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A study on seasonal variation in physico-chemical parameters and corrosion indices of coastal villages of Olpad and Choryasi taluka, Surat district

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Abstract

Ground water is one of the most important natural resources for drinking water. To estimate quality of water in coastal region of Surat district, the study was made by us. Ground water samples were collected from different sampling stations of coastal villages of Olpad and Choryasi talukas of Surat district, Gujarat (India). The samples were collected from 20 different locations and analyzed for physico-chemical properties and different indices were calculated. Seasonal study was carried out for all these stations from May 2015 to April 2016. In this study, The results are compared with water quality standards laid down by ICMR and WHO. The results revealed that some of the samples were having high concentration of salts causing deterioration in quality of drinking water.

Key words: Ground water, Physico-chemicals parameters, Corrosion indices, ICMR, WHO, Olpad and Choryasi Taluka.

Introduction

Water is unique liquid and is wonderful gift of nature, without it life is impossible. 2/3 rd part of earth's surface is covered by ocean water[1] and that consist of 97% of water, rest 2.3% is covered by glaciers and polar ice caps and land surfaces like rivers, lakes and ponds occupying 0.6% of water. Water is essential for survival; 70% body weight of all living organisms is due to water, so it should be clean, fresh and potable.

Good quality of drinking water is the basic requirement of every human and is one of the human rights. People of rural area who are living near the shore don't have generally municipal water purveyance in India and in many other countries. In many rural areas water is being used from bore well and well in most of all such cases the water is used directly for drinking purpose. Hence they render upon nearby groundwater sources for their daily needs

which include farming, washing and bathing etc. Near seashore location due to seasonal fluctuations and faster withdrawal of groundwater makes sea-water intrusion possible in such areas[2]. High TDS > 4000 ppm and chlorides value >2000 ppm clearly supports the sea-water intrusion at coastal aquifer[3].

Due to fast industrialization, the population of coastal villages of Olpad and Choryasi Taluka has increased; as a result, demand of water is also increasing for industrial, agricultural as well as for domestic purpose. Therefore, it is essential for protection and management of ground water quality[4]. After collecting the samples, physico-chemical parameters of groundwater were studied. These water quality parameters were used to determine the quality of water and compared with drinking water standards prescribed by WHO (1993)[5, 6] and ICMR (1986)[5, 6]. In this direction, many researchers have carried out ground water study[7-14a,b]. Main aim is to assess the groundwater quality and compare the results with drinking water standards and to study corrosive tendency of water as in industrial areas the water is used for various purposes in industrial application.

Methods and materials

Topography: Gujarat has area of 1, 95,984 sq. km. The state consists of the longest coastline of 7,516.6 kms in India[15]. Surat district is considered as developed district with pleasant climate. It is situated on the bank of Tapi river. Olpad is a Taluka in Surat district of Gujarat State, India. It is located 22 km towards North from district headquarters Surat. Choryasi is a Taluka in Surat district of Gujarat State, India. It is located 7 km towards west from district headquarters Surat. Olpad and Choryasi taluka covers the coastal track which is facing Arabian Sea. There is a chance of humidity in the weather. There are ample chances of sea water intrusion from Arabian Sea to Olpad and Choryasi taluka, if drinking water drawn at faster rate at SUDA area.

Study area: Different samples of ground water were collected from 20 sampling stations i.e. Junakavas, Hazira, Junagam, Suvali, Rajgari, Mora, Bhatlai, Damka, Vansva, Lavachha, Admor, Bhandut, Pinjarat, Tena, Motakosadiya, Chhini, Dhanser, Tunda, Maya and Dihen; Coastal villages of Olpad and Choryasi Taluka, Surat district is situated in radius 35 km. this area has large scale industrial development. Geographical location of study area is shown in the Figure 1.

Temperature and rainfall: Summer temperature of Olpad and Choryasi taluka ranges between 30°C to 32°C. The climate is pleasant during the monsoon, average temperature ranges between 22°C to 26°C. The climate in winter is cool; the temperature ranges from 17°C to 21°C. The average rainfall in Olpad taluka is 977 mm and Choryasi taluka is 1274 mm.

Figure 1: Coastal villages of Olpad and Choryasi Taluka, Surat,Gujarat(Image source google map)

Experimental

The present study deals with ground water quality monitoring of coastal villages during the may 2015 to april 2016. Samples were taken from coastal villages of Olpad and Choryasi taluka nearby residential area and industrial area of the Surat district. The results in Table 2 are compared with the standard values given by WHO (1993)[5, 6] and ICMR (1986)[5, 6]. The ground water samples were collected by grab sampling method, for the further analysis samples were taken to laboratory in cleaned polythene bottles having capacity of 2 liter and labeled properly and stored in ice-box. Analytical grade chemicals were used without further purification[16]. The physico - chemical analysis was done according to APHA standard methods[17] for examination of water and waste water. The various physico- chemical parameters like pH, odour, colour, temperature, alkalinity, sulphate, COD, DO, TS, TSS,

TDS, hardness, Ca hardness, Mg hardness, Ca^{++}, Mg^{++}, chloride, phosphate, bicarbonate, silica, Cu, Cr, Fe, and various corrosion indices viz. Langlier saturation index, Ryzner stability index, Puckorius scaling index and Larson skold index[18-21] studied. Some parameters like pH, colour, odour were checked within 6 hrs. The obtained results were reproducible within ± 3% error limit. Analytical methods for study of different parameters are shown in Table 1.

Result and Discussion

Drinking water standards by ICMR [5-6] and WHO [5-6] are summarized in Table 1. High, low and average values obtained from May 2015 to April 2016 for physico- chemical parameters of ground water from different locations are showed in Table 2 different for indices were calculated and discussed.

pH: It was observed form the pH values were ranging from 7.3 to 9.07. The lowest pH observed in winter and highest pH was observed in summer. So generally pH increased from winter to rainy and rainy to summer seasons. pH below 6.4 indicates that sample is out of limit of drinking water standards.

Odour: During the study period odour was evident from same sampling stations those showed odour in last study. Here, the samples had no odour so those water samples are acceptable for drinking purpose.

Colour: During the study period, in all the ground water samples colour was checked in Hazen unit[17, 19]. From the analysis all water samples were found to have acceptable color. Colour is not adversely affecting the water quality but colour is aesthetically not acceptable.

Temperature: During the study span temperature ranged from 17 ºC in winter to 33.5 ºC in summer. Temperature decreased from monsoon to winter and increased winter to summer.

Alkalinity: The data for total alkalinity study varied from 128.75 ppm in monsoon to 917 ppm in winter. Total alkalinity increased by progression of monsoon to winter and winter to summer. Here one sampling station showed lower alkalinity in monsoon, winter but in summer all samples showed higher alkalinity. More alkalinity needs more water softening during treatment of raw water[6].

Sulphate: During the study values ranged from 0.273 ppm in monsoon to 62.34 ppm in winter. Sulphate was lower in monsoon and summer and higher in winter. Here all seasons showed samples above permissible limit i.e >200 ppm. People unaccustomed to drinking water with elevated levels of sulphate can experience diarrhea and dehydration. Infants are often more sensitive to sulfate than adults. As a precaution, water with a sulphate level exceeding 400 mg/lit should not be used in the preparation of infant formulations[22].

COD: Juna kavas and Suvali sample showed higher COD in all three seasons indicating some contamination of the water body. COD ranged from 60.25 ppm in monsoon and summer it increased upto 173.5 ppm. Trend of COD; increased from monsoon to winter and winter to summer. Here it was clearly seen that monsoon rainwater makes soil strata rich with winter starting and dilute the content of water beneath the ground hence COD decrease in monsoon. The remaining groundwater samples contained no COD therefore not harmful for human health.

DO: Dissolved oxygen is an indicator of freshness as well as pollution indication of water. Generally groundawater dissolved oxygen does not changes except seasonal changes as compared to surface water. More the dissolved oxygen in winter more is freshness of water. From the study dissolved oxygen ranged from 3.34 ppm in summer to 16.7 ppm in winter. Season wise dissolved oxygen increased from summer to monsoon to winter.

SS: All ground water samples had no suspended solids except Rajgari and even that sample showed very negligible suspended solids i.e. 45 ppm in summer only.

TDS: The range of TDS from our study varied from 211.75 ppm in monsoon to 2041.75 ppm in summer. Here TDS increased from monsoon to winter and winter to summer. From study 3 locations in winter, 7 locations in summer and 2 locations in monsoon showed higher TDS i.e. >1000 ppm as per WHO. There was not much fluctuation in TDS with respect to seasonal variation.

Hardness: Total hardness varied from 86.88 ppm to 2063.94 ppm in summer. Here total hardness increased from monsoon to winter and winter to summer. Here 4 sampling stations during monsoon, 5

during winter and 3 stations during summer showed more hardness i.e. 300 ppm as per WHO standards. So the adverse effects of such water samples are (1) soap consumption by hard water causes economic loss due to water, (2) precipitation by hard water adhere to surface of tubes, sinks etc. and may stain clothing, dishes and other items, (3) $MgSO_4$ precipitates have laxative effect in persons unaccustomed to it[6].

Ca hardness and Mg hardness: During study Calcium hardness was ranging from 19.43 ppm in summer to 926.25 ppm in summer and Mg hardness varied from 37.51 ppm to 1137.69 ppm in summer. For indices calculation Ca as Ca^{+2} and Mg as Mg^{+2} were calculated. Here Ca as Ca^{+2} ranged from 13.96 ppm in monsoon to 371.20 ppm in summer where as Mg as Mg^{+2} ranged from 8.27 ppm in winter to 276.51 ppm in summer.

Chloride: Chloride was ranging from 581.71 ppm in winter to 4610.31 ppm in summer. Here chloride increased with winter to summer and summer to monsoon. During all seasons higher chloride was found than the prescribed limit. As per trend chloride increased but locations of samples decreased so in monsoon more water from precipitation lends to decease chloride of many region. High chloride reacts with sodium and makes water salty, which in unacceptable for human consumption. It also increases the TDS values there by affecting the quality of water.

Phosphate: Phosphate is a naturally occurring constituent. In surface water it plays major role for enrichment of phosphate of water body and leads to eutrophication. Phosphate was evident from 5.2 ppm in monsoon to 1210.15 ppm in winter, most of the locations showed negligible phosphate. From data obtained season wise trend for phosphate cannot be predicted as it seemed occurring at different locations in different seasons. There is no concern with industrial as well as agricultural water application with respect to phosphate. The only thing is that phosphate is vital nutrient for the growth of plants and here less phosphate does not affect their growth.

Bicarbonate: HCO_3^- (bicarbonate) is a natural constituent of water. Here during study we have analyzed HCO_3^- to study Ryznar index. HCO_3^- from the study ranged from 161.7 ppm in monsoon to 508.75 ppm in summer. Season wise HCO_3^- increased from monsoon to winter and winter to summer.

Silica: In all the samples, silica was very low at all the locations. The results varied from 0 ppm in all seasons to 0.0065 ppm in monsoon. Here silica increased with summer to monsoon and monsoon to winter. There is no standard for silica so as far as drinking water is concerned. Higher level of silica is not given but luck of silica in food intake may lead problems with the teeth and bones (decay and softening) and hardening of the arteries[23].

Copper: Copper from the study ranged 0 ppm all seasons to 0.009 ppm in winter. Copper was found negligible during the study period. Here during summer and monsoon 20 locations and in winter 5 locations showed slight copper.

Chromium: Chromium from the study ranged 0.0143 ppm to 0.121 ppm in monsoon. Chromium increased with monsoon to winter and winter to summer. Here all seasons showed chromium. Chromium is toxic to human health, animals and aquatic life. It can produce lung tumor and readily induces skin sensitization. But here chromium was found so there was big problem.

Iron: Iron concentrations in all the samples were within the limits during all the seasons. Out of 20 sampling stations only one stations showed negligible iron content in summer. Iron is found very less in surface water while ground water contains more iron than the surface water. Water containing iron>2 ppm causes staining on clothes and sanitary wares and imparts bitter astringent taste. Taste and odour are problems that may be caused by filamentous organisms that prey on iron compounds (Frenothrix, Galionella).

LSI: Langlier Saturation Index was calculated for all the sampling stations, and varied from -0.185 in winter to 19.90 in monsoon which showed moderate corrosion treatment recommended to mild scale forming-probable minor aesthetic problems[24].

RI: From all the samples Ryzner Stability Index (RSI) pHs-RI varied from 2.85-8.15 in summer that means heavy scale will form to corrosion significant based on Ryzner(1942) and indication based on improved Ryzner Index by Carrier(1965) respectively to 6.05-7.52 in monsoon it suggests that water is little scale or corrosion to corrosion significant by Ryzner

and improved index by carrier respectively. Ryznar stability index was calculated by using pH, Conductivity in TDS, Ca^{++}, HCO_3^-, water temperature data[24]. Ryznar stability index is used to predict calcium carbonate scale. A value of 6 indicates "stable" water, a value less than 6 indicates scale-forming tendency and a value greater than 6 indicates scale-dissolving tendency. This index estimated the degree to which calcium carbonate scale will form in drinking water and cooling water. Ryznar Index values indicate the water characteristics for scaling. RI varied from 5.85 to 8.25 in winter that means heavy scale will form to water is aggressive based on Ryznar(1942).

PSI: Puckorius Scaling Index (PSI) from analysis was found from 3.85 to 8.13 in winter. Puckorius scaling index increased with winter to monsoon and monsoon to summer. It was calculated from the alkalinity and pHeq data. Puckorius Scaling Index is modified version of the RSI that gives more accurate and consistent indication of calcium carbonate scaling potential of cooling water. As with RSI, a PSI values of 6 indicates stable water where as a value less than 6 indicate scale forming tendency[25].

LSI: From the results obtained Larson Skold Index values varied from 6.404 in winter to 50.72 in summer. This index showed increases with progression of monsoon to winter and winter to summer. This index was calculated by using Chloride, Sulfate and HCO_3^-. From the seasonal study on each physic-chemical parameter/ corrosion indices variation with seasonal trend are shown in Table 3.

Table 1 Methods used to determine Physico-chemical parameter along with WHO, ICMR Standards

Sr. no.	Physico-chemical Parameter	Method/ instrument used	Permissible limit as per WHO(Aesthetic quality)	Permissible limit for Drinking water as per Indian Council of Medical Research(1963)
1.	pH	PH meter	6.5 – 8.5	7 -8.5
2.	Colour	Colorimetric	—	5 Co-pt scale
3.	Odour	Physical smelling	TON	TON
4.	Alkalinity	Titrimetric	200	—
5.	Hardness	Titrimetric	500	300
6.	Calcium	Titrimetric		75
7.	Magnesium	Titrimetric		50
8.	Chloride	Titrimetric	250	200
9.	Silica	Colorimetric	—	—
10.	Sulfate	Titrimetric	200	200
11.	TDS	Gravimetric	1000	500
12.	COD	Reflux and Titrimetric	—	—
13.	SS	Gravimetric	—	—
14.	Iron	Titrimetric		0.3
15.	Copper	AAS	—	1
16.	Chromium	AAS	0.005	0.005
17.	Temperature	Thermometer	—	—
18.	DO	Azide winker method	No guidline	—
19.	Bicarbonate	Calculation from alkalinity	—	—
20.	Phosphate	Colorimetric	—	—

Note: Here all parameter in ppm except pH, Colour in Hazen and temperature in ° C, SS= Suspended Solids, TDS = Total Dissolve Solids, DO = Dissolve Oxygen, Odour in TON. Table 2 showed minimum, maximum and average data obtained from *average data of whole study i.e. from May 2015 to April 2016.

Table 2 High, low and average values from average values of physico-chemical parameters.

Sr.	Season	Monsoon			Winter			Summer		
No.	Parameters	Min.	Max.	Average	Min.	Max.	Average	Min.	Max.	Average
1.	pH	7.91	9.07	8.35	7.64	8.43	7.99	7.35	8.61	7.77
2.	Odour	Agree	Agree	Agree	Agree	Agree	Agree	Agree	Agree	Agree
3.	Colour	0	0	0	0	0	0	0	0	0
4.	Temperature	22.25	26.5	24.28	17	21.75	18.83	27.75	33.5	29.95
5.	Alkalinity	128.75	843	518.238	227.5	875	468.95	333	917	576.66
6.	Sulphate	0.273	3.61	1.54	0.424	62.34	5.10	0.205	5.705	1.627
7.	COD	8	60.25	36.998	0	69.5	21.925	3	173.5	42.46
8.	DO	6.78	9.70	8.15	6.465	16.7	11.60	3.34	6.174	4.48
9.	TS	751.75	2110.5	1522.16	694.25	1617.7	1191.00	682.5	2301.7	1112.37
10.	TSS	133.75	1100	803.01	188.75	631.75	456.63	45	387.25	178.38
11.	TDS	211.25	1276.7	698.313	322.75	1212.5	775.71	419.25	2041.7	933.99
12.	Hardness	131.47	857.33	354.907	86.88	1025.3	422.61	84.87	2063.9	429.78
13.	Ca Hardness	34.855	387.46	140.698	47.07	310.89	121.93	19.43	926.25	199.94
14.	Mg Hardness	52.2	732.08	216.066	34.05	894.55	300.65	37.51	1137.6	232.56
15.	Ca^{++}	13.965	155.19	56.3791	18.86	124.60	48.3847	15.995	371.20	80.8823
16.	Mg^{++}	12.68	177.73	52.82	8.27	217.37	73.045	9.11	276.51	56.68
17.	Chloride	793.44	2516.9	1173.06	581.71	2974.8	1279.02	593.59	4610.3	1102.71
18.	Phosphate	5.225	398.16	112.23	124.92	1210.1	703.759	49.637	738.87	193.774
19.	Bicarbonate	161.68	569.62	294.003	165	540.62	279.71	146.37	508.75	238.31
20.	Silica	0.0015	0.0065	0.00386	0.0013	0.0048	0.0033	0.0013	0.0063	0.0039
21.	Cu	0.0117	0.026	0.01944	0	0.009	0.0015	0.01	0.02	0.01
22.	Cr	0.0142	0.121	0.05944	0.0195	0.0362	0.0297	0.0415	0.0565	0.0468
23.	Fe	0.2197	1.1117	0.40424	0.0233	0.5783	0.1052	0	0.27	0.02
24.	RSI	-	-	-	-	-	-	-	-	-
	pHs	6.875	7.975	7.62125	5.925	8.175	7.735	6.875	8.15	7.583
25.	LSI	0.4325	19.905	1.700	-0.185	0.492	0.172	-0.239	0.66	0.196
26.	RI	6.05	7.525	7.056	5.85	8.25	7.583	2.85	8.15	7.173
27.	PSI	7.704	5.433	6.772	3.859	8.133	7.0639	4.88	7.76	6.595
	pHeq	8.826	7.632	8.471	7.991	8.85	8.41055	8.235	8.879	8.5592
28.	Larson skold index	27.698	8.731	12.9069	6.404	32.743	13.827	6.53	50.725	12.135

Note: all parameter in ppm except pH, Temperature in ºC, Odour in TON and indices has no parameter, TDS= Total Dissolve Solids,DO=DissolveOxygen,COD=ChemicalOxygenDemand

Table 3. Seasonal changes trend in physic-chemical parameters/corrosion indices

No.	Trend	Physic-chemical parameters/corrosion indices
1.	Winter to Monsoon and Monsoon to Summer	pH, Colour, Puckorius Scaling Index, Copper
2	Monsoon to winter and winter to summer	Total Alkalinity, Temperature, COD, TDS, Total Hardness, HCO^{3-}, Iron, Chromium, Larson Skold Index
3	Winter to summer and summer to Monsoon	Sulfate, Chloride
4	Summer to Monsoon and Monsoon to Winter	DO, Silica
5	Monsoon to Summer and Summer to winter	—

Conclusion

From the seasonal study of ground water properties of Olpad and Choryasi villages it can be summarized that most of the physico- chemical parameters increased with monsoon to winter and winter to summer. From various corrosion indices study during all seasons it can be summerzied that water possesses corrosion tendency more in summer as compared to other season as PSI, LSI and RSI indices showed such trend. Here Langlier Index showing higest corrosive property of water in winter as Ryznar Stability index showed less corrosive tendency of water in summer as well high in monsoon.

From Table 2- average data of all seasons for various indices showed different trend of corrosion from Langlier Index water is having balanced water in monsoon and winter to some faint coating properties in summer, in both case treatment generally not needed. From Ryznar Index during summer water having no difficulty to little scale formation where as during monsoon and winter water is aggressive to corrosion insignificant, which is quite opposite trend from Langlier Index, Purkorius Index average results, reflect that scaling may occur. From Larson Skold index it can be summarized that in all seasons LSI values are above 1.2 hence the tendency towards high corrosion rate of all local type should be expected. So here from all average data we can say that all indices showed probability of light scale or no scale except Ryznar Indnex which showed water is aggressive in monsoon and winter. So all industry lying in study area should be first checked for corrosion tendency of water and then it should be used otherwise, it will corrode pipes and boiler and makes loss of materials as well as boiler scaling may leads to accidents. It can be concluded from the results that the groundwater in radius of 22 km in Olpad and 7 km in Choryasi posses high value of Total alkalinity, Total Hardness, Chloride and TDS etc. Through all of these factors may pose health hazard (on long term), yet these degrade quality of drinking water and therefore require to be treated before directly drinking purpose.

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