Pre Monsoon Study of Water Quality with reference to Rapid Industrial Development in and around Gandhidham, Kachchh, Gujarat.

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Abstract

The major objective of the present report is to study the physiochemical parameters including heavy metal contamination in surface, ground and potable water in industrial, residential and commercial zone in and around Gandhidham, Kachchh.

To collect the information on the level of contamination 43 water samples were collected from various zones of Kachchh in and around Gandhidham Taluka, Gujarat during March and April 2015 i.e. Pre Monsoon Season. Parameters like pH, electrical conductivity, TDS, salinity, total dissolved solids, total hardness, calcium and magnesium hardness, fluoride, potassium, sulphate , nitrate, silicate chloride and metals like Iron , Cadmium , Cobalt, Zinc ,Manganese , Nickel and Copper were analyzed. Most of the parameters are exceeding the permissible limit recommended by the Indian Standard Specifications for Drinking Water IS: 10500. Analysis of various water quality parameters indicated the contamination of groundwater, Potable water and Surface water in the selected sites.

Keyword: Water quality, ground water, physico-chemical, Gandhidham and Anjar taluka.

Introduction

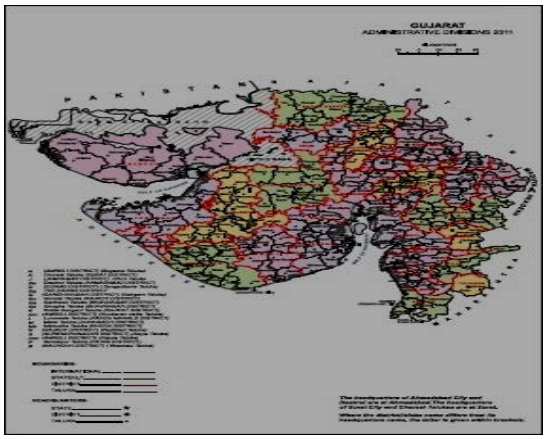
Water is one of essential compounds for all forms of plants and animals, thus its pollution is generally considered more important than soil and air. Due to its specific characteristics, this liquid bears unique properties. It is the most effective dissolving agent, and adsorbs or suspends many different compounds.

More than one billion people in the world do not have suitable drinking water, and two to three billions lack access to basic sanitation services. About three to five millions die annually from water related diseases.

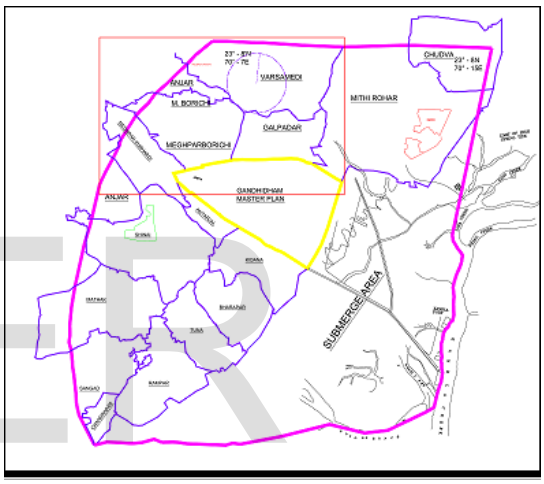
Surface water (fresh water lakes, rivers, streams) and groundwater (borehole water and well water) are the principal natural water resources. Nowadays one of the most important environmental issues is water contamination. Heavy metals are among the major pollutants of water sources. Despite this, heavy metals are sensitive indicators for monitoring changes in the marine environment. Due to human industrial activities, the levels of heavy metals in the aquatic environment are seriously increasing and have created a major global concern. Some of these metals are essential for the growth, development and health of living organisms, whereas others are non-essential as they are indestructible and most of them are categorized as toxic species on organisms. Nonetheless the toxicity of metals depends on their concentration levels in the environment. With increasing concentrations in environment and decreasing the capacity of soils towards retaining heavy metals, they leach into groundwater and soil solution. Thus, these toxic metals can be accumulated in living tissues and concentrate through the food chain.

Work Area

Gujarat



Kachchh



Gandhidham and area around Gandhidham

Kutch District forms part of the SAURASHTRA Region of Gujarat State having an area of 45652 Sq Km. the Largest in India. It is situated in the South western corner of the Gujarat between 22.44° and 24.41° North Latitude and 78.89° and 71.45° East Longitude.

Temperature fairly remains average in the district. Highest temperature goes up to 44.8 degree centigrade in summer and lowest temperature comes down to 3.7 degree centigrade in winter season. Rainfall is very low in Kutch district as low as 350 to 375 mm during the whole monsoon.

Nearly 75 % of the total minerals of Gujarat State are produced in the Kutch only.
There is no forest in the district as per the definition of forest that zone known as unfocussed length of huge grass reeds spread over the vast land in local terms being called as ‘Rakhal’. Though there are forest area which consists of babool thorny trees in nearly 2,87,948 hectares spread over the various talukas of the district. There is no forest produce in the district.

Bhuj town is the district headquarters **for** administration. Besides, there are nine other talukas namely Mandvi, Mundra, Abdasa, Bhachau, Lakhpat, Anjar, Rapar and **Gandhidham.** There are 8 towns and 950

villages in the district. Moreover, six Municipal Corporations in the towns namely Rapar, Bhachau, Anjar, Bhuj, Mandvi, and Gandhidham are functioning as administrators.

Population increase

- Total population of Kachchh District according to 2011 senses is 2,090,313 compared to 1,583,225 of 2001.
- Population Growth for Kachchh District recorded in 2011 for the decade has remained 32.03 percent. Same figure for 1991-2001 decade was 25.40 percent.
- Total Area of Kachchh District was 45,652 with average density of 46 per sq. km.

Kachchh faced a terrible earthquake on 26th January 2001. The scenario in the terms of investment facilities industrial setup norms, increase in population and finally water scarcity and pollution has been changed after the devastation of January 2001.

Sample Zones

Sr.No.	Sample site	Type	Population As per senses 2001	Population As per senses 2011	General characteristic of Sample site
1	Anjar	Rural	*	42211	Residential , Agricultural
2	Shinai	Rural	*	4342	Residential, , Agricultural
3	Khari Rohar	Rural	*	6851	Industrial
4	Sangad	Rural	2801	4305	Residential
5	Devadia	Rural	666	848	Green Belt
6	Meghpar Kumbharadi	Rural	*		Residential, Industrial
7	Meghpar Borichi	Rural	1564	17760	Residential, Industrial
8	Kandla	Urban	*	15780	Residential, Industrial, Port
9	Varsamedi	Rural	2143	10654	Residential, Industrial
9	Galpadar	Rural	*	11467	Residential, Industrial
10	Mithirohar	Rural	*	6749	Industrial, Residential
11	Kidana	Rural	*	16205	Residential
12	Bharapar	Rural	*	1462	Industrial
13	Tuna	Rural	3887	5114	Residential, Industrial
14	Rampar	Rural	953	1262	Residential, Industrial
15	Gandhidham / Adipur	Urban	*	197201	Residential
16	Mathak	Rural	1925	2268	Residential , Agricultural
17	Antarjal	Rural	*	11247	Residential

*Data not available

Sample collection

To examine the extent of the contamination by toxic metals leached from tailings, 20 groundwater, 8 surface water and 15 potable water samples were collected and analyzed from the studied area.

A total of 43 samples were collected from different areas located in and around Gandhidham from 23rd March to 20th April 2015. Samples were collected and preserved in a pre-cleaned, sterilized polyethylene bottles. After collection, the samples were transported to the laboratory within 24 hrs and subjected to analysis for various parameters such as pH, electrical conductivity, salinity, total dissolved solids, total hardness, calcium hardness, magnesium hardness, fluoride, potassium, sulphate, chlorides, magnesium, nitrate, phosphate, sodium and heavy metals – Lead, Cadmium ,Zinc, Iron , Nickel, Copper and Manganese samples were estimated in the Laboratory by using Standard Procedures . Fine grade chemicals were used throughout the study. All the reagents and standards required for the study was prepared using Millipore water.

Analysis methods –

Parameter	Method	Instrument/Apparatus
pH	Potentiometry	Digital pH/EC meter-Model- LabIndia
EC	Conductometry	
TDS	Conductometry	Digital TDS Meter
Nitrate	Brucine method	UV-VIS Spectrophotometer
Phosphate	Ascorbic acid method	
Sulphate	Turbidimetry	
Fluoride	SPADNS Method	
Silicate	Molybdosilicate method	
Sodium		AAS
Potassium		
Calcium	EDTA Titration Method	-------
Magnesium		-------
Total Hardness		
Free CO2	Titrimetric method	-------
Alkalinity		
Carbonate and bicarbonate		-------
Chloride	(Titrimetric)	-------
Heavy metals (Pb, Cu, Cd, Ni, Fe, Mn, Ni and Co etc.)	Solvent extraction cum pre-concentration method	Atomic Absorption Spectrometer

Results and Discussion

PRE MONSOON WATER ANALYSIS

SN.	Area	Type	pH	Cond.	TDS	Cl	Total alk.	Hardness as CaCo3	Ca2+	Mg2+	as SiO_2	as SO_4^{2-}	as NO3-	as F	Na	K	Fe	Ni	Mn	Cd	Pb	Cu	Zn	WQI		Type
		Desirable	6.5		500	250	200	300	75	30		200	45	1	200	1	0.3	0.02	0.1	0.01ppm	0.01ppm	0.05	5			
		permitted	8.5		2000	1000	600	600	200	100		400	100	1.5		4	1		0.3			1.5	10			
1	Bharapar	G	8	5357	3535.62	1204	490	1199	444	755	29.92	80.89	13.12	0.66	240	18	0.1818	0.216	0.145	0.018	0.007	0.38	0.219	104.76	not suitable	G	unfit
2	Tuna	G	7.2	5301	3498.66	1116	407	824	302	522	39.276	99	3.69	0.68	468	2.7	0.563	0.024	0.024	0.014	0.005	0.138	0.159	1938.14	not suitable	G	unfit
3	Rampar	G	7.2	2592	1710.72	486	356	534	184	350	28.98	21.07	0.92	0.94	578	5.4	0.091	0.018	0.024	0.011	0.004	0.069	0.2	42.94	good	G	unfit
4	Sangad	G(sch)	8.3	5022	3314.52	1108	369	535	145	390	26.341	110.8	5.95	0.72	774	3.5	0.127	0.054	0.072	0.0138	0.007	0.334	0.35	62.25	poor	G(sch)	unfit
5	Sangad	G(mi)	8.6	5687	3752.42	1266	540	275	83	192	26.46	119.65	8.82	2.24	800	7.2	0.054	0.024	0.048	0.0125	0.005	0.103	0.25	23013.3	not suitable	G(mi)	unfit
6	Kidana	G	7.4	2633	1737.7	480	289	375	195	180	18.22	12.64	1.578	0.726	334	11	0.091	0.015	0.2659	0.007	0.003	0.034	0.08	41.89	good	G	unfit
7	Antarjal	G	7.1	7714	5091.2	1506	1012	543	187	356	43.19	72.04	51.66	3.29	1070	5	0.08	0.02	0.008	0.012	0.008	0.138	0.105	73.94	very poor	G	unfit
8	Adipur	G	7.2	2067	1361.2	285	312	316	191	155	29.01	63.616	1.582	0.517	208	1.1	0.0272	0.009	0.012	0.0055	0.002	0.068	0.099	28.71	good	G	unfit
9	Shinai	G	6.8	3148	2077.6	783	348	751	435	316	74.9	75.42	5.658	0.338	296	1.7	0.8	0.006	0.024	0.0061	0.143	0.0225	0.152	340.04	not suitable	G	unfit
10	Varsamed	G	6.57	1721	1135	371	264	327	178	237	14.267	30.33	2.0705	0.258	184	0.909	0.018	0.004	0.024	0.004	0.086	0.0096	0.1487	50.96	poor	G	unfit
11	MeghparE	G	7	4195	2768	1044	361	664	289	375	20.755	79.204	29.48	2.75	535	5	0.55	0.0012	0.2367	0.0037	0.046	0.01	0.05	60.28	poor	G	unfit
12	Anjar	G	6.77	1751	1155.6	301	290	291	163	128	12.127	99.005	3.362	0.864	222.5	11.88	0.69	0.0003	1.394	0.008	0.026	0.006	0.026	50.12	poor	G	unfit
13	ar(Nani v	G	6.9	2886	1904.7	575	264	548	349	194	13.738	145.77	28.618	1.118	339.07	12.09	0.204	0.001	0.1225	0.004	0.04	0.007	0.015	49.78	poor	G	unfit
14	MeghparE	G	7.32	5374	3546.8	905	823	264	95	169	22.895	423.407	8.323	3.47	958.9	4.8	0.096	0.001	0.0765	0.004	0.033	0.003	0.256	54.68	poor	G	unfit
15	Galpadar	G	7.05	5290	3491.4	582	416	829	361	468	22.747	84.26	15.785	0.77	721.125	29.38	0.303	0.0015	0.1148	0.009	0.064	0.0094	0.0153	90.37	very poor	G	unfit
16	Jithi roha	G	7.6	5622	3710.5	594	454	337	106	231	14.186	281.85	210.125	1.149	943.046	0.462	0.65	0.0023	0.0459	0.005	0.022	0.0129	0.16	52.92	poor	G	unfit
17	Devadia	G	8	1534	1012.4	6	468	69	19	50	38.361	nil	3.895	0.343	264.9	0.462	0.746	0.0004	0.06126	0.0016	0	0.004	0.154	16.34	excellent	G	unfit
18	Mathak	G	7.2	5814	3837.24	120	377	954	301	653	24.308	96.89	67.24	0.386	757.62	7.15	0.289	0.003	0.107	0.0048	0.053	0.006	0.218	72.43	poor	G	unfit
19	andhidha	gopalpur	7.14	5554	3665	445	511	370	197	173	19.14	123.44	11.275	0.699	905.96	8.15	0.108	0.003	0.0426	0.008	0.053	0.004	0.152	54.76	poor	gopalpur	unfit
20	andhidha	G	7.17	6540	4316	451	696	550	250	300	25.49	189.59	72.775	0.464	1001.32	7.6	1.35	0.003	0.368	0.008	0.053	0.014	0.228	73.43	poor	G	unfit
1	Bharapar	potable	7.7	4670	3082.2	970	319	576	376	200	27.6	89.32	5.33	0.6	480	4	0.072	0.024	0.048	0.021	0.005	0.172	0.208	51.208	poor	potable	unfit
2	Tuna	potable	7.4	2285	1508	311	410	348	205	143	15.169	26.12	4.346	0.63	209	7.6	0.1818	0.012	0.072	0.0069	0.003	0.137	0.25	285.83	not suitable	potable	unfit
3	Kidana	potable	7.8	2535	1673.1	1456	264	458	329	129	13.41	65.3	5.309	0.587	263	12	0.9	0.009	0.012	0.002	0.003	0.069	0.102	46.66	good	potable	unfit
4	Antarjal	potable	7.6	2442	1611.7	497	240	442	290	152	13.54	292.8	7.667	0.54	284	12	0.072	0.012	0	0.0069	0.004	0.069	0.105	41.66	good	potable	unfit
5	Adipur	potable	7.7	2471	1630.8	520	255	465	299	166	15.12	60.24	3.71	0.49	267	12	0.7272	0.009	0.024	0.004	0.003	0.086	0.113	65.27	poor	potable	unfit
6	Shinai	potable	7.6	1650	1089	324	334	297	164	133	17.82	32.861	6.74	0.368	186	6.3	0.109	0.03	0	0.0024	0.086	0	0.148	35.75	good	potable	unfit
7	Tappar	potable	7.11	7169	4731.5	2152	160	1218	155	1063	5.41	325.24	2.93	0.388	989	120	0.836	0.036	0.048	0.0148	0.257	0.0096	0.1223	235.18	not suitable	potable	unfit
8	Narmada	potable	7.5	253.8	167.5	35	155	119	64	55	14.267	8.005	3.546	0.3	15	18	0.2181	0.006	0	0.0061	0	0.0032	0.821	26.26	good	potable	
9	Varsamed	potable	6.82	1997	1318	408	269	319	169	170	13.729	52.241	3.013	0.284	215	17	0	0.018	0	0.0086	0.097	0.0032	0.19	45.65	good	potable	unfit
10	ar(Nag-B	potable	7.5	801.3	520.8	135	174	213	134	79	17.053	13.06	7.278	1.557	74.172	3.45	0.114	0.0005	0.092	0.0004	0.02	0.0078	0.0075	19.17	excellent	potable	unfit
11	Galpadar	potable	7.8	3438	2269.1	356	244	542	276	266	11.239	80.047	3.075	0.52	439.7	12.28	0.657	0.0015	0.0099	0.0014	0.008	0.0047	0.224	48.39	good	potable	unfit
12	Kheri Roh	potable	7.9	4715	3111.9	589	334	917	522	385	20.553	109.54	16.81	0.85	429.14	5.79	0.65	0.0026	0.069	0.006	0.072	0.009	0.165	64.4	poor	potable	unfit
13	Devadia	potable	7.34	1179	778.14	59	236	212	140	72	10.364	25.27	9.225	0.219	137.74	5.48	0.132	0.0011	0.0612	0.0016	0	0.002	0.14	19.37	excellent	potable	unfit
14	andhidha	potable	7.25	1627	1073.8	139	126	261	137	124	14.94	5.05	6.56	0.24	164.238	2.74	0.53	0.00076	0.323	0.002	0.027	0.004	0.123	26.43	good	potable	unfit
15	Kandla	potable	7.8	2316	1528.5	81	170	358	213	145	12.34	34.54	9.84	0.318	264.9	3.85	0.42	0.0011	0.077	0.0016	0.004	0.004	0.1597	27.52	good	potable	unfit
1	Rampar	S	9.4	4875	3217.5	1247	297	598	50	548	3.55	84.26	6.56	1.02	640	4	0.236	0.016	0.048	0.0152	0.005	0.172	0.157	61.22	poor	S	unfit
2	Sangad	S	8.8	27400	18084	10740	697	3644	175	3469	1.749	790.78	39.98	2.57	417	35	0.145	0.096	0.0967	0.027	0.018	0.38	0.058	331.31	not suitable	S	unfit
3	Antarjal	S	7.7	880.1	581.06	172	167	103	51	53	1.891	31.59	1.71	0.569	105	22	0.4	0.009	0.036	0.005	0.006	0.1031	0.25	36.98	good	S	unfit
4	Kidana	S	8.2	1336	881.76	190	260	157	90	67	3.84	5.48	2.624	0.569	134	21	0.209	0.018	0.03	0.008	0.009	0.0689	0.223	38.95	good	S	unfit
5	Shinai	S	8.1	5270	3478	1478	300	382	143	239	12.235	162.62	1.2915	0.48	897	15	0.836	0.012	0.048	0.007	0.0257	0.0162	0.105	65.47	poor	S	unfit
6	Varsamed	S	8.66	3091	2040	761	261	335	90	245	5.41	86.366	1.25	0.804	405	15.4	0.0545	0.024	0	0.004	0.114	0.0096	0.102	57.99	poor	S	unfit
7	Galpadar	S	7.3	4378	2889.4	1129	216	565	245	320	4.212	179.47	0.205	1.44	625.17	10.48	0.13	0.0011	0.467	0.004	0.04	0.006	0.226	62.62	poor	S	unfit
8	Devadia	S	8.18	472.5	311.8	4	164	190	43	147	5.128	5.89	nil	0.657	52.98	5.48	0.754	0.0004	3.37	0.0016	0.0027	0.004	0.0546	52.76	very poor	S	unfit

Red colour – Beyond Desirable Limit
Green colour – Beyond Permitted Limit

pH: The parameter pH generally indicates the acid or alkaline nature of any solution and usually does not bear any direct impact on consumers. The data revealed that the pH value of Ground water was in a range of 6.5 to 8.6. The maximum range found in the sample 9 and the minimum was observed in the sample 24 and the average of the pH value found was 7.32. The pH value of supplied Potable water by municipalities is 6.82 to 7.8. The maximum range found in the sample 13 and 43 and the minimum was observed in sample 25 and the average of the pH value found was as 7.52. The pH value of Surface water was 7.3 to 9.4. The maximum range found in the sample 6 and the minimum was observed in the sample 33 and the average of the pH value found was as 8.29. The pH value of all the samples does not exceed the recommended limit (6.5-8.5) of BIS.

Electrical Conductivity: In case of electrical conductivity, the value ranged between 298.50 µS to 3283.50 µS. The maximum value of EC observed in the sample 22 and the minimum value found in the sample 6 and 7, and the average of the electrical conductivity shown in the range 1574.45 µS. Around 52% of the sample which exceeds the permissible limits 1400 µS recommended by BIS.

Total Dissolved Solids: The Total Dissolved Solids ranged between 167.5mg/L to 18084mg/L. The maximum level was found in the sample 8 and the minimum was found in sample 22. Average TDS value is 1056 mg/L. About 95.34% of the sample which exceeds the BIS limit of 500 mg/L because incidence of higher level of TDS is considered to be objectionable.

Total hardness: The total hardness is an important parameter of water quality whether it is to be used for drinking and hardness of such water mainly depends upon the amount of calcium or magnesium salts or both. The maximum total hardness is found to be 3644 mg/L in sample 8 and the minimum is observed as 69 mg/L in the sample 37. The maximum value observed for calcium hardness is 532 mg/L in the sample 34 and the minimum value 19 mg/L found in the sample 37. Similarly the maximum magnesium hardness 3469mg/L was seen in sample 8 and the minimum value 55 mg/L found in the sample of Narmada Water. The average value of Total Hardness, Calcium Hardness and Magnesium Hardness was recorded in the range of 542.3 mg/L, 205.67 mg/L and 338.69 mg/L respectively. Around 72% of the samples were crossing the permissible limit recommended by BIS which 300 mg/L which may be due to presence of carbonate and bicarbonate hardness.

Fluoride The maximum level of fluoride 3.29 mg/L was found in the sample 14 and the minimum value found in the range of 0.219 mg/L in the sample36 .The average values detected as 0.887 mg/L. About 20% of samples are not within the limit 1 mg/L recommended by BIS. Objectionable level of fluoride is found in Ground water samples of Antarjal, Meghpar Borichi, Sangad, Anjar and Mithirohar village and also in potable water supply of Anjar which is mainly used for drinking purpose.

Potassium: Potassium is an essential nutrient for both plant and human life which has its natural occurrence in ground water by weathering of rocks and minerals. The potassium values ranged0.462 mg/L sample no. 35 and 37 and the average potassium concentration was in the range of 13.88 mg/L. As per the study conducted, higher values of potassium were observed as 120 mg/L in the Potable Samples of Tappar Dam. 93% water samples are beyond the desirable limits as per BIS recommendations (1mg/l)

Sodium is an essential nutrient of human life which has its natural occurrence in ground water. The sodium values ranged between 15 mg/L in (SN. 22) Narmada water to 1070 mg/L (SN. 14) and the average sodium concentration was in the range of 448.96 mg/L. 86% water samples exceeds BIS desirable limit (200mg/l)

Heavy metals

Lead Concentration is in the range 0 to 0.143 in Shinai ground water (Sample no. 19). In 14 (33%) samples the level of **Pb** exceeded the permitted limit of 0.01 mg/l .

Cadmium :- 9 of the analysed samples (21%) are exceeding desirable limit of cadmium which is 0.01mg/l , it ranged from 0 in sample no 23 to 0.018 in sample no.1.

Iron concentration of iron ranged from 0 (Versamedi- SN- 25) to 0.836 in potable supply of Tappar dam (SN-21) and 1.35 in Gandhidham ground water (SN-41). 13 samples (30%) are exceeding desirable limit of 0.3 mg/l. **Iron** is essential elements and is generally considered to be non-toxic below certain levels.

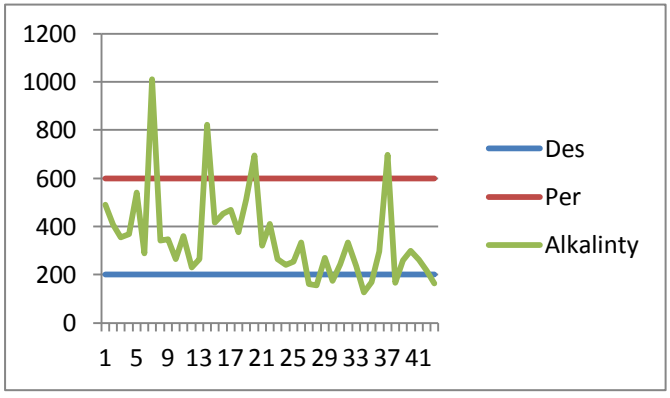
Nickel –minimum observed concentration of nickel 0.0003 in Anjar Ground Water (SN.-28) and maximum was 0.216 in Bharapar(SN. 1). 5 samples (12 %) are beyond permitted level that is 0.02mg/l.

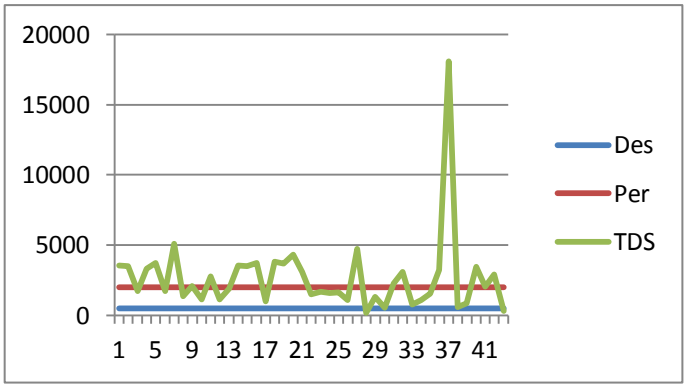
Manganese concentration of Manganese ranged between 0 to 3.37found in Devadia surface water (S. No. 38). 9 samples (21 %) were beyond BIS permitted level 0.1mg/l

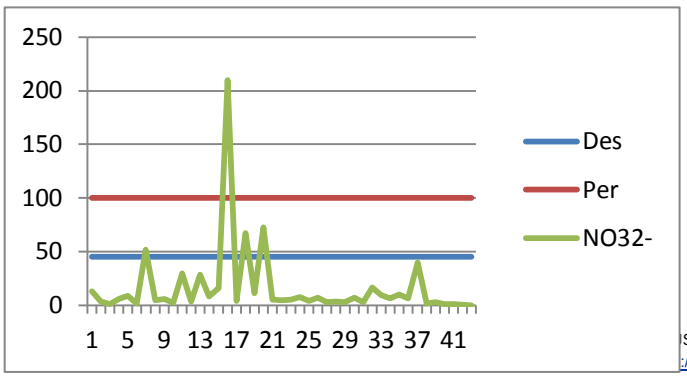
Copper is classified as a priority pollutant because of its adverse health effects.16 samples (37 %) were found to exceed permitted limit of 0.05mg/l . It ranged from 0 to 0.38 mg/l in Bharapar and Sangad ground water (SN.8 and 1).In potable water supplies of Bharapar, Tuna, Kidana, Antarjal and Adipur are having more than desirable limit.

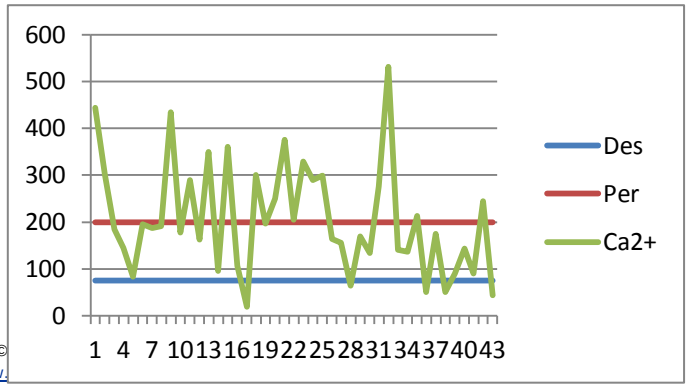
Zinc concentration ranged from0.0075 mg/l (Anjar potable water supply –SN.27) to 0.082mg/l in Narmada water(SN 22).All the samples are having concentration under permitted limit of 5mg/l

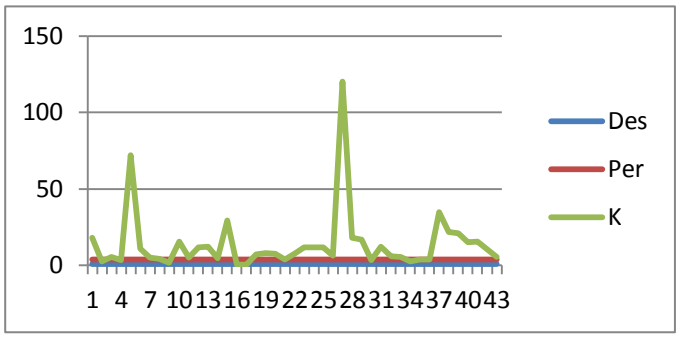
Graphical presentation of Observed Values, desirable (Des) and permitted (Per) values of different parameters.(Concentration of samples on Y axis is taken in mg/ l.)

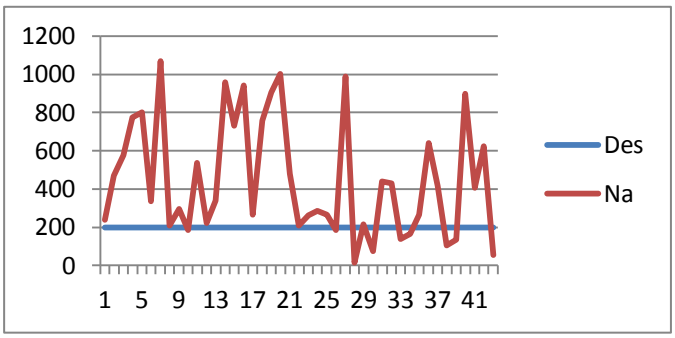









150
100
50
0
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43
Des
Per
K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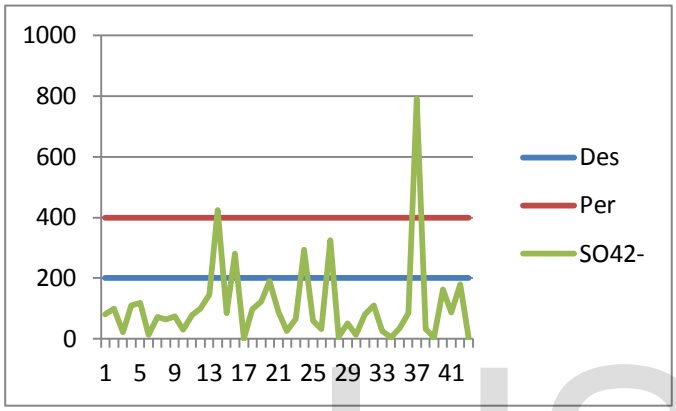
800
600
400
200
0
1 5 9 13 17 21 25 29 33 37 41
Des
Na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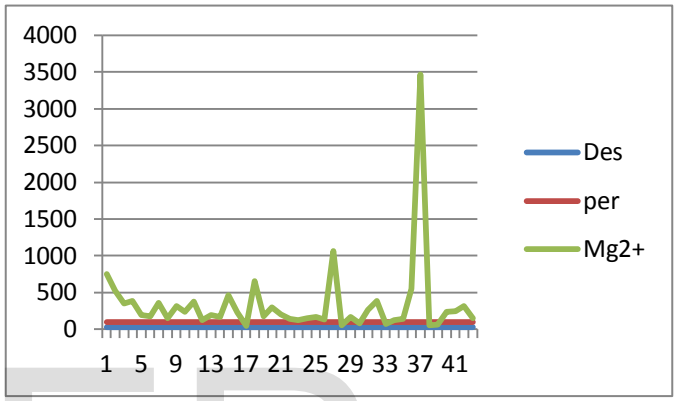
800
600
400
200
0
1 5 9 13 17 21 25 29 33 37 41
Des
Per
SO42-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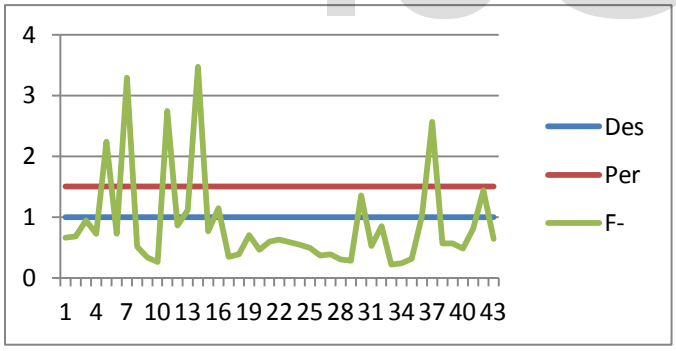
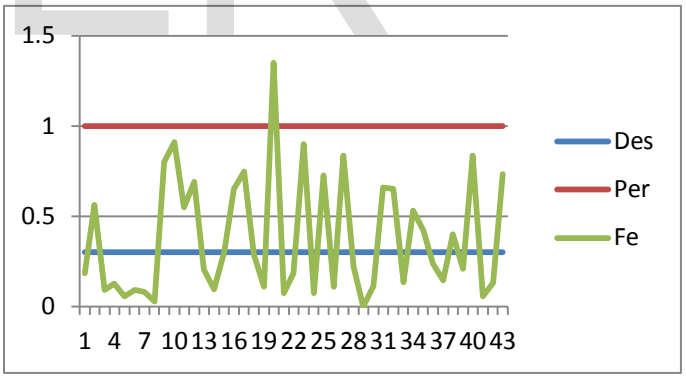
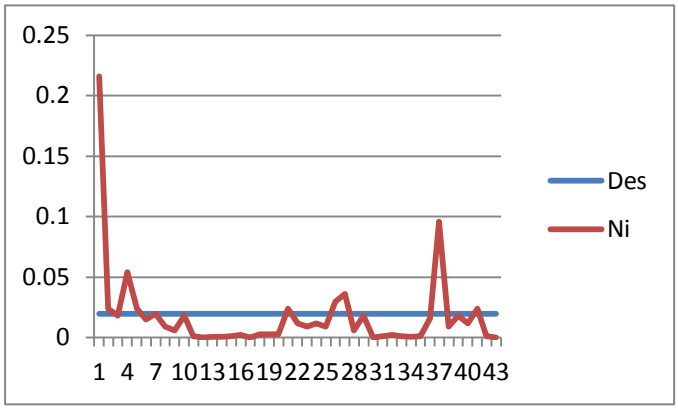
3500
3000
2500
2000
1500
1000
500
0
1 5 9 13 17 21 25 29 33 37 41
Des
per
Mg2+


4
3
2
1
0
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43
Des
Per
F-


1.5
1
0.5
0
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43
Des
Per
Fe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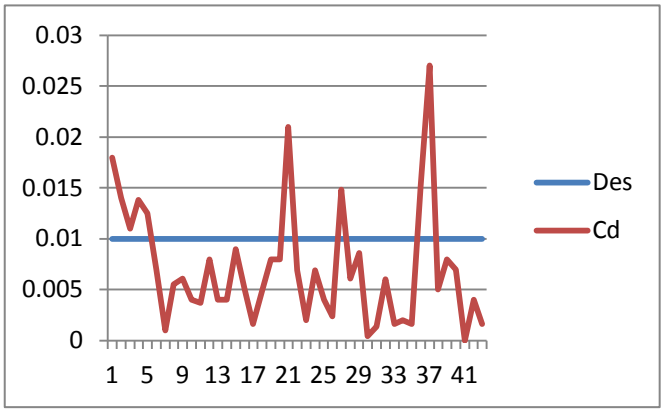
0.2
0.15
0.1
0.05
0
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43
Des
Ni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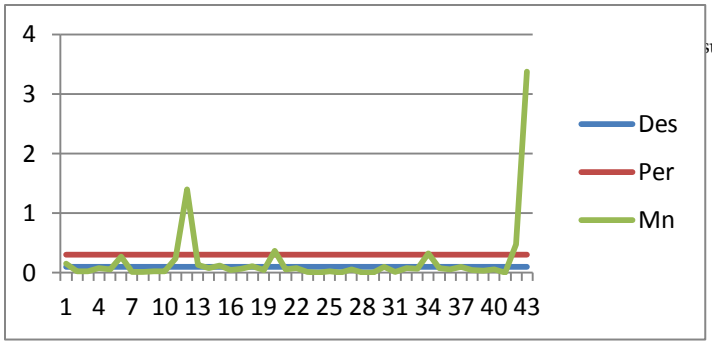
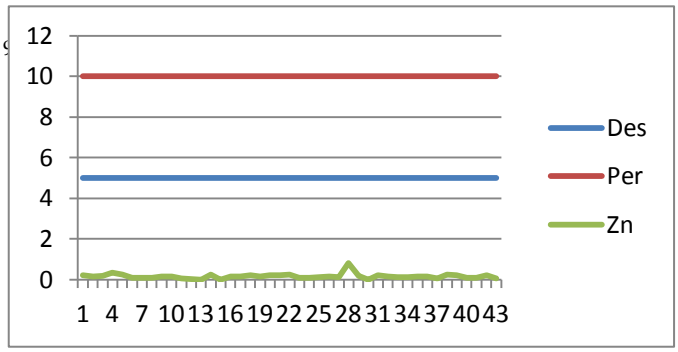
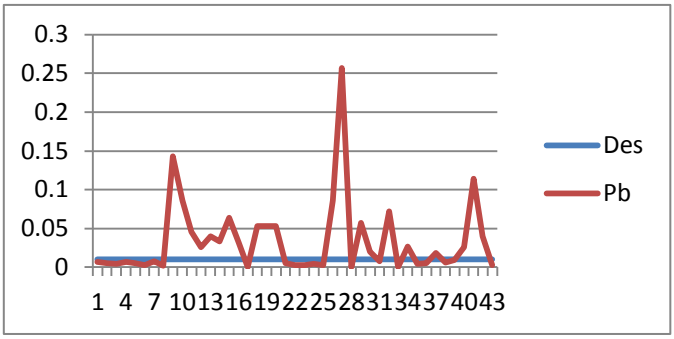
0.025
0.02
0.015
0.01
0.005
0
1 5 9 13 17 21 25 29 33 37 41
Des
Cd







Water Quality Index The composite influence of different analyzed water quality parameters are taken into consideration here for calculating the water quality index. Water quality index was done mainly to find the suitability of water source for human consumption.
The WQI is calculated by following the steps used by Brown et.al, 1972.

Calculation of Qn

Vs = Std.Value
Vn = Obs Value
Vi = Ideal Value

$$Qn = 100\frac{(Vn-Vi)}{(Vs-Vi)}$$

Vi = 0
For pH Vi=7

Calculation Of Wn:

$$Wn = \frac{K}{Sn}$$

K =Proportionality Constant
Sn = Std permissible Value of Parameter

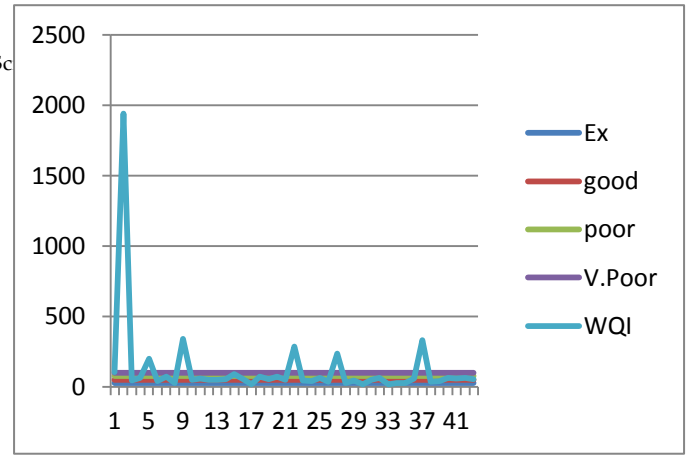
Calculation Of K

$$K = \frac{1}{\sum i = 1 \quad \frac{1}{(S1+S2+S3+-----+Sn)}}$$

Calculation Of WQI

$$WQI = \sum_{i-1}^{n} Qn\,Wn / \sum_{i-1}^{n} Wn$$

WQI<25 Excellent, <50 Good, <75 Poor, <100 Very Poor, above 100 not Suitable



WQI of 3 samples is below 25, 13 water samples is <50, 17 samples < 75, 7 Samples is >100 ,3 samples is <100,

Conclusion

Total hardness in water beyond the permitted limits in potable water is accumulated and is a cause of Stone formations.

Fluoride in groundwater has drawn worldwide attention due to its considerable impact on human physiology. Though fluoride is considered essential at very lower concentrations for human beings, whereas higher concentration will lead to health defects.

Lead is not an essential trace element in any organism and has no known biological function. It can cause a variety of harmful health effects and is known as a fatal neurotoxicant.

Nutritional iron deficiency enhances Pb toxicity, raising concern that pregnant women and young children in whom iron deficiency anemia is high, may be more susceptible to Pb toxicity . Pb absorption increases considerably with fasting or in persons whose diet is deficient in calcium, iron, phosphorous or Zinc. Pb is excreted very slowly from the body. Its biological half-life estimated at 10 years, facilitates accumulation in the body. Almost 90% lead is bound to red blood cells. Apart from haemoglobin, cytochrome synthesis, steroid metabolism, membrane integrity, synthesis of active metabolite of vitamin D in renal tubular cells are also affected.

Exposure to high concentrations of manganese over the course of years has been associated with toxicity to the nervous system, producing a syndrome that resembles Parkinsonism. This type of effect may be more likely to occur in the elderly.

Cadmium is regarded as the most serious contaminant of the modern age.Urinary excretion is slow, biological half life can be up to 30 years. Highest concentration is found in kidney and liver. The problem of cadmium toxicity in India is not known. Cadmium affects lungs, kidneys, liver and skeletal system. It binds to sulfhydryl groups, displacing other metals from metalloenzymes, disrupting those enzymes. Cadmium competes with calcium for binding sites on regulatory proteins. Cadmium has been classified as a suspected human carcinogen.

Copper is classified as a priority pollutant because of its adverse health effects. Zinc and iron are essential elements and are generally considered to be non-toxic below certain levels. Excessive concentrations of cobalt can cause death and various compounds of nickel are carcinogenic. These menaces provoke the studies on the monitoring of these heavy metals in this chain being important for protection of public health. Naturally occurring nickel in food may worsen or maintain the hand eczema of nickel-sensitive patients.

As a whole, this study concluded that most of the parameters exceed the permissible limits of BIS standards.

Although according to WQI some samples are good enough to be used for human consumption but high concentrations of one or other parameter makes them unfit for human consumption. **All the analysed**

samples are unfit as potable water. Narmada water is having all analysed parameter under desirable limits except potassium.
In pre monsoon analysis of various zones in and around Gandhidham it is found that most of the samples are unfit for drinking as per the desired standards.
In various rural and urban areas water used for drinking purpose is purified through Reverse Osmosis method which costs 0.50 to 1.00 rupees depending on the area by community plants , individual home RO system or private plant water suppliers.
Nutritional requirement of each person is 5 liters for drinking, 5 liters for cooking and 35 liters for other uses (hygiene). If the other uses are ignored then also 10 liters of water per person per day is required to sustain healthy life (standard set by WHO) .
Calculating the cost of potable water purification in Kachchh district with the population of 2090313 (according to censes 2011) 0.50 x 365 x 2090313 = Rupees 381,482,122.50 (Three hundred eighty one million , four hundred eighty two thousand , one hunded twenty two Rupees fifty Paise) are to be expended just for pure drinking water per annum.
In Gandhidham and area of Anjar adjacent to Gandhidham Population is 3,55,726.
So the cost of only Gandhidham is 0.50 x 365 x 355726 = 64,919,995 (Sixty four million nine hundred nineteen thousand , nine hundred ninety five rupees) .
In Narmada water only potassium concentration is beyond desirable limit. Drinking water cost can be cut down to negligible if Narmada water after purification through community purification plants can be directly supplied. A Cation exchange resin, usually in the form of a softener, can remove Potassium. It can also be reduced by 94 - 97% utilizing electro dialysis or reverse osmosis.

It may even restricts the medical costs for the treatment of various diseases caused due to high dissolved salt concentrations and presence of toxic metals like iron , lead etc.

The remedial measures include: i) Rain water harvesting should be encouraged. Excess rain water stored should be directed to recharging wells. ii) Awareness and training programs should be conducted for the NGO's and the local people for the sustainable use and management of groundwater of the region. iv) A short term and long term management action plan should be formulated for the efficient use of groundwater resources and other natural resources after taking into account the population distribution, agricultural activities etc.
Permanent set up of Narmada water canals in Kachchh should be established to avoid effect of Salts and heavy metals in water on industries agriculture and Human health .

Acknowledgement
The authors would like to thank IFFCO, Kandla, Kachchh, Gujarat for providing necessary Laboratory facilities and for the support to conduct this work.

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