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Appraisal of Ground Water prominence inn Bhuj (Kachchh), Gujarat (India) For its Imbibing and Irrigation Use

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Abstract

Ground water is charming and distinct deliberation as it has spun out to be a life-threatening resource for socio-economic progress of any country. However, it is catering a foremost bit of the demand from domestic, irrigation and industrial sectors in India. Unplanned and fast-tracked development is creating alarm among scientists, users and policy makers. The main anxiety is the very tiring resources volumetrically, and tumbling of water levels. Ground water is the backbone of drinking water supply in rural areas as well as supplement supply in urban areas; one more crucial concern is quality of ground water which is of a mind by nature and extent of rock-water dealings, formations and varying climatic conditions. Due to ground water contamination it become non-potable as outstrips the limits recommended by Bureau of Indian Standards (BIS).Bhuj taluka lies near Rann area of Kachchh. Present study of pH, Electrical conductivity (EC), Total Dissolved Solids (TDS),Nitrate (NO_3^-) and Fluoride (F^-)was conducted to assess suitability of groundwater for irrigation and domestic purpose by comparing with the World Health Organization (WHO) and Indian standards. The sample analysis reveals that groundwater is not entirely fit for drinking with respect to pH, TDS and F^-. In some of collected samples; concentrations of these parameters exceed the permissible limits of WHO and Indian standards.

Keywords: Groundwater quality; physiochemical; BIS; Bhuj; Kachchh

INTRODUCTION

Safe drinking water is crucial for life and adequate safe supply must be made available to patrons [1] Hence worthy drinking water is not an amenity but one of the most vital necessities of life itself [3].However, developing countries, have agonized from a lack of access to safe drinking water from better-quality sources and to ample sanitation services. World Health Organization (WHO) publicized that seventy-five percent of all diseases in developing countries arise from adulterated drinking water [58].

The problem(s) associated with chemical constituents of drinking water arise first and foremost from their ability to cause contrary health effects. Prolonged exposures of particular contaminants such as heavy metals have aggregate toxic properties which may cause detriment to health. Most common teething troubles in household water supplies may be accredited to hardness, iron, sulfides, sodium chloride, alkalinity, acidity and pathogens. This makes drinking water a mobile source of disease transmission [21].

Therefore, it is anticipated to control intake of these hypothetically toxic chemicals from drinking water because the ingestion from other sources which may be food or air [20]. Like other developing countries drinking water quality is major issue in India and studies associated to drinking water quality of Bhuj (India) have not been accompanied so far. The aim of this study was to look at the levels of some physico-chemical parameters of drinking water of Bhuj Taluka. The aptness of groundwater for agricultural and domestic drives were assessed by comparing values of different water quality parameters with those of the World Health Organization [58], and Indian standards specification (BIS:1991, Reaffirmed during 2005,2012 and 2015) guidelines values for drinking water.

MATERIALS AND METHODS

Generalnarrative of study taluka

Kachchhis virtually an island, as it is bounded by theArabian Seain the west; theGulf of Kachchhin south and southeast &Rann of Kachchhin north and northeast. Hence it has extreme climatic and geographical condition and it suffers both the problems of quantity and quality of water. Kachchh has low water resources i.e. 0.1% of the country’s resources.Bhuj taluka has total 182 Panchayat Villages. Appraisal on the literature showed that by & large, no through investigation has been undertaken in each & every village(s) of Bhuj taluka with regard to physico-chemical analysis of water yet. Hence main objective of this study was to explore the quality of ground water in most rural habitations of Bhuj taluka[15, 19, 59].

Sample assortment

The total area of the Bhuj taluka is estimated about 4500 square kilometer. Groundwater samples were collected from 182 panchayat villages of Bhuj. Samples were collected before monsoon. The location of sampling points is shown in Table1.

Table 1. Maximum Allowable Concentration of Various Drinking water quality standards

Parameter	**BIS:2012**	**ICMR:1975**	**WHO:2011**
p^H	6.5-8.5	6.0-8.5	6.5-8.5
EC(mS/cm)	2.250*	-	-
NO_3^-(mg/L)	100	45	50
F^-(mg/L)	1.5	1.5	1.5
TDS(mg/L)	2000	1500	1000

*BIS:IS:2296: 1992

Pre-cleaned and rinsed polythene fresh carboys of two litre capacity with necessary precautions, were used for sample collection [9]. The samples were collected from manually operated hand pump, open well and borewell. The samples were filled up to the brim and were instantly sealed to avoid exposure to air and were labeled thoroughly. The labeled samples were analyzed in laboratory for various physicochemical parameters. During sample collection, handling and preservation standard procedures recommended by the American Public Health Association (APHA, 2012) were followed to ensure data quality and consistency. Samples were kept in ice boxtill analysis was performed.

Sample analysis

Analytical grade (AR) chemicals were used for analysis of collected samples. NIST (National Institute of Standard and Technology)standard and double distilled water was used throughout the study. The pH and electrical conductivity (EC) were measured *in situ*, while Total Dissolved Solids (TDS), Nitrate and Fluoride were analyzed using the standard methods suggested by APHA (2012).

pH measurement

The potentia hydragenia (pH) of sample was measured by Digital pHmeter, Model: Systronics-361, with an accuracy of ± 0.01. The buffer solution of pH 4.0, 7.0 & 9.2 were usedfor standardization.

Electricalconductivity

The Electrical conductivity (EC) at 25ºCof sample was measured by Digital Conductivity meter, Model: Systronics-306, with an accuracy of ± 0.01. The standard solution of 0.01 M KCl has been used for standardization.

Totaldissolved solids

Total dissolved solid (TDS) are the solids present in water in the dissolved state and are measured as the residue left after evaporation of sample in Hot Air Oven at 103˚C to 105˚C. TDSwere analyzed by using gravimetric method. The difference in weight over that of pre-weight beaker represents the TDS in mg/L.

Nitrate

Nitrate (NO_3^-)is measured by colorimetric method, specifically followed by Phenol Di-Sulfonic Acid (PDA) Method using Spectrophotometer, Model:Systronics-2202 wasused for measurement of Nitrate.Standard graph was plotted before analysis of Nitrate.

Fluoride

Fluoride(F^-) is measured by SPAND Method using Spectrophotometer, Model: Systronic-2202. Standard graph was plotted before analysis of fluoride.

Calculation

Instrument gives direct reading of pH and EC value. However, Nitrate and Fluoride were calculated by (O.D x Factor ÷ sample taken), while TDS by (Final weight -Initial weight ÷ sample taken). EC is represented in mS/cm, while rest parameters are noted in mg/L (except: pH).

RESULTS AND DISCUSSION

pH, Electrical Conductivity (EC)andTotal Dissolved Solids (TDS) of water are very important indication of its quality and makes available information in many kinds of geochemical symmetry or solubility intentions. The analytical outcomesof pH, EC,TDS, NO_3^- and $F^-$for the groundwater samples in the study area are signified in Table 2 along with statistical analysis as noted in Table 3 and Table 4. Graphical analysis of these results is made known is Figs. 1-2. The analytical verdicts have been appraised to ascertain the appropriateness of groundwater in the study area for imbibing and Irrigation uses, with World Health organization (WHO), Bureau of Indian Standards (BIS) and Indian council for medical research (ICMR) standards for which arerepresented in Table 1.

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Table 2. Analysis of ground water quality parameters in villages of Bhuj taluka (Kachchh)

Vill. No.	Vill. Name	pH	E.C mS/cm	TDS mg/L	NO_3^- mg/L	F^- mg/L	Vill. No.	Vill. Name	pH	E.C mS/cm	TDS mg/L	NO_3^- mg/L	F^- mg/L
B1	Adhiyang	8.15	1.847	1176	5.8	0.39	B41	Dhrobana	8.25	1.851	1112	0.7	0.24
B2	Akau	8.22	2.140	1354	0.6	0.56	B42	Dhrung	8.30	2.019	1234	14.4	1.26
B3	Anandsar	8.14	2.238	1300	0.0	1.01	B43	Dinaramota	8.20	1.946	1306	8.3	0.60
B4	Andhau	8.23	2.370	1400	0.8	0.74	B44	Dinaranana	8.21	1.876	1140	0.7	0.16
B5	Baldiya	7.97	0.759	1520	0.0	0.65	B45	Dumado	8.17	1.916	1212	3.9	0.55
B6	Bandhanana	8.09	1.839	1130	0.6	0.62	B46	Fotadiharijvas	8.05	2.342	1526	0.2	0.10
B7	Bandharamota	8.29	1.146	1202	0.0	0.48	B47	Fotadipatelvas	7.99	2.367	1410	0.3	0.14
B8	Bandharanana	8.33	1.135	1260	0.0	0.80	B48	Fulay	7.80	0.949	586	0.0	0.93
B9	Bandhiya	8.18	2.377	1458	0.7	0.96	B49	Gada	8.04	2.319	1552	5.7	0.94
B10	Baukhoodhejava	7.91	2.164	1314	0.1	1.19	B50	Gajod	8.36	2.078	1152	0.0	0.86
B11	Baukhosamavalo	8.11	2.267	1340	0.0	1.12	B51	Galpadar	8.16	3.752	2512	18.8	1.14
B12	Berdo	8.16	2.049	1280	9.8	1.66	B52	Gandher	8.15	1.752	1054	0.0	1.24
B13	Bhagadiyo	8.22	3.044	1918	3.7	1.20	B53	Goparkhavada	8.07	2.176	***5296******	0.7	0.46
B14	Bharapar	8.12	2.457	1604	0.0	0.89	B54	Godparsarali	8.24	1.759	1066	0.0	0.48
B15	Bharasar	7.82	0.897	602	0.0	0.23	B55	Gorevali	8.14	1.853	1192	4.7	0.41
B16	Bhirandiyara	8.14	2.097	1226	4.0	0.56	B56	Habay	8.30	1.749	1110	0.0	0.64
B17	Bhitaramota	8.20	1.731	1060	4.8	0.10	B57	Hajapar	8.34	2.136	1340	0.0	0.98
B18	Bhitaranana	8.20	1.759	1078	4.1	0.38	B58	Harudi	8.20	2.261	1390	0.0	0.84
B19	Bhojardo	8.23	1.973	1220	3.8	0.54	B59	Hodko	8.12	1.982	1188	3.4	0.61
B20	Bhujcity	8.25	2.986	2036	0.00	0.79	B60	Jaduramota	8.03	0.654	392	0.0	0.04
B21	Bhujodi	8.11	2.642	1722	4.3	0.56	B61	Jaduranana	8.00	0.662	398	0.0	0.36
B22	Boladi	8.22	2.268	1454	0.0	0.92	B62	Jambudi	7.92	1.512	848	34.9	0.18
B23	Chakar	7.98	1.542	1008	0.0	0.36	B63	Jamkunariya	8.41	2.419	1462	0.8	3.32
B24	Chapredi	7.98	1.839	1258	0.0	0.68	B64	Jatvandh	8.14	3.076	1976	3.4	1.04
B25	Chubdak	8.06	1.345	1354	31.2	0.98	B65	Jawaharnagar	8.38	1.967	998	6.6	1.42
B26	Chunadi	8.38	0.546	296	0.0	0.04	B66	Jumkha	8.02	0.949	548	0.0	1.19
B27	Daddharmoti	8.11	1.984	1198	4.6	0.48	B67	Kalitalavdi	8.22	2.631	1460	0.1	1.53
B28	Daddharnani	8.22	1.946	1254	8.5	0.74	B68	Kalyanpar	7.82	2.639	1598	0.1	0.57
B29	Dagada	8.02	1.653	942	7.4	0.08	B69	Kamaguna	8.22	3.768	2346	0.0	0.50
B30	Dahisara	8.12	1.749	1018	0.0	0.87	B70	Kanaiyabe	8.06	2.098	1138	0.0	0.81
B31	Dedhiyanana	8.25	2.179	1434	0.8	0.60	B71	Kandherai	7.98	1.453	812	0.0	0.65
B32	Dedhiyanamota	8.11	1.746	1216	3.7	0.69	B72	Kanpar	7.89	0.941	592	0.0	0.89
B33	Deshalpar	8.13	1.643	1026	0.1	0.97	B73	Kera	8.14	2.143	1134	0.0	0.10
B34	Dhandhi	8.14	1.831	1130	0.7	0.53	B74	Khari	8.12	2.131	1332	0.6	1.26

Vill. No.	Vill. Name	pH	E.C mS/cm	TDS mg/L	NO_3^- mg/L	F^- mg/L	Vill. No.	Vill. Name	pH	E.C mS/cm	TDS mg/L	NO_3^- mg/L	F^- mg/L
B35	Dhaneti	7.98	1.647	978	5.4	0.38	B75	Khavda	8.09	1.840	1104	1.5	2.80
B36	Dharampar	8.13	1.851	958	0.0	1.15	B76	Kodaki	7.84	2.856	1980	0.0	0.60
B37	Dhonsa	8.11	3.754	2244	0.0	0.28	B77	Kotadathamana	7.92	1.915	1492	***51.7***	0.38
B38	Dhoravar	8.00	1.435	872	1.0	0.54	B78	Kotadachakar	8.15	1.948	1038	0.0	1.41
B39	Dhordo	8.16	1.951	1152	4.0	0.62	B79	Kotadugamana	8.02	1.658	1252	40.6	0.30
B40	Dhori	7.87	3.744	2412	0.0	0.65	B80	Kotay	7.98	3.644	2410	0.0	0.75
B81	Kukma	7.98	1.561	1020	0.0	1.78	B121	Paiyanana	7.62	1.651	1440	0.8	0.98
B82	Kunariynnamota	8.02	3.641	2424	0.0	0.50	B122	Pannavali	8.18	1.961	1178	5.7	0.46
B83	Kuran	8.16	1.861	1092	0.7	0.55	B123	Patgar	8.16	1.977	1212	3.9	0.44
B84	Kurbai	8.11	2.852	1648	0.0	0.87	B124	Pirvadi	7.92	2.467	1636	0.0	0.45
B85	Kuvathada	8.05	3.875	2428	0.0	0.89	B125	Purasar	8.10	3.948	2562	0.0	0.59
B86	Lakhond	7.96	2.948	1812	0.0	0.73	B126	Pyarka	8.08	3.849	2480	0.0	0.91
B87	Ler	8.14	1.135	686	8.4	0.31	B127	Raiyado	***8.69***	1.989	1260	3.13	0.78
B88	Lodai	8.36	1.951	1126	0.0	1.02	B128	Ratdiya	7.65	1.617	1276	0.8	0.78
B89	Loriya	8.29	3.217	2128	3.3	1.22	B129	Ratiya	7.94	2.514	1690	0.1	0.65
B90	Lothiya	7.94	1.835	974	0.0	1.20	B130	Raydhanpar	8.02	3.259	2200	0.0	0.78
B91	Ludiya	8.11	2.132	1364	0.8	0.40	B131	Rehamota	8.06	1.644	1018	0.0	0.84
B92	Lunamota	7.78	1.841	1316	1.1	0.61	B132	Rehanana	8.09	1.647	1004	0.0	0.05
B93	Lunanana	8.05	1.716	1084	0.9	0.54	B133	Reldi	8.14	1.952	1184	3.7	0.44
B94	Madan	8.17	1.562	1146	3.4	0.90	B134	Reldimoti	8.07	1.439	810	0.0	0.48
B95	Madhaprjunavas	8.29	3.154	2132	0.0	1.04	B135	Reldinani	7.97	1.437	804	0.0	0.51
B96	Madhaparnavas	8.20	2.547	1648	0.0	1.46	B136	Rudramata	8.22	2.978	2094	4.1	1.30
B97	Makanpar	8.08	3.652	2332	0.0	0.72	B137	Sadai	8.15	1.946	1188	3.9	0.52
B98	Makhna	7.91	2.701	1808	0.0	0.54	B138	Saiyadpar	8.14	1.634	1100	32.5	1.40
B99	Mamuara	7.95	1.812	974	8.8	1.61	B139	Samtra	7.93	3.099	1940	0.4	0.24
B100	Mankuva	8.15	3.958	2530	0.2	0.50	B140	Sanosara	8.02	0.659	576	25.9	0.30
B101	Meghpar	8.20	2.854	1806	0.0	1.66	B141	Saraspar	7.86	3.839	2542	0.0	0.89
B102	Mindhiyari	8.06	2.247	1414	0.7	0.59	B142	Sardamota	8.16	2.871	2024	3.9	0.94
B103	Mirzapar	7.95	2.457	1516	0.2	0.82	B143	Sardanana	8.03	2.854	1996	3.4	1.18
B104	Misriyado	8.09	1.944	1178	3.3	1.09	B144	Sargu	8.11	1.943	1168	3.9	0.62
B105	Mithadi	8.14	1.945	1194	4.7	0.22	B145	Sarli	8.28	1.784	1050	0.0	1.05
B106	Mithadinani	8.21	1.839	1202	4.1	0.54	B146	Sedata	8.08	3.359	2148	8.3	0.72
B107	Modsar	8.40	1.919	1024	0.0	1.55	B147	Servo	8.25	2.841	1910	3.8	1.16
B108	Mokhana	8.11	1.364	724	0.0	0.42	B148	Siriyado	8.03	1.932	1292	4.4	0.00
B109	Nadapa	8.43	1.966	1108	0.0	1.00	B149	Soyala	8.12	2.171	1408	0.6	0.34

Vill. No.	**Vill. Name**	**pH**	**E.C mS/cm**	**TDS mg/L**	**NO_3^- mg/L**	**F^- mg/L**	**Vill. No.**	**Vill. Name**	**pH**	**E.C mS/cm**	**TDS mg/L**	**NO_3^- mg/L**	**F^- mg/L**
B110	Nagiyari	7.86	0.964	568	0.0	0.18	B150	Sukhpar	8.09	2.446	1600	0.0	0.78
B111	Nagore	8.09	5.169	3304	0.0	0.98	B151	Sumrasarjat	8.01	2.461	1614	0.0	0.54
B112	Naranparavri	8.17	1.116	1950	0.0	0.82	B152	Sumrasarshekh	8.03	3.652	2400	0.0	0.78
B113	Naranparpasayati	8.36	1.987	1566	0.0	0.98	B153	Surajpar	8.05	1.711	1006	0.0	0.87
B114	Natherkui	8.18	3.772	2446	0.0	0.78	B154	Tankansar	8.06	2.564	2010	0.0	0.49
B115	Neri	8.17	1.976	1164	3.3	2.00	B155	Tharavadamota	8.09	2.145	1398	41.4	0.16
B116	Nokhaniya	8.17	2.954	2146	5.3	1.12	B156	Tharavadanana	8.05	2.231	1492	41.4	0.34
B117	Notiyarbhakhari	8.07	3.879	2338	0.0	0.61	B157	Thikariyado	8.13	1.948	1182	4.0	0.26
B118	Paddhar	8.01	2.089	1216	0.0	0.74	B158	Trambau	7.89	3.641	2360	0.0	0.66
B119	Paiya	8.45	2.659	1578	2.14	0.95	B159	Traya	8.09	2.349	1422	0.0	0.69
B120	Paiyamota	7.95	1.517	870	0.7	0.67	B160	Tuga	8.39	2.456	1548	0.8	4.66
B161	Udai	8.19	1.941	1214	3.5	0.44	B172	Vantra	8.10	1.873	968	0.0	1.22
B162	Udhamo	8.19	1.821	1206	4.0	0.53	B173	Varli	8.15	0.891	1330	0.0	0.10
B163	Udomoto	8.17	1.925	1198	3.9	0.44	B174	Varnoramota	8.09	2.264	1384	0.0	0.82
B164	Udonano	8.18	1.961	1172	4.0	0.16	B175	Varnoranana	7.98	2.369	1426	0.0	0.75
B165	Ukhadmora	7.75	1.342	810	0.0	0.36	B176	Vatachhad	7.94	2.661	1774	0.0	0.49
B166	Umedpar	8.43	1.987	1080	0.0	1.05	B177	Vehro	8.21	3.867	2410	0.0	0.88
B167	Vadasar	8.21	3.842	2558	0.0	4.32	B178	Vinchhiya	8.16	3.847	2402	0.0	0.81
B168	Vadvahoti	8.25	1.088	1382	0.0	***5.02***	B179	Virai	8.09	2.455	1570	0.0	0.50
B169	Vadvala	8.00	1.462	814	0.0	0.63	B180	Vyara	8.01	***6.079****	4158	0.2	2.14
B170	Vadzar	8.07	0.979	552	0.0	0.54	B181	Zikadi	8.03	2.158	1424	0.0	0.80
B171	Vandhai	7.81	0.135	1070	0.0	0.86	B182	Zura	8.12	1.947	1268	4.2	1.00

* Minimum, maximum and average value highlighted as **Bold** and *Italic*.

Source:http://www.citypincode.co.in/gujarat/kachchh/bhuj;

https://www.census2011.co.in/data/subdistrict/3726-bhuj-kachch-gujarat.html.

Table 3. Statistical analysis: minimum, maximum and average groundwater concentration of Bhuj

Parameter	**Minimum**	**Maximum**	**Average**	**Standard Deviation**
pH	7.62	8.69	8.11	0.15
EC (mS/cm)	0.135	6.079	2.2	0.86
TDS(mg/L)	296	5296	1448	629
NO_3^-(mg/L)	0.0	51.7	3.21	8.01
F^-(mg/L)	0.0	5.02	0.82	0.68

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Table 4. Statistical analysis: Samples beyond prescribed limit of ground water quality of Bhuj

Parameter↓	No. of samples beyond prescribed limits from below Standard (Total samples=182)			% of samples beyond prescribed limits from below Standard		
STD→	BIS:2012	ICMR:1975	WHO:2011	BIS:2012	ICMR:1975	WHO:2011
p^H	01	01	01	0.5%	0.5%	0.5%
TDS	31	59	155	17%	32%	85%
NO_3^-	00	01	01	00%	0.5%	0.5%
F^-	13	13	13	07%	07%	07%

Table 5. BIS: IS: 11624:1986: Guideline for water quality standard (EC)

Type	Water quality class	Electrical Conductivity (mS/cm)	No of sample within range
1	Low	Below 1.500	08
2	Medium	1.500 – 3.000	42
3	High	3.000 – 6.000	09
4	Very High	Above 6.000	01

pH

pH is an extent of the hydrogen ion concentration in water. Drinking water pH between6.5 to 8.5 is well thought-out acceptable. In this study, pH range is documented between 7.62 to 8.69(Table 2 and3 and Fig. 1) with average mean of 8.11.pHvalue of 7.4 was a safe range for drinking as well as for the growth of plants [33].While combination with total salinity, temperature, calcium content and total alkalinity is used to conclude whether a water is corrosive in nature or having scale forming tendency.

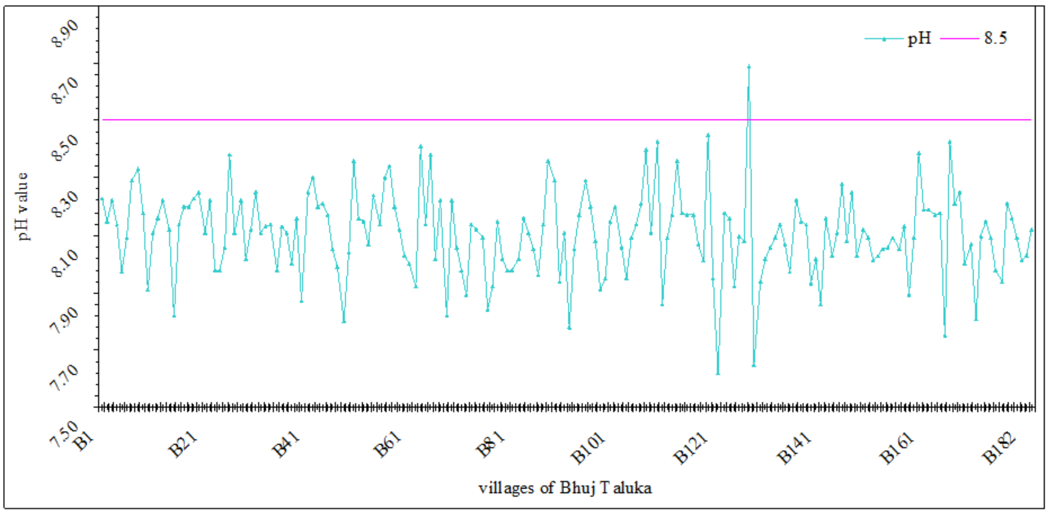

Figure 1. Graphical analysis of pH in groundwater of Bhuj taluka

As per World Health Organization (WHO), Bureau of Indian Standards (BIS), Indian Council of Medical Research (ICMR) (Table 1) standards, pH range between6.5 to 8.5 point out that, Maximum pH8.69 was recorded at Raiyado village, the measured pH values of the only Raiyado village water samples were not within permissible value i.e. pH value of Bhujtalukais well within in nature. Water with pH above 8.5 may tend to have a biter or soda-like taste which will cause harmful effect to the consumers. The pH of water is very vital indication of its eminence and provides information in many types of geochemical equilibrium or solubility calculations [42]. pH above 8.0 would be unfavorable in the treatment and disinfection of drinking water with chlorine [45].Higher pH fetches the formation of toxic tri halo methane [55]. Superfluous use of detergents, soap-based items and fertilizers is the common cause which may enrich pH levels of surface and groundwater. Generally high pH and TDS is due to, low recharge, and over-exploitation of the ground water resource.

Total dissolved solids (TDS)

TDS take account of all mineral constituents and other solids dissolved in water. TDS in water is a wide-ranging indicator for suitability of water for many applications. Like high TDS values stimulus taste, hardness and corrosive property of the water [11].Water with more than 500mg/L of dissolved solids usually has a tasteless and may have emetic effect or makes the water objectionable for drinking uses. High TDS concentrations is due to occurrence of bicarbonate, carbonate, sulphate, chloride and calcium, which may originate from natural sources, sewage, urban runoff, and industrial wastewater **[26,** 49**]** .TDS can be removed by reverse osmosis, electro dialysis, exchange and solar distillation. To determine suitability of groundwater for any purpose, it is important to classify it according to its hydro-chemical properties based on TDS values, which are represented in Table 2;it depicts TDS contamination concentration level in collected samples according to WHO, ICMR, BIS criteria. These results show that TDS level is higher than described standards in some parts of study area and need treatment for its use for drinking purpose.

The palatability of water with a total dissolved solids (TDS) level of less than about600 mg/L is generally considered to be good; drinking-water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/L. The presence of high levels of TDS may also be objectionable to consumers, owing to excessive scaling in water pipes, heaters, boilers and household appliances [58]. Total 155 village of Bhuj taluka is having TDS values beyond prescribed limits from WHO standard (>1000mg/L). Permissible limit in the absence of alternate source for TDS in drinking water is given, 1500 mg/L and 2000 mg/L by ICMR and BIS, respectively. Total 59 villages in taluka having TDS values beyond prescribed limits from ICMR Standard(>1500 mg/L)and 31 villages are the apparent source of High TDS (>2000 mg/L)i.e. not within limit as per BIS. Hence, all above scenario indicate that total 85%, 32% and 17% of the analyses groundwater samples were classified as not acceptable using WHO, ICMR and BIS, respectively. The highest TDS concentration (5296 mg/L) was recorded for village Godpar (Khavada).The high TDS occur in Bhujtaluka may be due to over exploitation and low recharge. Based on our study of TDS, the water samples need treatment before its use because most of values exceed the WHO limits. There is an prompt need to take essential steps to diminish dissolved solid in this region and to take precautionary action for the inhabitants from adverse health effects like kidney stone and constipation [7].

3.3ElectricalConductivity(EC)

Electrical conductivity (EC) is a measure of water capacity to convey electric current. The most desirable concentration of EC in drinking water is not obligatory but suggested as 1.4mS/cm by WHO. EC of the groundwater is fluctuating from 0.135 to 6.079 mS/cm with an average value of 2.2 (Table 2 and Table 3). Higher EC in the study area indicates the enrichment of salts in the groundwater. EC value may be an estimated index of the total content of dissolved substance in water. It depends upon temperature, concentration and types of ions present [30, 50]. In the existent study, bestowing to the guideline of BIS: IS 11624-1986, Classification of irrigation water (Table 5) based on EC value as under:Type(I)EC value- (<1.5 mS/cm),14 % samples belong to type 1 with enrichments of salts are lowand It is more appropriate with greater than 30 % Clay texture for semi tolerance crop like wheat, cotton, maize, bajara, jowar, tomato, cabbage, onion, cabbage, cauliflower.Type (II)EC value-(1.5-3.0 mS/cm) Total70 % samples belong to type II with the enrichment of salts are medium and It is more suitable with greater than 30% clay texture for tolerance type crop like barley, sugar beet.Type(III)EC value-(3.0-6.0mS/cm) ,Total 15 % samples belong to type III with the enrichments of salts are high and It is more suitable with greater than 20 % Clay texture for semi tolerance crop like wheat, cotton, maize, bajara, jowar, tomato, cabbage, onion, cabbage, cauliflower.Type(IV)EC value(>6.0 mS/cm), According to the BIS:11624 :1986, Village Vyara 's bore-well EC value is recorded 6.08 mS/cm, it is Very high saline/ High conductive type of water and classified as poor quality water.

In India, Central Pollution Control Board (CPCB) has identified water quality requirements in terms of a few chemical characteristics, known as primary water quality criteria, Bureau of Indian Standards has recommended same by standard IS:2296:1992 and classified as Class-A,B,C,D& E; in Class E- Designated best use of water, for Irrigation, and Industrial purpose EC(at25˚C) value is decided up to 2.250 mS/cm(maximum). Hence use of bore water for class E, it must be less than 2.250 mS/cm. Study data revels that, 64% villages having EC value less than 2.25mS/cm, hence bore-well water of 116 villages is used to fit for class E. The effect of saline intrusion may be the reason for medium and high enrichment of EC in the study area. The effect of pH may also increase the dissolution process, which eventually increases the EC value.

Nitrate

During the study, Nitrate value fluctuated between 0.0 to 51.7 mg/L with average 3.21 mg/L(Table 2 and Table 3).Maximum Nitrate concentration 51.7 mg/L recorded at Kotada-athamana village, it is also point out as beyond limit as per WHO and ICMR. No borewell was found beyond prescribed limit for Nitrate concentration as per BIS. Nitrate is the primary anthropogenic source of groundwater contamination from sewage disposal, agriculture, and industry in India [18, 47]. No such anthropogenic contamination is observed in Bhujtaluka during this research. The excessive usage of nitrogenous fertilizers for agricultural items and inadequate sanitary system may be the reason for higher nitrate values [6]. Above study reveal no such anthropogenic activity is acute in this area.

Fluoride

Literature reported that fluoride in a minute quantity is an extremely crucial part for normal mineralization of bones and formation of dental enamel [25]. Average concentration of fluoride was recorded 0.82 mg/L, and 93% of Bhujtaluka villages having fluoride concentration within limit as per WHO, BIS and ICMR Standards (i.e.1.5 mg/L),(Tables 2, 3, 4, Fig 3).

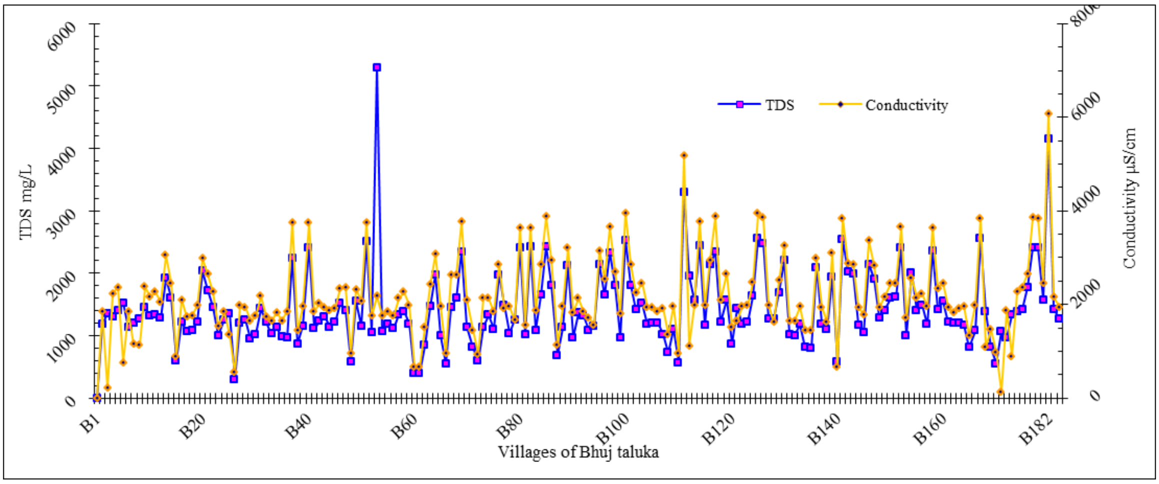

Figure 2. Graphical analysis of Conductivity and TDS of Bhuj taluka.

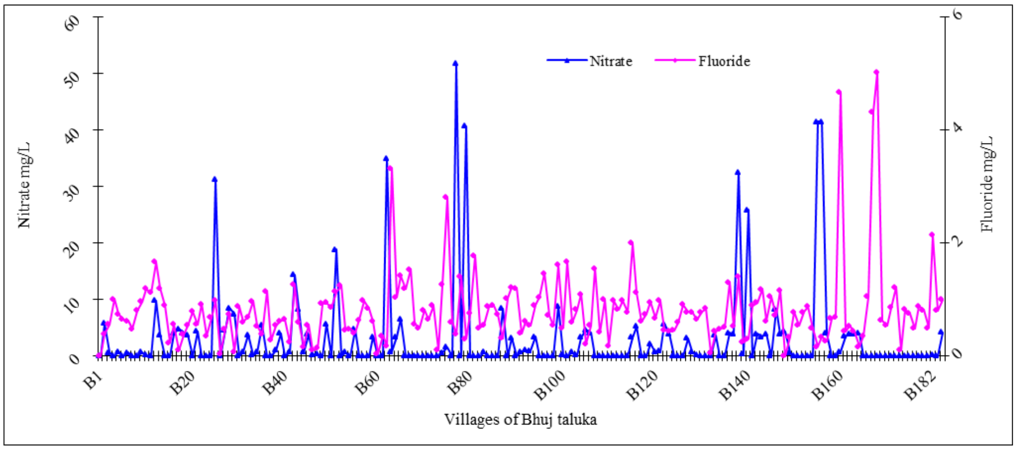

Figure 3. Graphical analysis of fluoride and nitrate in groundwater of Bhujtaluka

In other hand Fluoride is a very toxic element and priority pollutant known to cause adverse health effects [12, 17]. Higher concentration of fluoride in ground water appears to create dental, skeletal and non-skeletal fluorosis[48]. Our study reveals that 07% sample having fluoride concentration greater than1.5 mg/L fluoride (Table 4).

In India, fluoride concentration was first detected at Nellore district of Andhra Pradesh in 1937 [18, 31] and reported as a Geogenic contaminant [37. 47]. In the BhujTaluka highest fluoride concentration is recorded at village Vadavahoti with value 5.02 mg/L.Groundwater fluoride concentration value more than 1.5 mg/L is affecting 260 million people around the world, [4, 23, 24, 58].Total 13 samples out of 182are revealed fluoride concentrationsgreater than the permissible limit as per BIS, WHO and ICMR standards in Bhuj taluka. Fluoride concentration in our study was recordedfrom 0.0 to 5.02 mg/L.

Fluorides in natural occursis mainly in three forms *viz.*Fluorspar (CaF_2), Rock phosphate [$Ca_5F(PO_4)_8$] and Sodium aluminum fluoride [Na_3AlF_6]. The fluoride minerals are nearly insoluble. Hence, fluoride is usually not present in ground water until the conditions favor their solution i.e. contamination of water [22, 29, 32, 41, 46].

"Anthropogenic or geogenic contamination" refers to human activity or naturally occurring elevated concentration of fluoride elements in ground water having negative health effect.For that technology of de-fluoridation is adopted for future plan. The objective of fluoride removal meant the treatment of contaminated water to bring down fluoride concentration to acceptable limits, Pretreatment is classified into 2 classes, specifically membrane (Reverse Osmosis) and surface assimilation techniques [34, 51, 57]. Fluoride removal efficiencies up to 98% by Reverse Osmosis have been documented by many researchers [8, 16, 38, 39, 52, 53].

Nalgonda technique [13, 40, 44, 54] involves addition of Aluminium salts, lime and bleaching powder followed by rapid mixing, flocculation, sedimentation, filtration and disinfection. It is opined that this technique is preferable at all levels because of the low price and ease of handling, is highly versatile and can be used in various scales from household level to community scale water supply [27, 43, 56] .

The Nalgonda technique can be used for raw water having fluoride concentration between 1.5 and 20 mg/L[28, 56] and the total dissolved solids should be <1500 mg/L, and total hardness<600 mg/L [2, 35, 36].

FINDINGS

The spatial distribution analysis of groundwater quality in the study area as per Total Dissolved Solids indicates that currently groundwater in most of the villages of Bhuj does not falls within the standards for drinking water set by World Health Organization (WHO) and Bureau of Indian Standards (BIS). However, there is a wide disparity between the standards set by WHO and BIS. In our study pH and Nitrate concentration are well within limit (if only one sample having maximum concentration value refers as rare) while fluoride concentration exceeded with respect to WHO,BIS and ICMR standard is 07% only. In our study TDS, values exceeded with respect to BIS,ICMR and WHO standards are 17%, 32% and 85% villages.

Groundwater will continue to be the major source of drinking water in all over India; the resource must be managed and protected. The findings of the current study would help general public, local administrators and government agencies to recognize the current and future threats to groundwater quality of Bhuj Taluka. It is suggested to set up groundwater monitoring system anddevelop methods for dealing with current and future depletion and pollution of the resources.

We represent the following recommendations for preventing further groundwater quality deterioration and developing a strategy for sustainable development.

i. Identify groundwater recharge locations and structures and ensure that these are protected from surface pollution. Agricultural activities, particularly those using large quantities of fertilizers and pesticidesmust be excluded from the recharge sites.

ii. Continuously monitor groundwater levels and quality so that problems can be recognized and dealt quickly.

CONCLUSIONS

pH values of 181 out of 182 Borewell sample was observed well within limit i.e between 6.5 to 8.5 in nature. EC Values (>2.25 mS/cm) found in 36% Borewell samples, indicates the enrichment of salt in groundwater, the effect of saline intrusion may be the reason for same. The effect of pH may also increase dissolution process, which eventually increases the EC value. Permissible limit in the absence of alternate source for TDS in drinking water is given, 1000mg/L,1500 mg/L and 2000 mg/L by WHO,ICMR and BIS, respectively. All above scenario indicate that total 85%, 32% and 17% of the analyses groundwater samples were classified as not acceptable using WHO, ICMR and BIS standard in that order. The presence of high levels of TDS may also be objectionable to consumers, owing to excessive scaling in water pipes, heaters, boilers and household appliances [58].Due to overexploitation of groundwater and water mismanagement the results were not falling in the range of standards. All of these problems will only become worse unless steps are taken in the very near future. It is expected that the present study provides some guidance for the development of a comprehensive groundwater uses and water management program. It is recommended that to use the groundwater of the study area for drinking purpose only after boiling and filtering or by Reverse Osmosis treatment. This may be useful for a good guide to individual well owners.

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