Water Quality Assessment of Groundwater of Gadchandur Area in Terms of Water Quality Index

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Abstract

Water is one of the most important resources for life. It is considered that groundwater to be used for drinking purpose should possess high degree of purity. It should be free from chemical contamination and micro-organisms. Groundwater is the essential thing for living organisms. The water crisis arises due to short period of rainfall, failure of monsoon and improper management of rain water. During last few decades, it is observed that the groundwater is being polluted drastically due to increased human activities. Hence, a continuous monitoring of groundwater quality becomes necessary to minimize and also control on the pollution causing various contaminated factors. The present study around Gadchandur area reveals the study of physico-chemical parameters of groundwater such as pH, total dissolved solids (TDS), temperature, total hardness, nitrate, alkalinity, iron, chloride, fluoride, dissolved oxygen and turbidity. The observed values for samples were compared with standard values given by world health organization (WHO). Water quality index (WQI) was calculated from these analytical results and to find the range of all quality of water samples which comes under the slightly polluted in characteristics.

KEYWORDS : Groundwater quality, Water quality index, Physico-chemical parameters, Water quality rating.

INTRODUCTION

Water is the chief constituent of ecosystem. Water is present mainly in the form of rivers, lakes, glaciers, rain water, ground water etc. Besides the need of water for drinking, water plays an important role in various sectors like agriculture, domestic, forests, industrial activities, hydropower generation and pisciculture. The availability and quality of all forms of water have been declined due to increasing population, industrialization, urbanization etc. Physical, chemical and biological parameters can be used to assess water quality of any specific area or specific source. The values of these parameters, if present beyond the prescribed limit, are harmful for human health[1-2]. Therefore, the suitability of groundwater for drinking purpose has been described in terms of Water Quality Index (WQI). This is one of the most effective way to express the quality of water. It has been realized that it is difficult to use individual water quality variable in order to describe the water quality for common public[3-4].

WQI reduces the huge amount of information into a single value to express the data in a simplified and logical form[5]. They increase the understanding ability of water quality issues by the policy makers as well as for the general public as users of the water resources[6]. Here attempt has been made to calculate the water quality index of the study area on the basis of hydrochemical data with the help of Weighted Arithmetic Water Quality Index Method. The concept of water quality index was developed by Horton in 1965[7]. WQI is a single number that expresses the overall quality of water at a certain area and time based on several water quality parameters. WQI reflects a composite influence of contributing factors on the quality of water for any water system[8]. WQI a well known method as well as one of the most effective tools to express water quality that offers a simple, stable, reproducible unit of measure and communicate information of water quality to the policy makers and concerned citizens. Thus it is an important parameter for the assessment and management of ground water[9-10]. Water quality of different sources has been communicated on the basis of calculated water quality indices[11-12].

STUDY AREA

Gadchandur is located in the western edge of Chandrapur district in 'Maharashtra' region. It is located between 19^{0}38'30'' N to 19^{0}50'30''N Latitude and 79^{0}04'00''E to 79^{0}11'00''E longitude[13]. Physiographically, Gadchandur is surrounded by Pagadiguddam and ammalnala dam[14]. Gadchandur is surrounded by cement factories which include Ambuja Cements, Manikgarh Cements, ACC Cements and huge lime stone deposits[15].

MATERIALS AND METHODS

Fifteen sampling sites (bore wells) were selected from different locations mainly around the cement factories in the study area. Sampling was done in summer, rainy and winter seasons of 2016. Water samples from identified bore wells were collected in pre-cleaned two liter polythene bottles and were analyzed for 12 parameters i.e. temperature, pH, total dissolved solids, dissolved oxygen, alkalinity, total hardness, chloride, fluoride, sulphate, iron, turbidity and nitrate. The physico-chemical analysis was carried out as per the standard methods[16].

RESULTS AND DISCUSSIONS

Three steps are followed to calculate WQI. In the first step, each of the parameters has been assigned a weight (Wn) according to its relative importance in the overall quality of water for drinking purpose. A maximum weight of 5 has been assigned to nitrate due to its major importance in water quality assessment. In the second step, the relative weight is calculated from the following equation

$$WQI = \frac{\sum q_n W_n}{\sum W_n}$$

where Wn is the unit weight, qn is quality rating and n is the number of parameters. Calculated Wn values of the parameter are given in Table 1. In the third step, a quality rating scale (qn) for each parameter is assigned by dividing its concentration of each water sample by its respective standard according to the laid down in the BIS and the result multiplied by 100.

Relation used is

$$q_n = 100\left[\frac{(V_n - V_i)}{(S_n - V_i)}\right] \qquad q_{PH} = 100\frac{(V_{pH} - 7.0)}{(8.5 - 7.0)}$$

where VpH = observed value of pH. Ideal value for pH = 7.0 and permissible value is 8.5.

$$q_{DO} = 100\frac{(V_{DO} - 14.6)}{(6 - 14.6)}$$ where V_{DO} = observed value of dissolved oxygen.

Table 1 : Standard Values of Water Quality Parameters and their Corresponding Ideal Values and Unit Weights

Sr. No.	Parameter	Sn	Recommending agency	Ideal value (Vi)	K value	Unit weight (Wn)
1	**pH**	8.5	BIS	7.0	0.220	0.025882
2	**TDS**	500	BIS	0	0.220	0.00044
3	**Turbidity**	5	BIS	0	0.220	0.044
4	**Alkalinity**	200	ICMR	0	0.220	0.0011
5	**Chloride**	250	ICMR/BIS	0	0.220	0.00088
6	**Fluoride**	1.5	BIS	0	0.220	0.146666
7	**Iron**	0.3	BIS	0	0.220	0.733333
8	**Hardness**	300	ICMR	0	0.220	0.000733
9	**NO_3^-**	45	ICMR/BIS	0	0.220	0.004888
10	**SO_4^{2-}**	200	BIS	0	0.220	0.0011
11	**Dissolved oxygen**	6	ICMR/BIS	14.6	0.220	0.036666

$\sum Wn =$ 0.9956

The following formula can be used to determine the unit weight for each water quality parameter. $Wn = \frac{K}{S_n}$ Where Sn is standard Value of nth parameter, K is constant for proportionality. $K = \frac{1}{\sum \frac{1}{S_n}}$ The calculated WQI values are classified into five types as shown in Table 2.

Table 2 : WQI and Corresponding Water Status

Sr. No.	WQI	Status	Possible usage
1	0 – 25	Excellent	Drinking, irrigation, industrial
2	26 – 50	Good	Domestic, irrigation, industrial
3	51 – 75	Fair	Irrigation and industrial
4	76 – 100	Poor	Irrigation
5	101 – 150	Very poor	Restricted use for irrigation
6	Above 150	Unfit for drinking	Proper treatment required before use

Table 3 : Analysis of Ground Water Samples in Summer Season (May 2016)

Sr. No.	Site Code	Temp. (^oC)	pH	TDS (ppm)	Turbidity (NTU)	Alkalinity (ppm)	Cl^- (ppm)	F^- (ppm)	Fe (ppm)	Total Hardness (ppm)	NO_3^- (ppm)	SO_4^{2-} (ppm)	Dissolved oxygen (ppm)
1	W1	31.5	7.25	472	0.40	392	26	2.25	0.033	376	0.35	55	3.6
2	W2	29.4	7.62	607	0.46	308	32	0.00	0.019	568	0.69	110	4.0
3	W3	30.5	7.65	528	0.76	332	36	2.20	0.025	348	0.08	20	3.6
4	W4	29.8	7.43	342	0.50	312	28	2.0	0.082	204	0.03	15	4.2
5	W5	30.6	7.10	692	14.58	288	110	2.20	0.117	484	0.832	115	3.4
6	W6	29.3	7.37	403	0.99	240	46	2.34	0.034	264	0.832	30	4.4
7	W7	29.8	7.48	808	0.28	288	108	2.25	0.063	600	0.677	70	3.6
8	W8	29.5	7.40	753	0.40	352	120	2.02	0.117	528	0.956	60	4.6
9	W9	29.2	7.60	575	0.03	320	44	2.29	0.127	300	0.939	50	4.8
10	W10	30.6	7.70	674	0.12	370	38	2.68	0.074	380	0.739	45	4.4
11	W11	30.3	7.35	905	1.12	180	98	2.38	0.042	328	0.801	120	4.2
12	W12	29.7	7.33	573	0.68	300	52	2.19	0.082	476	0.70	315	3.6

13	W13	29.2	7.71	610	0.83	336	88	2.12	0.122	248	0.10	65	4.6
14	W14	30.3	7.29	648	1.30	260	92	2.17	0.095	348	0.11	85	4.2
15	W15	30.5	7.49	467	0.36	180	100	2.27	0.034	392	0.58	48	4.0

Table 4 : Analysis of Ground Water Samples in Rainy Season (August 2016)

Sr. No.	Site Code	Temp. (^oC)	pH	TDS (ppm)	Turbidity (NTU)	Alkalinity (ppm)	Cl^- (ppm)	F^- (ppm)	Fe (ppm)	Total Hardness (ppm)	NO_3^- (ppm)	SO_4^{2-} (ppm)	Dissolved oxygen (ppm)
1	W1	29.5	7.10	530	1.65	157	55.98	1.195	0.221	290	150.2	60	4.0
2	W2	28.8	7.28	505	0.54	143	37.99	3.442	0.078	562	12.88	140	4.2
3	W3	30.1	7.34	382	1.79	146	43.99	0.532	0.265	298	16.70	30	3.8
4	W4	29.2	7.20	331	2.72	115	21.99	0.437	0.240	240	3.98	20	4.0
5	W5	29.2	7.12	730	20.5	149	115.96	0.620	0.999	322	7.29	135	3.8
6	W6	28.9	7.24	418	0.78	118	23.99	1.714	0.073	288	12.65	35	4.0
7	W7	29.3	7.19	974	0.35	150	197.94	0.739	0.043	732	153.39	65	3.8
8	W8	29.3	7.25	776	1.16	144	115.96	0.939	0.162	490	153.41	70	4.4
9	W9	28.9	7.44	565	0.36	189	53.98	1.715	0.038	334	15.67	60	4.6
10	W10	30.1	7.35	658	4.36	227	47.99	1.572	0.285	406	17.27	40	4.2
11	W11	29.7	7.17	581	0.69	131	45.99	1.157	0.107	294	9.78	130	4.4

12	W12	29.1	6.98	1110	5.96	119	199.94	0.658	0.457	490	153.31	380	3.8
13	W13	28.6	7.30	541	1.35	144	39.99	2.154	0.137	368	20.32	50	4.4
14	W14	29.3	7.19	573	2.13	148	55.98	0.263	0.231	222	9.06	70	4.0
15	W15	29.5	7.50	525	4.69	153	47.99	1.375	0.171	144	5.64	50	4.2

Table 5 : Analysis of Ground Water Samples in Winter Season (November 2016)

Sr. No.	**Site Code**	**Temp. (^oC)**	**pH**	**TDS (ppm)**	**Turbidity (NTU)**	**Alkalinity (ppm)**	**Cl^- (ppm)**	**F^- (ppm)**	**Fe (ppm)**	**Total Hardness (ppm)**	**NO_3^- (ppm)**	**SO_4^{2-} (ppm)**	**Dissolved oxygen (ppm)**
1	W1	28.1	7.20	495	0.60	272	36	2.15	0.013	410	12.20	44	4.4
2	W2	26.0	7.42	674	0.56	210	48	0.94	0.009	544	11.15	75	4.6
3	W3	27.1	6.92	342	1.20	230	46	1.20	0.020	314	9.65	95	4.0
4	W4	26.6	6.83	305	2.50	212	26	2.15	0.090	226	10.30	35	4.2
5	W5	27.2	6.56	690	13.65	145	105	1.60	0.705	390	9.80	150	4.2
6	W6	26.0	7.00	410	0.89	140	67	1.34	0.025	244	11.30	55	4.0
7	W7	26.6	7.15	825	0.18	230	217	1.85	0.090	560	12.70	58	4.4
8	W8	26.7	7.10	676	0.60	315	190	1.75	0.127	480	13.35	68	4.6
9	W9	26.0	7.25	525	0.15	275	63	2.10	0.107	290	7.15	72	3.8
10	W10	27.2	7.20	585	0.05	257	58	2.25	0.050	410	8.85	38	3.4

11	W11	27.0	7.10	715	1.27	149	118	1.26	0.010	340	14.12	142	4.2
12	W12	26.3	6.95	995	4.70	217	175	1.87	0.090	514	11.15	327	4.0
13	W13	26.0	7.31	580	0.60	252	108	2.10	0.112	288	9.30	76	3.8
14	W14	26.9	7.00	540	1.10	238	119	1.80	0.020	384	7.16	66	4.6
15	W15	27.1	7.19	570	0.76	226	120	2.20	0.205	414	14.30	49	4.2

Table 6 : Water Quality Index of Bore Well Water of Study Area in Summer Season (May 2016)

Parameter	pH	TDS	Turbidity	Alkalinity	Cl^-	F^-	Fe	Total Hardness	NO_3^-	SO_4^{2-}	D.O.	$\sum q_n Wn$	WQI
W1	7.25	472	0.40	392	26	2.25	0.033	376	0.35	55	3.6	**36.287**	**36.44**
W2	7.62	607	0.46	308	32	0.00	0.019	568	0.69	110	4.0	**11.703**	**11.75**
W3	7.65	528	0.76	332	36	2.20	0.025	348	0.08	20	3.6	**34.549**	**34.70**
W4	7.43	342	0.50	312	28	2.0	0.082	204	0.03	15	4.2	**45.109**	**45.31**
W5	7.10	692	14.58	288	110	2.20	0.117	484	0.832	115	3.4	**67.559**	**67.85**
W6	7.37	403	0.99	240	46	2.34	0.034	264	0.832	30	4.4	**37.459**	**37.62**
W7	7.48	808	0.28	288	108	2.25	0.063	600	0.677	70	3.6	**46.010**	**46.21**
W8	7.40	753	0.40	352	120	2.02	0.117	528	0.956	60	4.6	**53.298**	**53.53**
W9	7.60	575	0.03	320	44	2.29	0.127	300	0.939	50	4.8	**59.218**	**59.48**

W10	7.70	674	0.12	370	38	2.68	0.074	380	0.739	45	4.4	**49.549**	**49.77**
W11	7.35	905	1.12	180	98	2.38	0.042	328	0.801	120	4.2	**39.580**	**39.75**
W12	7.33	573	0.68	300	52	2.19	0.082	476	0.70	315	3.6	**48.288**	**48.50**
W13	7.71	610	0.83	336	88	2.12	0.122	248	0.10	65	4.6	**63.343**	**63.62**
W14	7.29	648	1.30	260	92	2.17	0.095	348	0.11	85	4.2	**51.059**	**51.28**
W15	7.49	467	0.36	180	100	2.27	0.034	392	0.58	48	4.0	**36.617**	**36.78**

Table 7 : Water Quality Index of Bore Well Water of Study Area in Rainy Season (August 2016)

Parameter	**pH**	**TDS**	**Turbidity**	**Alkalinity**	**Cl^-**	**F^-**	**Fe**	**Total Hardness**	**NO_3^-**	**SO_4^{2-}**	**D.O.**	$\sum q_n Wn$	**WQI**
W1	7.10	530	1.65	157	55.98	1.195	0.221	290	150.2	60	4.0	**72.536**	**72.85**
W2	7.28	505	0.54	143	37.99	3.442	0.078	562	12.88	140	4.2	**58.804**	**59.06**
W3	7.34	382	1.79	146	43.99	0.532	0.265	298	16.70	30	3.8	**77.434**	**77.78**
W4	7.20	331	2.72	115	21.99	0.437	0.240	240	3.98	20	4.0	**70.686**	**70.99**
W5	7.12	730	20.5	149	115.96	0.620	0.999	322	7.29	135	3.8	**274.628**	**275.84**
W6	7.24	418	0.78	118	23.99	1.714	0.073	288	12.65	35	4.0	**40.529**	**40.71**
W7	7.19	974	0.35	150	197.94	0.739	0.043	732	153.39	65	3.8	**25.194**	**25.31**
W8	7.25	776	1.16	144	115.96	0.939	0.162	490	153.41	70	4.4	**56.818**	**57.07**

W9	7.44	565	0.36	189	53.98	1.715	0.038	334	15.67	60	4.6	**31.95**	**32.09**
W10	7.35	658	4.36	227	47.99	1.572	0.285	406	17.27	40	4.2	**94.788**	**95.21**
W11	7.17	581	0.69	131	45.99	1.157	0.107	294	9.78	130	4.4	**43.27**	**43.46**
W12	6.98	1110	5.96	119	199.94	0.658	0.457	490	153.31	380	3.8	**132.409**	**132.99**
W13	7.30	541	1.35	144	39.99	2.154	0.137	368	20.32	50	4.4	**61.269**	**61.54**
W14	7.19	573	2.13	148	55.98	0.263	0.231	222	9.06	70	4.0	**66.369**	**66.66**
W15	7.50	525	4.69	153	47.99	1.375	0.171	144	5.64	50	4.2	**65.192**	**65.48**

Table 8 : Water Quality Index of Bore Well Water of Study Area in Winter Season (November 2016)

Parameter	**pH**	**TDS**	**Turbidity**	**Alkalinity**	**Cl^-**	**F^-**	**Fe**	**Total Hardness**	**NO_3^-**	**SO_4^{2-}**	**D.O.**	$\sum q_n Wn$	**WQI**
W1	7.20	495	0.60	272	36	2.15	0.013	410	12.20	44	4.4	**30.375**	**30.51**
W2	7.42	674	0.56	210	48	0.94	0.009	544	11.15	75	4.6	**17.437**	**17.51**
W3	6.92	342	1.20	230	46	1.20	0.020	314	9.65	95	4.0	**22.544**	**22.64**
W4	6.83	305	2.50	212	26	2.15	0.090	226	10.30	35	4.2	**49.894**	**50.11**
W5	6.56	690	13.65	145	105	1.60	0.705	390	9.80	150	4.2	**204.901**	**205.80**
W6	7.00	410	0.89	140	67	1.34	0.025	244	11.30	55	4.0	**24.95**	**25.06**
W7	7.15	825	0.18	230	217	1.85	0.090	560	12.70	58	4.4	**45.618**	**45.81**
W8	7.10	676	0.60	315	190	1.75	0.127	480	13.35	68	4.6	**53.875**	**54.11**
W9	7.25	525	0.15	275	63	2.10	0.107	290	7.15	72	3.8	**52.469**	**52.70**
W10	7.20	585	0.05	257	58	2.25	0.050	410	8.85	38	3.4	**39.964**	**40.14**
W11	7.10	715	1.27	149	118	1.26	0.010	340	14.12	142	4.2	**21.057**	**21.15**

W12	6.95	995	4.70	217	175	1.87	0.090	514	11.15	327	4.0	**49.717**	**49.94**
W13	7.31	580	0.60	252	108	2.10	0.112	288	9.30	76	3.8	**55.222**	**55.47**
W14	7.00	540	1.10	238	119	1.80	0.020	384	7.16	66	4.6	**28.242**	**28.37**
W15	7.19	570	0.76	226	120	2.20	0.205	414	14.30	49	4.2	**77.837**	**78.18**

From above analysis, it is concluded that in summer season, water quality of W2 is excellent, W1, W3, W4, W6, W7, W10, W11, W12, W15 sites have good quality water, W5, W8, W9, W13 and W14 sites have water with fair quality. W12 has very poor water quality. In rainy season, water quality of W6, W7, W8, W9, W11 is good. W1, W2, W4, W8, W13, W14 and W15 sites have fair quality water, W3 and W10 sites have poor quality of water. W5 is unfit for drinking purpose. In winter season, water quality of W2, W6 and W11 is excellent. W8, W9, W11 is good. W1, W2, W4, W8, W13, W14 and W15 sites have fair quality water. W3 and W10 sites have poor quality of water. W5 is unfit for drinking purpose.

CONCLUSIONS

In summer season, almost all samples have very good quality except W12 which has very poor quality. W5 is found to be unfit for drinking purpose in rainy seasons. Same observation is made in winter season.

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