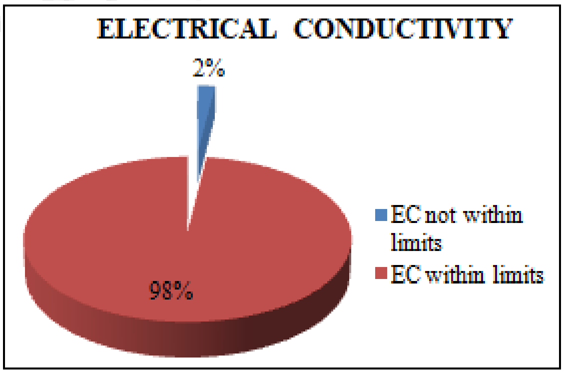
45.	Narwal bala	8	790	0	384	32	Tr	55	0.2	40	58	17	202	0.15	340	CaMg-HCO3
46.	Upper kanal	7.3	1270	0	641	67	32	14	0.3	158	26	30	206	0.49	500	CaNa-HCO3
47.	Chorli	7.4	660	0	452	11	Tr	Tr	0.4	46	47	78	1.7	2.42	315	MgCa-HCO3
48.	Bhola chak	7.1	610	0	281	18	52	10	0.5	80	22	32	1.4	0.1	290	CaMg-HCO3
49.	Laswara	7	650	0	360	7.1	Tr	3	0.4	26	50	16	1.3	Tr	270	MgCa-HCO3
50.	Bishnah samadhiyan	7.2	620	0	415	7.1	Tr	Tr	0.6	70	33	20	2	Tr	310	CaMg-HCO3
51.	Chak chimna	7	1140	0	571	43	15	11	0.5	82	26	21	108	0.78	310	CaMg-HCO3
52.	Chak bhuvan	7.1	530	0	323	7.1	8	13	0.5	68	21	52	1.8	Tr	255	CaMg-HCO3
53.	Lower garigarh	7.7	610	0	354	18	28	19	0.3	82	33	19	1.2	Tr	340	CaMg-HCO3
54.	Haripur rakh	7.45	650	0	458	11	18	Tr	0.6	70	39	12	2.7	0.49	335	CaMg-HCO3
55.	Tohana ist	7.6	620	0	445	3.5	28	Tr	0.5	80	21	38	21	Tr	435	CaMgNa-HCO3
56.	Kharkha	7.3	470	0	275	11	9	16	0.13	78	10	13	0.9	0.1	230	Ca-HCO3
Values as per IS 10500-1991	Desirable	6.5-8.5	250 WHO	*	*	250	200	45	1.0	75	30	*	*	0.3	300	
	Permissible					1000	400		1.5	200	100			1	600	

3.5 Analysis of Physico- Chemical parameters of groundwater for drinking water quality as per ISI and WHO standards-

(I) pH- pH of solution is taken as negative logarithm of H2 ions. The pH of ground water in the study area ranges from a minimum value of 6.9 in Mulechak to a maximum of 8.85 in devipur. When compared with the standard values, the samples are found to be in the permissible limit at most of the places with a few expections in shallow ground water samples which have high degree of pH i.e they are alkaline in nature. Due to high pH, water has a bitter taste which makes it unfit for drinking. The shallow ground water having high pH exceeding the maximum permissible limits for drinking water is found in Muthi(8.6), Akhnoor (8.7), Pangli colony (8.7), Bishnah (8.7), Jhiri(8.8) and Devipur (9.0). The high alkalinity of groundwater in certain locations in the study area may be due to the presence of bicarbonate and some salts.



(II) EC- Electrical conductivity of water is a direct function of its total dissolved salts. Hence it is an index to represent the total concentration of soluble salts in water. Excess salt increases the osmotic pressure of the soil solutions that can result in physiological drought conditions. In the present investigation maximum conductivity 2800 µmhos/cm was observed at Suchetgarh of shallow ground water exceeding desirable limits for drinking water and minimum of 210 µmhos/cm at pangli colony of shallow ground water. Out of the total 181 samples only 3 samples are having EC as per the limits prescribed by WHO. The remaining samples have high EC. This may be due to the increased dissolution of salts along with the monsoon rains into the groundwater.



(III) Carbonate (CO3) Whenever the pH touches 8.3, the presence of carbonates is indicated. 20 water samples out of the 125 shallow groundwater samples are having pH greater than 8.3 and their carbonate value ranges from 6 mg/l to a maximum of 48mg/l in Nagbani and Raipur khairi. In deep ground water samples all are having ph less then 8.3 so no carbonate is found in water.

(IV) Bicarbonate (HCO3) - Bicarbonates concentration in water relies on pH and is usually less than 500 mg/l in groundwater. It affects alkalinity and hardness of water. The weathering of rocks adds bicarbonate content in water. From an analysis of the data, the value of HCO3 ranges from 836 mg/l in shahpur nadrol to 73 mg/l in Pangli colony. 14 samples out of 125 shallow ground water samples have bicarbonate value above 500mg/l and 28 samples out of 56 deep water samples have value above 500 mg/l with upper kanal with 1270 mg/l of bicarbonate.

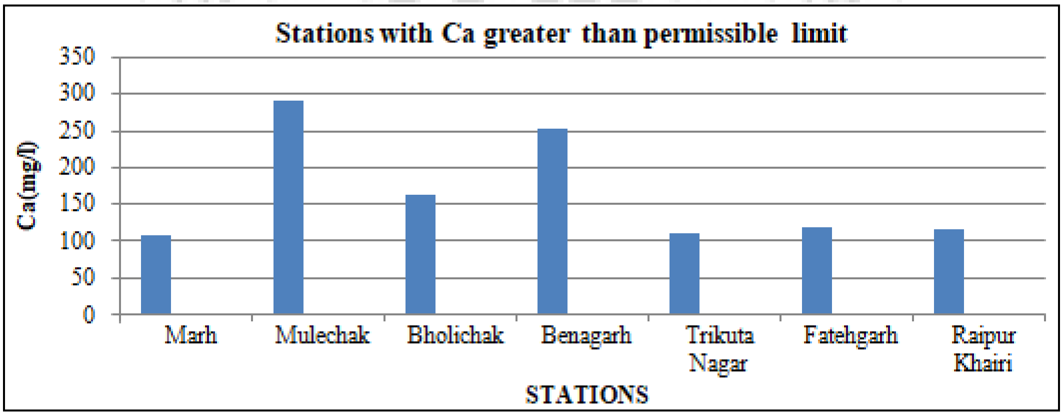
(V) Chloride (Cl) - Chloride is mainly obtained from the dissolution of salts of hydrochloric acid as table salt (NaCl) and added through activities carried out in agricultural area, industrial waste, sewage, trade wastes, sea water etc. Most drinking water treatment plants use chlorine as a disinfectant. Chloride values for almost all the stations are within the permissible limits except for suchetgarh (405 mg/l) in shallow aquifer. Chloride in excess imparts salty taste to water. Long-term consumption (> 50 mg/l) increases risk for cancer, development of essential hypertension, risk for stroke, left ventricular hypertension, osteoporosis, renal stones and asthma in human beings.

(VI) Sulphate (SO4) - The sulphate ion is one of the important anion present in natural water which is mainly derived from the dissolution of salts of sulphuric acid, from gypsum on oxidation of pyrites and is also present in industrial wastes. It is one of the least toxic anions and is soluble in water. It produces catharsis, dehydration and gastrointestinal irritation effect upon human beings when it is present in excess. All the groundwater samples collected from spring, shallow and deep aquifers have sulphate content ranging from 0.1 mg/l in Purkho to 28 mg/l in Lower garigarh and are within the desirable limit for drinking water. In some samples, sulphate content is found in traces.

(VII) Nitrate (NO3) - Nitrate is present in ground water and mainly it is a form of N2 compound (of its oxidizing state). Nitrate is produced from chemical and fertilizer factories, nitrogen cycle, nitrogenous fertilizers used in agriculture, matters of animals, decline vegetables, domestic and industrial discharge. In the study area, the very high nitrate concentration is found in Narwal bala (72mg/l), company bagh (60 mg/l), Deeli (63mg/l), Digiana 77mg/l) exceeding the desirable limits for drinking water. The higher values of nitrate are the most common indication of agricultural impact on groundwater quality. In some samples, nitrate content is found in traces while other samples have nitrate concentration within desirable limits. If consumed in excessive limits, it contributes to the illness known as methenglobinemia / blue baby syndrome in infants.

(VIII) Flouride (F) - Fluoride is one of the main trace elements in groundwater which generally occurs as a natural constituent. It is one of the essential elements for maintaining normal development of healthy teeth and bones. Factors which control the concentration of fluoride are the climate of the area and the presence of flouride in the bed rock through which the ground water is circulating. Concentrations of fluoride in samples taken from the study area varied from 0.07 mg/l to 0.96 mg/l in Gangyal sector 6. Flouride values for almost all the stations are within the permissible limits indicating that it is portable.

(IX) Calcium (Ca) - Calcium is an important element for human cell physiology and bones. It has high solubility and is very common in groundwater because of its availability in all kinds of rocks. The source of calcium and magnesium in natural water are various types of rocks, industrial waste and sewage. From an analysis of the data, it is concluded that high concentration of Ca ions is found in marh (108 mg/l), Mulechak (290 mg/l), Bholichak (164mg/l), Benagarh (253mg/l), trikuta nagar (112mg/l), fatehgarh(120mg/l), Raipur khairi (116mg/l). Rest of the water samples have calcium content as desired.

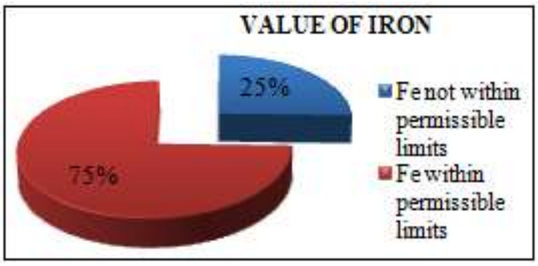


(X) Magnesium (Mg) - Magnesium is a natural constituent of water. The magnesium is derived from dissolution of magnesium calcite, gypsum and dolomite from source rocks. Magnesium is an essential ion for functioning of cells in enzyme activation. Maximum concentration of Mg is observed in Suchetgarh of shallow aquifer i.e. 144 mg/l. At higher concentration, it is considered as laxative agent and has unpleasant taste. In the study area, most of the locations are having low concentration of Mg. Such a low concentration somewhat effects health of residents as it is essential for human body.

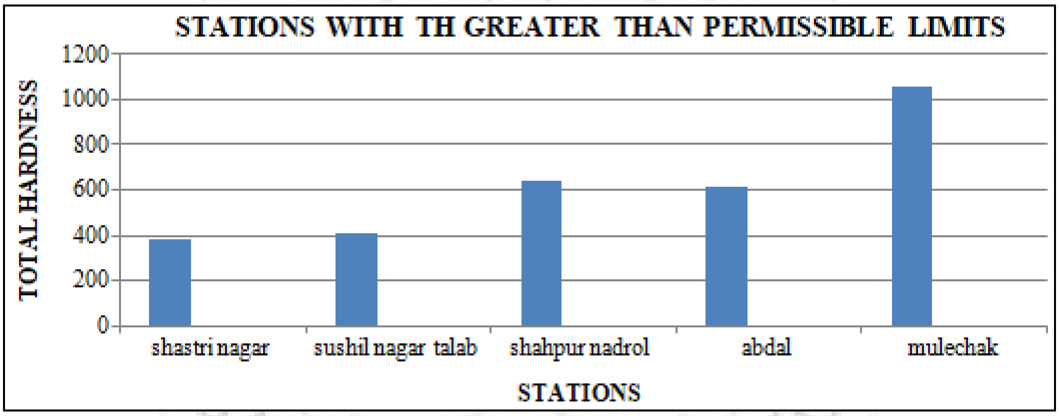
(XI) Sodium (Na) - Sodium is a silver white metallic element and found in less quantity in water. Proper quantity of sodium in human body prevents many fatal diseases like kidney damages, hypertension, headache etc. It is analyzed that the concentrate on of Na in spring and deeper aquifer is less with respect to shallow aquifer. Maximum presence is found in water sample from Suchetgarh (320 mg/l) and minimum in Akhnoor (4 mg/l).

(XII) Potassium (K) - Potassium is silver white alkali which is highly reactive with water. Potassium is necessary for living organism functioning hence found in all human and animal tissues particularly in plants cells. The major source of potassium in natural fresh water is weathering of rocks but the quantities increase in the polluted water due to disposal of waste water. Potassium is deficient in rare but may led to depression, muscle weakness, heart rhythm disorder etc. Only one location i.e. bisnah has a greater amount of K i.e. 330 mg/l. Rest of the values of 181 stations lie between 0.5 mg/l in Dalheri to 108 mg/l in Chakchimna.

(XIII) Iron (Fe) - Iron is an essential element in the body system, being a metal that couple with ligand which constitutes blood. pH is an important factor that could influence the solubility and resultant concentration of iron. Other factors include local geological structure and hydrological conditions of the basin. However, its toxicity could cause transfusional siderosis in spleen, disturbance in liver function and diabetes mellitus. Out of the 181groundwater samples for Fe concentration in both shallow and deep water, 46 samples are having Fe concentration exceeding maximum permissible limits for drinking water. Highest concentration is found in muthi shallow groundwater i.e 14.4 mg/l. At some places it is found in traces.



(XIV) Total Hardness (TH) - Hard water is characterized with high mineral contents that are usually not harmful for humans. It is often measured as calcium carbonate (CaCO3). Hard water can clog household pipes with scale, cause incrustations on kitchen utensils, is unsuitable for domestic use and increase soap consumption. Very hard water is not suitable for drinking purpose and causes the gastro diseases. Groundwater in the area exceeding the limit of 300 mg/l as CaCO3 are shastrinagar (385 mg/l), sushil nagar talab (405 mg/l), shahpur nadrol (640 mg/l), abdal (610 mg/l), mulechak (1054mg/l)are considered to be hard. This may be due to solid waste leachate and geology of the rocks. Rest of the water samples have total hardness within the desirable limit for drinking water.



3.6 Impact of water quality hazards on health

S.No.	*Parameters*	*Probable Effects*
1.	Colour	Makes water aesthetically undesirable.
2.	Turbidity	High turbidity indicates contamination/pollution
3.	$CaCO_3$(mg/l)	Causes urinary concretions, diseases of kidney or bladder and stomach disorder.
4.	Iron(mg/l)	Gives bitter sweet astringent taste, causes staining of laundry and porcelain. In traces it is essential for nutrition
5.	Chloride(mg/l)	May be injurious to some people suffering from diseases of heart or kidneys. Taste, Indigestion, corrosion and palatability are affected.
6.	TDS(mg/l)	Palatibility decreases and may cause gastro-intestinal irritation in human, may have laxative effect particularly upon transits and corrosion, may damage water system
7.	Calcium(mg/l)	Causes encrustation in water supply system. while insufficiency causes a severe type of rickets, excess causes concretions in the body such as kidney or bladder stones and irritation in urinary passages. It is essential for nervous and muscular system, cardiac functions and in cogulation of blood.
8.	Magnesium(mg/l)	Its salts are cathartics and diuretic. High conc. May have laxative effect particularly on new users. Magnesium deficiency is associated with structural and functional changes. It is essential as an activator of much enzyme system.
9.	Copper(mg/l)	Deficiency results in nutritional anaemia in infants. Large amount may result in liver damage, cause central nervous system irritation and depression.
10.	So_4(mg/l)	Causes gastro-intestinal irritation. Along with Mg or Na, can have a cathartic effect on users, concentration more than 750 mg/l may have a laxative effect along with magnesium.
11.	NO_3(mg/l)	Causes infant mathaemoglobinaemia (blue babies) at very high concentration, causes gastric cancer and affects adversely central nervous system and cardio-vascular system.
12.	Fluoride(mg/l)	Reduces dental carries, very high concentration may cause crippling skeletal flouorosis.
13.	Cd(mg/l)	Acute toxicity may be associated with renal, arterial hypertension, itai-itai disease. Cadmium salts causes cramps.nausea, vomiting and diarrhoea.

14.	lead(mg/l)	Toxic in both acute and chronic exposures. Burning in the mouth, severe inflammation of the gastro-intestinal tract with vomiting and diarrhoea, chronic toxicity produces nausea, severe abdominal pain, paralysis, mental confusion, visual disturbances, anaemia e.t.c
15.	Zinc(mg/l)	An essential and beneficial element in human metabolism. Taste threshold for Zn occurs at about 5 mg/l, imparts astringent taste to water.
16.	Chromium(mg/l)	Hexavalent state of chromium produces lung tumors can produce cutaneous and nasal mucous membrane ulcers and dermatitis.
17.	Boron(mg/l)	Affects central nervous system its salt may cause nausea, cramps, convulsions, coma e.t.c.
18.	Phosphate(mg/l)	High conc. May cause vomiting and diarrhoea, stimulate secondary hyperthyroidism and bone loss.
19.	Sodium(mg/l)	Harmful to persons suffering from cardiac. Renal and circulatory diseases.
20.	Pottasium(mg/l)	Its excessive amounts are cathartic.
21.	Nickel(mg/l)	Non-toxic element but may be carcinogenic in animals, can react with DNA resulting in DNA damage in animals.
22.	Pathogens (a)Total coliform(per 100ml) (b)Faecal coliform(per 100ml)	Cause water borne diseases like coliform jaundice, typhoid, cholera e.t.c produce infections involving skin mucous membrane of eyes, ears and throat.

About half million people in India are suffering from ailment due to excess fluoride in drinking water. The prominent health related problems are dental caries, teeth mottling, skeletal damage, deformation to children and adults. Flouride reduces dental caries in concentration range of 0.8-1.0mg/l in drinking water.

Arsenic and arsenical compounds are found in effluents form dyeing industries and pesticide manufacturing industries, petroleum refineries, rare earth industries and other organic and inorganic chemical industries.

Acute poisoning by arsenic in drinking water involves the central nervous system, leading coma. The gastrointestinal tract, the respiratory tract abd the skin can be severely affected. Neurological manifestations and even malignant tumors in vital organs may also occur. In groundwater, nitrate form of nitrogen is of greater interest though in water or wastewater the forms of nitrogen that prevails are nitrate, nitrite, ammonia and organic nitrogen. The toxicity of nitrate to human health is due to body reduction of nitrate to nitrite. When nitrite combines with haemoglobin to form an oxidised product methemoglobinemia, oxygen transfer capability of blood decreases causing cellual anoxia and clinical cyanosis (blue baby syndrome). This phenomenon occurs in baby when nearly 10% of the total haemoglobin has been converted to methemoglobin.

3.7 Groundwater Management Strategy-Ground Water Development

The district being partially under plain and hilly terrain, traditional sources of ground water mainly dug wells, tube wells has played a major role since past in providing assured irrigation and water supply. In some of the areas, at present groundwater structures are the only sources for the water supply for irrigation, domestic and industrial use. However, modern means for tapping the ground water have been emphasized in recent years. During the last 15-20 years, Irrigation and Public Health Department has constructed number of bore wells fitted in the area to meet the water requirement especially in peak summer.

Outer plains occupy more than 75 % of the area of the district. During the very past years, the traditional ground water source has served the settlements. Ground water development on moderate scale is seen in the areas particularly in the outer plains.

Water Conservation & Artificial Recharge

Ground water extraction through dug wells, hand pumps, tube-wells, are the major sources of water supply to both rural and urban areas, but the availability of water during summer is limited particularly in drought years and requires immediate attention to augment this resource. Based upon the climatic conditions, topography, hydro-geology of the area, suitable structure for rain water harvesting and artificial recharge to ground water are required. Roof top rainwater harvesting need to be adopted in urban and water scarce hilly areas and proper scientific intervention for development of groundwater is required in water scarce areas.

In the urban areas and hilly areas, roof top rainwater harvesting structures like storage tanks are recommended while in low hill ranges, check dam and roof top rainwater harvesting structures can be adopted. Kandi region of the district faces acute shortage of water supply round the year because of deep water level and hard boulders in clayey matrix. To recharge and conserve the groundwater resources, de-silting and revival of *Kandi* ponds appears an effective solution. Central Ground Water Board has taken up a few pilot schemes on Artificial Recharge to groundwater in J&K State. Such schemes are completed in which roof top water is collected and stored in groundwater at Kot Bhalwal (Aknoor) in rural area and at *Nirman Bhawan* in Jammu city. Some schemes have also completed in other parts viz. Govt. College for Women, Gandhi Nagar, Air port building, Satwari, Jammu etc.

4. Conclusion

The study of ground water quality in Jammu district has indicated that concentration of various dissolved solids, specific conductance, chlorides, nitrate fluoride, iron and other water quality parameters are increasing marginally and in some isolated pockets remarkably. Ground water samples from entire district were collected with prescribed norms and analysed by adopting standard methods of analysis. The results of current study indicate that the drinking water, used by the people residing in villages of Jammu district is potable except some few pockets which are contaminated It has been evaluated that in the study area, nature of water is acidic to alkaline in nature. Some of the samples collected from shallow ground water and deep ground water of jammu district are acidic. The maximum value of PH 9.0 is recorded in sample collected from Devipur of Jammu district. Water sample of Suchetgarh of jammu district is reported to have maximum value of EC 2800 micro mhos /cm at 25 °C. In springs of Jammu region, bicarbonate ranges from 43mg/l at Shantani to 628 mg/l at Satinator. The maximum concentration of bicarbonate 836mg/lfrom shallow ground water of Jammu region is observed in the water sample collected from Shahpur nadrol of jammu district.

In majority of samples, chloride concentrations are less but at few places high values are also recorded. It has been assessed that the chloride concentration in water collected from the study area is very high in Suchetgarh with 405mg/l. Nitrate and fluoride concentrations are generally low but high values are also reported in some of the samples collected from the Jammu district. However, highest concentration of magnesium is found in the water samples collected from Suchetgarh with 144mg/l. Suchetgarh has also been recorded to have highest concentration of sodium with 305mg/l respectively. High value of potassium is reported in water sample collected from shallow and deep ground water of study area. Bishnah is having the highest concentration of about 330mg/l.

High concentration of carbonates, bicarbonates of calcium and magnesium found in ground water causes hardness. Maximum concentration of TH of 1050mg/l is found at Mulechak. In Jammu district, 32 wells are found to have Iron concentration beyond maximum permissible limit, 1.0 mg/l(Muthi 8.4 mg/l, Khour 8.3 mg/l and Nagbani 6.76mg/l). Muthi has been observed to comprise of highest concentration of Iron with 8.4mg/l respectively and so it causes a major threat to the people residing there due to its contamination with the highest proportion of Fe. Village Suchetgarh has been demarcated as the water challenge for J&K state because of contamination due to Sodium, magnesium and chloride and electrical conductivity.

Sustainability in water quantity must imply sustainability in water quality. Contaminated groundwater resources cannot be used as a resource. Therefore, every effort should be taken to ensure that groundwater quality is preserved for the benefit of present and future generations. The analysis reveals that the groundwater of some areas needs some degree of treatment before consumption and it also needs to be protected from contamination. Care needs to be taken to monitor the interaction between the geological formations in the area and the groundwater, especially in the present scenario of over extraction of groundwater. Based on these results and analysis of water samples, it is also recommended to use water only after boiling and filtering or by reverse osmosis treatment for drinking purpose by the individuals to prevent adverse health effects. It is recommended that water analysis should be carried out from time to time to monitor the rate and kind of contamination.

It is the need of an hour to take up comprehensive studies on ground water quality of both shallow and deep ground waters analyzing major elements, heavy metals, pesticides, microbial contamination. Areas identified with higher concentrations of heavy metals, nitrates and fluorides need to be given special attentions.

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