

Assessment of Ground Water Quality in and Around Gadchiroli District

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Abstract— Various samples of groundwater were collected from different areas of in and around Gadchiroli District, Maharashtra state (India) and analyzed for their physicochemical characteristics. The various physicochemical parameters such as pH, Electrical conductivity, BOD, DO, Turbidity, Lead, Zinc, Calcium, Magnesium, Iron, Total dissolved solids, Chloride, Sulphate, Nitrate, Fluoride, Total Alkalinity, hardness etc. were determined using standard procedures of USPHS. The results of analysis were compared with the water quality standards of Indian Standard Institute (ISI), Indian Council for Medical Research (ICMR) and World Health Organization (WHO). The overall groundwater quality of the study area has pH values, Nitrate, total hardness, calcium, magnesium, phosphate, and chlorine contents show variation within different sites. The study indicates that the water at present do not possess any pollution problem for the ecosystem.

Keywords— Physicochemical parameters, Quality of groundwater, Water quality standards.

I. INTRODUCTION

Nature and mankind's forms an inseparable part of the life support system. This system has five elements: air, water, land, flora and fauna which are interconnected, inter-related and inter-dependent and have co-evolved and are co-adopted. In recent days ground water is deteriorating at an alarming rate due to increased industrial activity in rural areas of Maharashtra state. The chemical and pharmaceutical industries generally located outside the city area and discharge their effluent on the ground along low lying areas or in river water¹⁹. The ground water can pollute by landfills, septic tank, livestock yards, petroleum tanks, fertilizers and pesticides. The quality of water is a vital concern for mankind since it is directly linked with human welfare. Polluted water is the culprit in all such cases. The major source of water pollution is domestic waste from urban and rural areas and industrial waste which is discharged into natural water bodies.

The health of the community is affected by water that they consume. Rapid increase in population and industrialization together with the lack of wisdom to live in harmony with nature has led to the deterioration of the quality of water, thus resulting in water pollution³. To boost the increase in production of agriculture, huge amounts of artificial feed, pesticides, chemical additives and antibiotics are continuously added.

These compounds with excrements from the farms make the water polluted. Therefore, pollution of water resources needs a serious and immediate attention to understand the importance and control of water quality.

The present study aims at the assessment of water quality in Gadchiroli district of Maharashtra state, India. Water samples were collected from the bore wells and tube wells in and around different areas of Gadchiroli district. Various physical and chemical parameters were determined by using standard methods of APHA (APHA, 1998).

II. MATERIALS AND METHODS

A. Sampling Sites

Ground water samples from different tube wells and bore wells of ten sampling sites of Gadchiroli district are selected randomly. The distance between two sampling sites was kept more than 200 meters. The depths of collected water from bore wells and tube wells were in the range of 20 to 50 feet.

B. Sample Collection

Water samples from the selected sites were collected in a good quality polyethylene bottle of one-litre capacity during the period (2011 to 2013) and analyzed on the same day. The samples after collection were immediately kept in dark boxes and analyzed in the laboratory for various parameters at the earliest. Water samples were separately collected in BOD bottles for DO determination. Manganese (II) sulfate (MnSO_4) solution is added to fix the DO at the collection sites (APHA, 1998).

C. Water Analysis

The present study was carried out for 2011 to 2013. Samples were analyzed in the laboratory by using standard methods of analysis (APHA, 1998). High purity chemicals and double distilled water were used for preparing solutions for analysis. Various physical parameters like EC, and TDS were determined within two hours with the help of a Conductivity meter in the laboratory. The water temperature and pH were measured at the place of sampling sites using standard mercury thermometer and microprocessor based pocket pH meter. Ca^{2+} , Mg^{2+} , Cl^- , CO_3^{2-} , HCO_3^- and SO_4^{2-} were determined by volumetric titration methods; while Na^+ and K^+ by Flame photometry as recommended by APHA. The respective values for all these parameters are reported in

Table 1. All results are compared with standard limit recommended by the ISI, WHO and ICMR (Table 2). All parameters are studied in the laboratory within a one day after collection of samples. The results of analysis were expressed as mg/L except temperature and conductivity measured as °C and miliamper's (ms) respectively.

III. RESULTS AND DISCUSSION

Table no. 1.1 Water sampling station

No.	Station and Location	Discription	Longitude	Latitude
G ₁	Dug well, Desaiganj	Residential area	81.493093	20.271907
G ₂	Dug well, kurkheda	Residential area	80.2075969	20.6205753
G ₃	Tube well, korchi	Residential area	80.3575	20.6205753
G ₄	Dug well, Gadchiroli	Residential area	79.9989795	20.1836482
G ₅	Tube well, Aheri	Residential area	79.47541	20.01837
G ₆	Dug well, chamorshi	Residential area	80.15795	19.9033
G ₇	Dug well, Lakhandur	Residential area	79.884957	20.7501233
G ₈	Dug well, Bramhapuri	Residential area	79.8536471	20.6179116
G ₉	Dug well, Armori	Residential area	79.9753451	20.4713966
G ₁₀	Dug well, Sironcha	Residential area	79.09955	19.94197

Table 1.2 the drinking water standard of various organizations

Parameter	USPHS	ICMR		WHO		ISI(MP L)
		HDL	MPL	HD L	MPL	
pH	6.0-8.5	6.5-9.2	7.0-8.5	7.0-8.5	6.5-9.2	6.5-8.5
Turbidity JTU	-	25JTU	5JTU	-	-	10 NTU
TDS mg/l	500	1500-3000	500	-	-	500
Hardness mg/l	-	600	300	200	600	300
BOD mg/l	5.0	-	-	5.0	5.0	-
COD mg/l	4.0	-	-	-	-	-
DO mg/l	4.0-6.0	-	--	-	-	-
Electric Conductivity	300 µmho/cm					
Chloride mg/l	250	1000	200	200	400	250
Sulphate mg/l	250	400	200	200	400	150
Iron mg/l	0.3	1.0	0.1			0.3
Lead mg/l		0.05				0.10
Zinc mg/l	5.5	0.1	5.0	-	-	5.0
Magnesium mg/l	30	-	50	50	150	30
Calcium mg/l	100	200	75	75	200	75
Nitrate mg/l	10	100	25	45	45	45

Analyzed physico-chemical parameters of water sample
 Table 1.3. Analyzed physico-chemical parameters of the Dug well of Desaiganj

Parameters	2011-2012			2012-2013		
	Winter	Summer	Rainy	Winter	Summer	Rainy
Temperature	17.9	38.5	28	18.2	40	28.5
Ph	7.36	7.5	7.2	7.2	7.8	7.2
Turbidity	3.8	3.5	4.6	3.9	3.2	4.6
TDS	287	392	274	296	405	298
BOD	3.5	3.8	3.2	3.7	4.0	3.3
DO	6.2	6.8	5.6	6.4	6.9	5.8
Total Alkalinity	98	104	96	98	106	94
E C	654	679	615	666	694	616
Magnesium	27	34	23	30	38	24
Calcium	35	42	33	37	44	34
Sulphate	168	195	149	170	200	153
Chloride	29.5	35.2	26.0	28.2	37.6	27.3
Lead	0.003	0.0032	0.002	0.003	0.0034	0.0021
Zinc	0.007	0.0082	0.006	0.0078	0.0085	0.0064
Hardness	104	117	97	108	119	101
Nitrat	5.6	6.7	5.0	7.8	9.0	6.8
Iron	0.4	0.6	0.3	0.43	0.7	0.4
Fluoride	0.2	1.1	0.21	0.28	1.09	0.24

Table 1.4 Analyzed physico-chemical parameters of the Dug well of Kurkheda

Parameters	2011-2012			2012-2013		
	Winter	Summer	Rainy	Winter	Summer	Rainy
Temperature	17.9	37.7	27.8	18.0	40.2	28.9
pH	6.6	6.8	6.3	6.7	6.9	6.2
Turbidity	3.6	3.5	3.9	3.7	3.5	4.2
TDS	254	317	234	266	325	237
BOD	3.6	3.9	3.4	3.8	4.0	3.5
DO	6.2	6.9	5.4	6.6	6.8	5.4
Total Alkalinity	97	106	94	99	106	93
E C	461	499	454	463	517	447
Magnesium	16	22	13	19	26	14
Calcium	37	47	33	38	55	35
Sulphate	97	121	77	107	123	82
Chloride	29.9	33.1	27.2	25.9	35.1	29.4
Lead	0.0034	0.0025	0.002	0.0027	0.0031	0.0026
Zinc	0.008	0.0091	0.0075	0.0084	0.0095	0.0078
Hardness	158	172	132	164	176	145
Nitrate	5.7	6.6	5.2	7.6	8.5	7.0
Iron	0.0039	0.0058	0.0030	0.0046	0.0072	0.0035
Fluoride	1.1	1.3	1.0	1.21	1.29	1.20

Table 1.5 Analyzed physico-chemical parameters of the Tube well of Korchi

Parameters	2011-2012			2012-2013		
	Winter	Summer	Rainy	Winter	Summer	Rainy
Temperature	17.9	38	28	17.8	39	28.3
pH	6.3	6.5	6.2	6.4	6.6	6.2
Turbidity	3.3	3.9	3.5	3.4	4.1	3.6
TDS	290	319	264	292	325	266
BOD	0.9	1.2	0.7	1.3	1.4	0.9
DO	5.8	6.3	5.5	5.9	6.7	5.6
Total Alkalinity	109	113	100	111	123	108
E C	562	572	545	564	574	167
Magnesium	51	57	49	53	60	52
Calcium	63	76	58	65	80	60
Sulphate	89	109	73	98	113	79
Chloride	32	36.6	28	31.5	36.6	29
Lead	0.0023	0.0029	0.0021	0.0024	0.0030	0.0020
Zinc	0.0055	0.0072	0.0040	0.0058	0.0076	0.0048
Hardness	159	174	131	166	180	137
Nitrate	5.6	6.3	5.2	5.8	6.5	5.4
Iron	0.53	0.64	0.49	0.57	0.69	0.51
Fluoride	0.82	1.08	0.90	0.90	1.06	0.91

Table 1.6 Analyzed physico-chemical parameters of the Tube well of Gadchiroli

Parameters	2011-2012			2012-2013		
	Winter	Summer	Rainy	Winter	Summer	Rainy
Temperature	18.2	38.5	28	18	40	28.5
pH	7.36	7.5	7.22	7.25	7.8	7.20
Turbidity	3.8	3.5	4.6	3.9	3.2	4.6
TDS	219	248	209	226	252	213
BOD	3.5	3.8	3.2	3.7	4.0	3.3
DO	6.2	6.8	5.6	6.4	6.9	5.8
Total Alkalinity	98	104	96	98	106	94
E C	794	879	766	817	884	769
Magnesium	27	38	21	28	40	24
Calcium	35	52	33	37	54	34
Sulphate	98	125	89	100	134	90
Chloride	229	225	235	230	2258	237
Lead	0.0021	0.0030	0.0018	0.0023	0.0032	0.0019
Zinc	0.0074	0.009	0.006	0.0076	0.01	0.0068
Hardness	156	178	152	157	180	154
Nitrate	5.7	6.2	5.4	5.8	6.5	5.5
Iron	0.4	0.6	0.3	0.43	0.7	0.4
Fluoride	1.2	1.4	1.0	1.2	1.39	1.1

Table 1.7 Analyzed physico-chemical parameters of the Tube well of Aheri

Parameters	2011-2012			2012-2013		
	Winter	Summer	Rainy	Winter	Summer	Rainy
Temperature	17.6	36	27	17.7	37	27
pH	7.3	7.6	7.4	7.2	7.8	7.5
Turbidity	3.8	3.5	4.6	3.9	3.2	4.6
TDS	191	206	187	195	211	189
BOD	2.8	3.6	2.4	2.7	3.4	2.3
DO	5.6	6.2	5.3	5.4	6.0	5.1
Total Alkalinity	100	107	98	102	109	99
E C	656	766	628	657	769	639
Magnesium	12	18	09	14	20	11
Calcium	18	26	15	21	28	17
Sulphate	138	145	132	140	152	135
Chloride	218	232	206	228	236	212
Lead	0.0017	0.0023	0.0014	0.0019	0.0025	0.0017
Zinc	0.037	0.050	0.026	0.041	0.060	0.028
Hardness	143	152	139	147	156	141
Nitrate	4.6	5.3	4.3	4.8	5.7	4.5
Iron	0.034	0.046	0.032	0.035	0.047	0.034
Fluoride	1.0	1.2	0.9	1.02	1.23	0.9

Table 1.8 Analyzed physico-chemical parameters of the Dug well of Lakhandur

Parameters	2011-2012			2012-2013		
	Winter	Summer	Rainy	Winter	Summer	Rainy
Temperature	18	38	27	17.8	38.8	27
pH	7.3	7.6	7.3	7.4	7.7	7.3
Turbidity	4.0	4.5	4.4	4.2	4.7	4.5
TDS	174	192	169	179	196	171
BOD	3.9	4.7	3.4	4.3	5.0	3.7
DO	6.0	6.6	5.7	6.2	6.7	5.6
Total Alkalinity	101	114	97	102	116	99
E C	256	271	239	258	276	241
Magnesium	25	34	22	27	37	23
Calcium	32	41	30	34	42	32
Sulphate	188	192	185	190	196	186
Chloride	27.9	36.2	29.0	28.3	37.6	30.3
Lead	0.0028	0.0031	0.0026	0.0029	0.0034	0.0027
Zinc	0.0066	0.0092	0.0062	0.0068	0.010	0.0063
Hardness	159	174	155	161	177	157
Nitrate	5.7	6.3	5.2	6.2	7.0	6.0
Iron	0.41	0.62	0.39	0.43	0.67	0.40
Fluoride	1.0	1.4	0.9	1.1	1.39	1.0

Table 1.9 Analyzed physico-chemical parameters of the Dug well of Bramhapuri

Parameters	2011-2012			2012-2013		
	Winter	Summer	Rainy	Winter	Summer	Rainy
Temperature	17.8	39	27	17.9	39.4	27
pH	7.4	7.6	7.3	7.5	7.7	7.4
Turbidity	4.2	4.7	4.5	4.3	4.9	4.6
TDS	169	178	156	170	182	159
BOD	1.4	2.9	1.2	1.6	3.3	1.5
DO	6.2	6.9	5.9	6.4	7.3	6.1
Total Alkalinity	104	118	100	106	120	99
E C	460	475	455	463	479	456
Magnesium	33	40	30	35	48	31
Calcium	42	53	39	45	57	40
Sulphate	185	190	181	189	196	184
Chloride	229	235	211	230	239	213
Lead	0.0024	0.0029	0.0021	0.0026	0.0034	0.0022
Zinc	0.0055	0.0069	0.0052	0.0060	0.0075	0.0056
Hardness	165	188	157	169	191	161
Nitrate	5.7	6.4	5.2	6.5	7.9	6.1
Iron	0.044	0.067	0.041	0.046	0.077	0.043
Fluoride	1.02	1.29	0.93	1.1	1.3	1.0

Table 1.11 Analyzed physico-chemical parameters of the Dug well of Sironcha

Parameters	2011-2012			2012-2013		
	Winter	Summer	Rainy	Winter	Summer	Rainy
Temperature	15.4	35	26.1	15.2	36.4	26.4
pH	5.5	6.0	5.3	5.6	6.1	5.2
Turbidity	2.3	3.5	3.6	2.9	3.7	3.9
TDS	267	301	219	276	306	224
BOD	3.4	3.9	3.6	3.7	4.0	3.9
DO	7.3	7.9	6.7	7.5	8.4	6.9
Total Alkalinity	96	113	101	100	119	106
E C	347	363	324	348	367	334
Magnesium	36	48	35	37	49	34
Calcium	47	65	38	49	71	42
Sulphate	137	157	145	140	160	143
Chloride	28.9	31	31.2	29.2	31.9	32.1
Lead	0.0012	0.0019	0.0014	0.013	0.0026	0.0015
Zinc	0.0053	0.012	0.0069	0.0068	0.015	0.0079
Hardness	32	59	27	39	60	30
Nitrate	6.3	7.4	6.1	6.4	7.8	6.2
Iron	0.36	0.57	0.31	0.41	0.76	0.40
Fluoride	0.9	1.0	0.82	1.0	1.09	0.98

Table 1.10 Analyzed physico-chemical parameters of the Dug well of chamorshi

Parameters	2011-2012			2012-2013		
	Winter	Summer	Rainy	Winter	Summer	Rainy
Temperature	16.2	36.2	26	15.7	36.4	26.4
Ph	5.9	6.3	5.6	6.1	6.4	5.5
Turbidity	2.8	3.6	3.4	2.9	3.8	3.5
TDS	212	228	209	217	231	211
BOD	3.3	3.7	3.2	3.4	3.9	3.3
DO	7.5	8.8	6.6	7.8	9.0	6.9
Total Alkalinity	98	117	85	110	119	87
E C	239	251	214	242	256	218
Magnesium	26	33	23	28	35	24
Calcium	36	41	32	38	44	35
Sulphate	139	150	142	140	153	144
Chloride	28	31	29	29.2	33	30.4
Lead	0.0021	0.0025	0.0019	0.0020	0.0027	0.0018
Zinc	0.0038	0.009	0.0057	0.0044	0.0094	0.0062
Hardness	128	140	131	129	148	132
Nitrate	5.0	5.9	4.9	5.3	6.2	5.0
Iron	0.26	0.40	0.28	0.30	0.45	0.32
Fluoride	0.9	1.01	0.86	0.91	1.2	1.0

Table 1.12 Analyzed physico-chemical parameters of the Dug well of Armori

Parameters	2011-2012			2012-2013		
	Winter	Summer	Rainy	Winter	Summer	Rainy
Temperature	17.8	39.2	27	18	41	28.5
pH	6.6	6.7	6.4	6.5	6.9	6.5
Turbidity	4.7	5.3	5.9	4.9	5.4	6.3
TDS	220	319	204	216	310	208
BOD	3.8	4.2	3.1	3.3	4.1	3.5
DO	5.9	6.3	5.7	6.1	6.4	5.9
Total Alkalinity	128	138	123	134	148	121
E C	265	288	251	272	296	267
Magnesium	16	24	13	18	29	14
Calcium	37	43	39	38	46	37
Sulphate	90	98	89	91	100	88
Chloride	36.1	42.7	39.6	37.3	49.8	38.9
Lead	0.0026	0.0031	0.0024	0.0031	0.0040	0.0020
Zinc	0.0097	0.012	0.0086	0.0099	0.010	0.0089
Hardness	239	289	188	259	290	225
Nitrate	6.8	8.7	6.9	7.0	8.8	7.4
Iron	0.0032	0.0044	0.0026	0.0039	0.0047	0.0028
Fluoride	0.9	1.22	0.8	1.0	1.27	0.91

Results of analyses of various physico-chemical parameters of water. Water temperature of sampling site ranged from a low of 15.2°C in Winter session to a high of 41°C in Summer session throughout the period of study. A minor variation of temperature was recorded in all the sites, pH value of aquaculture ponds were ranged between 5.2 to 7.8 during the study period. There was a marginal variation of pH observed in all the sites during the period of investigation. pH did not change much among sites. Conductivity values of ground water at ten different sites varied greatly during these investigation period.

The conductivity was found maximum in the Summer session i.e. 884 ($\mu\text{mho/cm}$) and minimum in the rainy session i.e. 214 ($\mu\text{mho/cm}$), where as the permissible limit is 300 $\mu\text{mho/cm}$ prescribed by USPHS. Almost all the groundwater samples exceeded the permissible limit except Armori, Chamorshi and Lakhandur. Oxygen deficiency was never noticed in the samples. DO content was ranged from 5.0 – 9.0 mg/l in the study area in all the season during the study period, where as the prescribed limit for DO by WHO is 5.0 mg/l. Based on present investigation, Hardness varied from 53 to 330 mg/l. However the permissible limit of Hardness for drinking water is 300 mg/l (ISI and ICMR). Classification of groundwater on the basis of Total Hardness,

Total Hardness Range	Description	No of Samples
0 – 0-60	Soft	06
61 61– 120	Moderately hard	06
121 121-180	Hard	40
>18>180	Very hard	08

The concentration of Calcium and Magnesium varied from 17 to 80 mg/l and 9.0 to 60.0 mg/l respectively. All the samples were within the permissible limit i.e. 75 mg/l for Calcium and 50 mg/l for Magnesium (ICMR) in all seasons. Turbidity ranged It varied from 0.7 to 5.0 mg/l during the study period. Turbidity was found within the prescribed limit in all the water samples. In the study area TDS varied from 156 to 405 mg/l. As prescribed limit of TDS for drinking water is 500 mg/l, all the water samples have TDS concentration well below the prescribed limit.

The low BOD value in all groundwater samples showed good sanitary condition of the water. It varied from 0.7 to 5.0 mg/l during the study period where as the permissible limit for BOD is 5 mg/l prescribed by WHO. Chloride and Total Salinity concentration at or below the drinking water standards are normally specified for waters used to irrigate salt sensitive crops. However, in the study area there is no significant change in Chloride concentration and it ranged from 25.9 to 239 mg/l. Chloride which have been associated with pollution as an index are found below the permissible value set at 250 mg/l in most of the study area. The concentration of Sulphate ranged between 73 mg/l to 200 mg/l in the groundwater. In the present study Phenolphthalein alkalinity was absent in all samples and Methyl Orange alkalinity was ranged from 85 mg/l to 148 mg/, this indicates the absence of Hydroxyl and Carbonate alkalinity and presence of Bicarbonate of the study area. However the prescribed limit for Total alkalinity is 120 mg/l (USPHS). The value of Total alkalinity exceeded the limit in the water samples of Armori. In all samples, the Fluoride is very less

i.e. from 0.2 to 1.39 mg/l. Enquiries with dental practitioners in the Gadchiroli district also testify that there are no cases of fluorosis of teeth reported from the patients.

The iron concentration of the study area varies from 0.0026 mg/l to 0.76 mg/l. Iron was relatively high in case of Sironcha, Chamorshi, Lakhandur, Gadchiroli, Korchi, Desaijanj exceeds the permissible limit. The concentration of Zinc as obtained from the analysis of water sample collected varied from 0.0038 mg/l to 0.06 mg/l. Since the desired level of Zinc is 5.0 mg/l (Prescribed by ISI), none of the samples has exceeded the limiting value. The concentration of Lead varied from 0.0012 to 0.0040 mg/l. the maximum permissible limit for Lead as prescribed by WHO and ISI is 0.1 mg/l. Nitrate – Nitrogen ranges from 4.3 mg/l to 9 mg/l where as the permissible limit for Nitrate – Nitrogen is 45 mg/l.

The results of the analyzed parameters of groundwater and surface water of the different locations of in and around Gadchiroli District are compared with the related standards for drinking water prescribed by ISI, USPHS, ICMR and WHO. The drinking water standard of various organizations is given in table 4.22.

CONCLUSION

Groundwater quality in and around Gadchiroli district area has been analyzed in the present work. It is observed that about Iron was relatively high in case of Sironcha, Chamorshi, Lakhandur, Gadchiroli, Korchi, Desaijanj exceeds the permissible limit. The conductivity was almost all the groundwater samples exceeded the permissible limit except Armori, Chamorshi and Lakhandur. The value of Total Alkalinity exceeded the limit in the water samples of Armori. Prescribed by ISI (1991), ICMR (1975) and WHO (2006).

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