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EVALUATION OF PHYSICO-CHEMICAL CHARACTERISTICS AND SCALING INDICES OF GROUND WATER QUALITY OF COASTAL VILLAGES OF HANSOT AND ANKLESHWAR TALUKAS OF BHARUCH DISTRICT, GUJARAT, INDIA.

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ABSTRACT

Study on the ground water quality was carried out among the coastal villages of Hansot and Ankleshwar talukas of Bharuch district, Gujarat state, India in the year 2018-2019. Ground water samples were collected from 40 different sampling stations of coastal villages of Hansot and Ankleshwar talukas of Bharuch district and were analyzed for their physico-chemical characteristics and different indices for corrosion. The results were evaluated using the standard analytical procedure of APHA (2005). On the basis of evaluation the uses of groundwater for drinking purpose, agriculture as well as industrial was decided. Physico-chemical parameters like pH, TDS, TH, Ca Hardness, Mg Hardness, Ca as Ca^{+2}, Mg as Mg^{+2} and corrosion indices like Langelier Saturation Index, Ryznar Stability Index, Puckorius Scaling Index and Larson Skold Index were calculated by standard methods. By comparing the results against drinking water quality standards laid by Indian Standards, it is found that most of the water samples are non-potable for human being due to high concentration of one or the other parameter. Most of samples have TDS and TH values higher than the permissible limit prescribed by IS. Even at some places corrosion indices are found higher too. The higher values of these parameters may have health implications and therefore these need attention. From different indices it is summarized that water samples at many places have corrosion tendency. So from these locations water should be given pre-treatment before using it for cooling water and boiler purpose.

KEYWORDS

Ground water, Physico-chemical parameters, Corrosion indices, LSI, RSI, PSI, Larson Skold Index.

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.

In continuation of our earlier studies on ground water [2, 3], we are extending the study and scope by increasing physico-chemical parameters and sampling stations of Bharuch district. 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 do not 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. Industrialization and many other things like fertilizer, pesticide, manure, process waste, seepage from sump or gutter and percolation through contaminated area are mainly probable sources of groundwater pollution [4, 5].

Due to fast industrialization, the population of coastal villages of Hansot and Ankleshwar talukas of Bharuch district 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 [6]. 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 IS [7]. Main aim of this study is to assess the groundwater quality in Bharuch district and to compare the result with drinking standards. In this direction, many researchers have carried out ground water study [8-10]

Study area:

Different samples of ground water were collected from 40 sampling stations. Geographical location of study area is shown in the Figure 1.

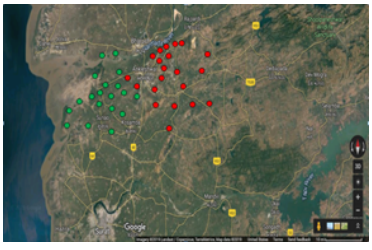

Fig.1: Google view of Coastal villages of Hansot and Ankleshwar talukas of Bharuch-Gujarat (Image source: Google earth) Agricultural area and Industrial area sampling stations.

MATERIALS AND METHODS: The present study deals with ground water quality assessment of coastal villages of Hansot and Ankleshwar talukas nearby residential area and industrial area of the Bharuch district. Different samples of groundwater were taken from coastal villages.

[1]Agricultural area: (Hansot to Ankleshwar) Sahol, Balota, Dhamrad, Ankalva, Vaghwan, Chhilodara, Dantrai, Koteshwar, Katpor, Kantiyajal, Samli, Badodara, Hansot, Alva, Rayma, Aniyadara, Malanpor, Sunevkhurd, Sunevkalla

[2]Industrial area: (Ankleshwar to Bharuch) Utraj, Shera, Mothiya, Navadhanturiya, Matied Junapungam, Sajod, Sangpor, Hirapore, Libhet, Talodra, Selod, Digas, Nangal, Telva, Junadiva, Divi, Boidara, Kharchi, Uchhali, Motali during the april 2018 to march 2019. The average results of the study period of the respective sampling stations are given in Table 1 and compared all results with the standards values given by IS[7].

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 [11]. The physico - chemical analysis was done according to APHA standard methods [12] for examination of water and waste water. The various parameters were analyzed pH, TDS, Hardness, Ca Hardness, Mg Hardness and various corrosion indices LSI, RI, PSI and Larson scold Index calculated using standard methods[13].

Some parameters, like pH, colour, odour were checked within 6 hrs. The obtained results were reproducible within ± 3% error limit. Other statistical methods are used to determine correlation between all parameters.

RESULTS AND DISCUSSIONS:

Drinking water standards by Indian Standard. Average values from April 2018 to march 2019 of physico-chemical parameters of ground water from different sampling stations are showed in table 1.

pH: The pH values in the study area were ranged from 6.99 to 8.17 with the mean value of 7.29 where as permissible range of pH as per IS[7] is 6.5 to 8.5. The results indicate that the characteristic of groundwater was slightly acidic to moderately alkaline. In general, all samples were having pH values less than 8.17. The highest value of pH 8.17 was recorded at S33 (Nangal), where the lowest value of pH 6.99 was recorded at S5 (Vaghwan).

TDS: TDS concentration beyond 500 ppm decreases palatability and may cause gastrointestinal irritation [11].In the study area TDS varied from 194 to 1651 ppm with a mean value 706 ppm. The lowest value of TDS (194 ppm) was recorded at S16 (Aniyadara), whereas, the highest value of TDS (1651 ppm) was recorded at S6 (chhilodara). The desirable limit of TDS is 500 ppm and permissible limit is 1500 ppm as per IS [7]. In the present study, the increase in TDS is mainly due to increase in salts containing carbonates, bicarbonates and chlorides [12].

Total Hardness: TH of water samples in the study area varied from 125.45 to 889.20 ppm with the mean value of 359.46 ppm. The desirable limit of TH is 300 ppm and permissible limit is 600 ppm as per IS [7]. The lowest value of TH (125.45 ppm) was recorded at S14 (Alva), whereas, the highest value of TH (889.20 ppm) was recorded at S38 (Kharchi). so the adverse effect 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. All these samples were considered as hard water samples [14]. So water from these areas cannot be used for washing, drinking as well as in industrial applications without treatment of water softening.

Calcium Hardness: Ca hardness in groundwater samples in the study area varied from 47.60 to 269.75ppm with the mean value of 115.19 ppm, The desirable limit is for calcium is 75 ppm and permissible limit is 200 ppm as per IS[7]. The lowest value of Ca hardness (47.60 ppm) was recorded at S9 (Katpor), whereas, the highest value of Ca hardness (269.75 ppm) was recorded at S6 (Chhilodara).

Magnesium Hardness: Mg hardness in groundwater samples in the study area varied from 71.50 to 646.47 ppm with the mean value of 242.95 ppm. The lowest value of Mg hardness (71.50 mg/l) was recorded at S3 (Dhamrad), whereas, the highest value of Mg hardness (646.47 ppm) was recorded at S38 (Kharchi). As per the IS [7] the desirable limit of Mg is 30 ppm and permissible limit is 90 ppm.

Langelier Saturation Index (LSI): From the data obtained of measured pH, TDS, Ca^{+2}, HCO_3^- and water temperature. LSI was calculated for all the sampling stations. LSI values from calculation were found between 1.70 to 3.47 with the mean value of 2.28. It varied from serious corrosion and scale forming but non corrosive (by carrier 1965) [15]. All results are shown in table 2 for their Langelier saturation index property.

Ryznar Stability Index (RSI): Ryznar stability index was calculated by using pH, conductivity, TDS, Ca^{+2}, HCO_3^- and water temperature data [17]. RSI values from calculation were found between 1.00 to 5.09 with the mean value of 2.79. Ryznar stability index is used to predict calcium carbonate scale. A value of 6 indicates "stable" water, value < 6 indicates sacle-forming tendency and value > 6 indicates scale-dissolving tendency. This index estimates the degree to which calcium carbonate scale will form in drinking water and cooling water [16]. Ryznar index values indicate the water characteristics for sacling[17]. Ryznar stability index interpretation along with sampling stations with respect to data has been shown in table 3.

Puckorius Scaling Index (PSI): Puckorius Scaling Index [10] (PSI) values from calculation were found between -0.39 to 9.688 with the mean value of 1.77. It was calculated from the alkalinity and pHeq data. Puckorius scaling index is modified version of the RSI that gives a more accurate and consistent indication of the calcium carbonate scaling potential of cooling water [17].

As with RSI, a PSI value of 6 indicates stable water; value < 6 indicate scale forming tendency, PSI > 6 indicates that scaling may occur. Tendency of water from industrial area which are using water as cooling water in industry with respect to scaling index PSI shown in table 4.

Larson Skold Index(LSI): From the results obtained; Larson Skold Index values varied from 0.010 to 19.33 with the mean value of 4.45. The index has been a proven useful tool in predicting aggressiveness of sample through cooling water [17]. The Larson Scold index interpretations along with sampling locations with respect to data are shown in table 5.

Table 1: All data average of Physico-chemical parameters year April-2018 to March- 2019

Sampling Stations	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Parameter	Sahol	Balota	Dhamrad	Ankalva	Vaghwan	Chhilodara	Dantrai	Koteshwar	Katpor	Kantiyajal
pH	7.11	7.04	8.10	7.30	6.99	7.48	7.05	7.02	7.10	7.09
TDS	1589	637	846	348	863	1651	378	627	325	491
Hardness	561.46	237.41	147.71	195.18	339.24	814.22	234.10	300.68	231.27	214.06
Ca Hardness	232.20	65.57	76.21	73.77	122.25	269.75	129.50	108.91	47.60	78.45
Mg Hardness	329.26	171.84	71.50	121.41	216.98	536.97	104.60	191.77	183.67	135.61
Ca as Ca^{+2}	92.65	26.02	29.93	29.29	48.57	119.17	51.57	43.34	18.71	31.08
Mg as Mg^{+2}	80.01	41.75	17.32	27.31	52.72	136.82	25.41	46.60	44.63	32.95
LSI	2.44	1.82	3.17	2.06	2.00	2.72	1.98	1.91	1.81	2.12
RI	2.15	3.50	1.76	3.38	2.96	1.96	3.08	3.06	3.39	2.89
PSI	0.609	2.048	1.032	2.57	1.56	1.05	1.92	2.013	1.997	1.353
Larson Skold Index	0.010	0.012	7.651	9.207	8.117	0.0103	19.33	0.0193	8.283	6.459

(Table 1 Contd.)

Sampling Stations	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20
Parameter	Samli	Badodara	Hansot	Alva	Rayma	Aniyadara	Malanpor	Sunevkhurd	Sunevkalla	Utraj
pH	7.14	7.25	7.03	7.59	7.17	7.16	7.20	7.10	7.12	7.24
TDS	434	742	374	231	339	194	334	414	224	446
Hardness	197.01	293.71	224.94	125.45	171.71	133.31	241.49	353.03	178.88	279.79
Ca Hardness	69.93	84.32	94.74	53.71	80.78	56.51	90.31	183.61	71.53	89.47
Mg Hardness	127.08	209.40	130.20	71.74	90.93	76.80	151.18	169.42	107.36	190.26
Ca as Ca^{+2}	27.84	33.50	37.77	21.29	35.17	22.08	35.80	72.82	28.06	35.30
Mg as Mg^{+2}	30.83	50.88	31.63	17.43	22.09	18.66	36.73	41.17	26.08	46.23
LSI	2.04	2.08	2.00	2.22	2.01	1.70	2.10	1.98	1.74	2.07
RI	5.09	3.12	3.07	3.13	3.31	3.74	2.99	3.13	3.63	3.09
PSI	1.662	1.964	9.688	2.565	2.158	2.825	1.914	2.181	2.758	1.646
Larson Skold Index	6.833	0.016	0.011	0.010	0.01	0.014	0.012	0.030	0.020	9.808

(Table 1 Contd.)

Sampling Stations	S21	S22	S23	S24	S25	S26	S27	S28	S29	S30
Parameter	Shera	Mothiya	Navadhanturiya	Matied	Junapungam	Sajod	Sangpor	Haripore	Libhet	Talodra
pH	7.13	7.28	7.39	7.33	7.07	7.27	7.25	7.02	7.38	7.18
TDS	289	1704	910	946	306	954	1132	878	1085	264
Hardness	191.01	308.88	232.47	293.44	197.37	207.46	794.72	655.44	356.14	201.69
Ca Hardness	80.05	65.93	88.54	71.71	88.94	57.75	218.79	130.08	107.71	86.76
Mg Hardness	110.96	251.28	143.93	221.72	108.43	149.72	575.93	525.36	248.44	114.93
Ca as Ca^{+2}	31.61	25.84	35.09	28.35	35.09	22.52	82.37	51.60	42.72	42.70
Mg as Mg^{+2}	26.96	61.06	34.97	53.88	26.34	36.38	139.95	127.61	60.40	27.93
LSI	1.97	1.99	2.35	2.03	1.82	2.09	2.32	2.11	2.21	2.09
RI	3.18	3.30	2.73	3.28	3.46	3.24	2.60	2.83	2.98	3.00
PSI	2.122	1.995	1.558	2.267	2.343	1.912	1.458	1.356	1.993	2.12
Larson Skold Index	0.010	5.436	9.277	0.012	0.016	9.124	10.850	9.865	0.010	9.373

(Table 1 Contd.)

Sampling Stations	S31	S32	S33	S34	S35	S36	S37	S38	S39	S40
Parameter	Selod	Digas	Nangal	Telva	Junadiva	Divi	Boidara	Kharchi	Uchhali	Motali
pH	7.19	7.15	8.17	7.82	7.49	7.31	7.45	7.18	7.70	7.54
TDS	656	783	970	665	1059	602	686	1096	1419	932
Hardness	293.60	267.80	378.99	606.97	489.99	522.65	416.26	889.20	660.85	719.98
Ca Hardness	109.45	48.50	86.47	131.37	158.60	141.82	132.95	191.90	191.26	255.64
Mg Hardness	182.48	227.64	292.52	475.60	331.38	380.75	284.98	646.47	469.58	464.33
Ca as Ca^{+2}	43.37	19.20	50.23	75.60	63.12	59.78	52.77	76.65	76.15	102.38
Mg as Mg^{+2}	44.75	91.79	70.91	115.57	80.50	92.53	69.25	169.44	114.11	112.88
LSI	2.08	1.99	3.47	3.15	2.98	2.63	2.76	2.61	3.25	3.28
RI	3.05	3.18	1.39	1.52	1.55	2.05	1.93	1.79	1.25	1.00
PSI	1.981	1.522	0.505	0.698	0.093	0.747	0.646	0.391	-0.115	-0.394
Larson Skold Index	0.019	8.266	7.823	0.010	6.853	0.017	0.010	9.846	6.644	8.675

Table 2: Langlier Saturation Index property for various sampling stations.

No.	LSI	Indication (carrier 1965)	Sampling stations
1.	-2.0 < -0.5	Serious corrosion	S1(Sahol), S3(Dhamrad), S4(Ankalva), S5(Vaghwan), S6(Chhilodara), S7(Dantrai), S10(Kantiyajal), S11(Samli), S12(Badodara),S13(Hansot), S14(Alva), S15(Rayma), S17(Malanpor),S18(Sunevkhurd), S20(Utraj), S21(Shera), S22(Mothiya),S23(Navadhanturiya),S24(Matied), S26(Sajod), S27(Sangpor), S28(Haripore),S29(Libhet), S30(Talodra), S31(Selod), S32(Digas), S33(Nangal), S34(Telva), S35(Junadiva), S36(Divi), S37(Boidara), S38(Kharchi), S39(Uchhali), S40(Motali).
2.	-0.5 < 0	Slightly corrosion but non-scale forming	--
3.	LSI = 0.0	Balanced but pitting corrosion possible	--
4.	0.0 < 0.5	Slightly scale forming and corrosive	--
5.	0.5 < 2	Scale forming but non corrosive	S2(Balota), S8(Koteshwar), S9(Katpor), S16(Aniyadara), S19(Sunevkalla), S25(Junapungam)

Table 3: Ryznar Stability Index property for various sampling stations.

No.	RI(1942)	Indication	Sampling stations
1.	RI < 5.5	Heavy scale will form	S1(Sahol), S2(Balota), S3(Dhamrad), S4(Ankalva), S5(Vaghwan), S6(Chhilodara), S7(Dantrai), S8(Koteshwar), S9(Katpor), S10(Kantiyajal), S11(Samli), S12(Badodara), S13(Hansot), S14(Alva), S15(Rayma), S16(Aniyadara), S17(Malanpor), S18(Sunevkhurd), S19(Sunevkalla), S20(Utraj), S21(Shera), S22(Mothiya), S23(Navadhanturiya), S24(Matied), S25(Junapungam), S26(Sajod), S27(Sangpor), S28(Haripore), S29(Libhet),S30(Talodra), S31(Selod), S32(Digas), S33(Nangal), S34(Telva), S35(Junadiva), S36(Divi), S37(Boidara), S38(Kharchi), S39(Uchhali) and S40(Motali).
2.	5.5 < RI > 6.2	Scale will form	--
3.	6.2 < RI > 6.8	No difficulties	--
4.	6.8 < RI > 8.5	Water is aggressive	--
5.	RI > 8.5	Water is very aggressive	--

Table 4: Puckorius Scaling Index property for various sampling stations.

No.	PSI	Indication	Sampling stations
1	< 6	Scale forming tendency	S1(Sahol), S2(Balota), S3(Dhamrad), S4(Ankalva), S5(Vaghwan), S6(Chhilodara), S7(Dantrai), S8(Koteshwar), S9(Katpor), S10(Kantiyajal), S11(Samli), S12(Badodara), S13(Hansot), S14(Alva), S15(Rayma), S16(Aniyadara), S17(Malanpor), S18(Sunevkhurd), S19(Sunevkalla), S20(Utraj), S21(Shera), S22(Mothiya), S23(Navadhanturiya), S24(Matied), S25(Junapungam), S26(Sajod), S27(Sangpor), S28(Haripore), S29(Libhet), S30(Talodra), S31(Selod), S32(Digas), S33(Nangal), S34(Telva), S35(Junadiva), S36(Divi),S37(Boidara), S38(Kharchi), S39(Uchhali) and S40(Motali).
2	6-7	Stable water	–
3	> 7	Scaling may occur	--

Table 5: Larson Skold Index property for various sampling stations.

No.	LSI	Indication	Sampling stations
1	< 0.8	Chloride and sulfate probably will not interfere with natural film formation	S1(Sahol), S2(Balota), S6(Chhilodara), S12(Badodara), S13(Hansot), S14(Alva), S15(Rayma), S16(Aniyadara), S17(Malanpor), S18(Sunevkhurd), S19(Sunevkalla), S21(Shera), S24(Matied), S25(Junapungam), S29(Libhet), S31(Selod), S34(Telva), S36(Divi),S37(Boidara)
2	0.8 < LSI < 1.2	Chloride and Sulfate may interfere with natural film formation. Higher than desirable corrosion rates might be anticipated.	--
3	LSI > 1.2	The tendency towards high corrosion rates of a local type should expected as the index increases.	S3(Dhamrad), S4(Ankalva), S5(Vaghwan), S7(Dantrai), S8(Koteshwar), S9(Katpor), S10(Kantiyajal), S11(Samli), S20(Utraj), S22(Mothiya), S23(Navadhanturiya), S26(Sajod), S27(Sangpor), S28(Haripore), S30(Talodra), S32(Digas), S33(Nangal), S35(Junadiva), S38(Kharchi), S39(Uchhali), S40(Motali)

CONCLUSION:

It can be concluded from the results that the groundwater possesses high value of Total Hardness, Ca Hardness, Mg Hardness and TDS by comparing the results against drinking water quality standards laid by Indian Standards; it is found that most of the water samples are non-potable for human being due to high concentration of one or the other parameter. Hence pre-treatment for purpose of drinking is needed.

Sahol, Balota, Dhamrad, Ankalva, Vaghwan, Chhilodara, Dantrai, Koteshwar, Katpor, Kantiyajal, Samli, Badodara, Hansot, Alva, Rayma, Aniyadara, Malanpor, Sunevkhurd, Sunevkalla, Utraj, Shera, Mothiya, Navadhanturiya, Matied, Junapungam, Sajod, Sangpor, Haripore, Libhet, Talodra, Selod, Digas, Nangal, Telva, Junadiva, Divi, Boidara, Kharchi, Uchhali and Motali 40 sampling stations showed Heavy scale will form Ryznar Stability Index and Scale forming tendency Puckorius Scaling Index.

34 sampling stations [Sahol, Dhamrad, Ankalva, Vaghwan, Chhilodara, Dantrai, Kantiyajal, Samli, Badodara, Hansot, Alva, Rayma, Malanpor, Sunevkhurd, Utraj, Shera, Mothiya, Navadhanturiya, Matied, Sajod, Sangpor, Haripore, Libhet, Talodra, Selod, Digas, Nangal, Telva, Junadiva, Divi, Boidara, Kharchi and Uchhali, Motali] showed Serious corrosion and 6 sampling stations [Balota, Koteshwar, Katpor, Aniyadara, Sunevkalla, Junapungam] showed Scale forming but non corrosive. So from these sampling stations water should be given pre-treatment before using it for cooling water and boiler purpose. All of these factors may pose health hazard (on long term), degraded quality of drinking water and therefore require to be treated before directly drinking purpose.

Out of Fourty, 19 sampling stations [Sahol, Balota, Chhilodara, Badodara, Hansot, Alva, Rayma, Aniyadara, Malanpor, Sunevkhurd, Sunevkalla, Shera, Matied, Junapungam, Libhet, Selod, Telva, Divi, Boidara] showed Chloride and sulfate probably will not interfere with natural film formation; while 21 sampling stations [Dhamrad, Ankalva, Vaghwan, Dantrai, Koteshwar, Katpor, Kantiyajal, Samli, Utraj, Mothiya, Navadhanturiya, Sajod, Sangpor, Haripore, Talodra, Digas, Nangal, Junadiva, Kharchi, Uchhali and Motali] showed, the tendency towards high corrosion rates of a local type should expected as the index increases. The water from these sites needs to be treated before taken up for cooling water or boiler uses otherwise pipeline and boiler internal surface corrodes at faster rate. Scaling of boiler due to carbonate may cause bursting of boiler which is threatening life and pollution to the environment.

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REFERENCES:

[1] Das,N.C.(**2013**),"Physico-Chemical characteristics of selected ground water samples of Ballarpur city of chandrapur district, Maharashtra, India", International Research Journal of Environment Sciences , 2(11),96-100.
[2] Patel, F. T., Patel, A. S. Malik, G. M. and Mitchla, S. M. (**2018**), "A study on seasonal variation in physico-chemical parameters and corrosion indices of coastal villages of Olpad and Choryasi taluka, Surat district", Journal of ultra chemistry, 14(1), 14-21.
[3] Patel, F. T., Mitchla, S. M., Patel, A. S. and Malik, G. M.(**2019**), "Seasonal Variation of Groundwater Quality of Coastal Villages of Olpad and Choryasi Taluka, Surat District, Gujarat, India", Journal of Applicable Chemistry, 8 (4), 1946-1952.
[4] Rana, A. K., Kharodawala, M.J., Dabhi, H. R., Suthar, D. M., Dave, D. N., Patel, B. S. and Rai, R. K. (**2002**), "Physico-chemical studies on bore wells water of Dahod[Gujarat]", Asian J. of Chemistry, 14(3-4), 1178-1184.
[5] Hamliton, P. A. and Hesel, D.R. (**1995**), Ground water, 33, 2.
[6] Singh, M. K., Jha D., and Jadoun, J. (**2012**), "Assessment of Physico-chemical status of Groundwater samples of Dholpur District, Rajasthan, India", International Journal of Chemistry, 4(4), 96-104.
[7] Standards for Drinking Water IS-105000-(**1991**).
[8] Raval, V. H., and Malik, G. M. (**2012**), "Study on seasonal variation in physico-chemical parameters and corrosion indices in and around surat city", International Journal of Chemistry, 1(1), 80-88.
[9] Kumar, A. (**2017**), "Assessment of Water Quality For Drinking Purpose In Agra City, India", Journal of Applicable Chemistry, 6(6), 1229-1233.
[10] Rao, J.S., Hari Haran, A.V.L.N.S.H., Rao, T.S. and Machiraju P.V.S.(**2014**), "Hydro geochemistry Evaluation of Ground Water using Multivariate Factor Analysis in Srikakulam Costal Region of Andhra Pradesh, India", Journal of Applicable Chemistry, 3(2), 769-775.
[11] Raval, V. H. and Malik, G. M. (**2010**), "Physico– Chemical Characteristics of ground Water in and around Surat City, (India)", J. Environ. Engg. & Sciences, 52(4), 343-348.
[12] APHA,(**1995**), Standard method for the examination of water and Wastewater American Public Health Association, American Water Works Association and water pollution Control Federation, 19th Washington, D.C.
[13] www.lentech.com.
[14] Maiti S.K., Handbook of Methods Environmental studies Volume-1, Water and Wastewater analysis.
[15] www.csgnetwork.com.
[16] www.tpub.com.
[17] www.corrosion-doctor.org.