Assessment of Water Pollution in Tipparthi Revenue Sub-Division, Nalgonda (District), Andhra Pradesh, India

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Abstract: A systematic study has been carried out to explore the physicochemical characteristics of drinking water sources of Tipparthi revenue sub-division, Nalgonda (District), Andhra Pradesh, India. Totally 49 water samples were collected from the different locations (22 villages) of the study area including bore well, open well and hand pump water and analyzed for pH, EC, TDS, turbidity, total hardness, fluoride, chloride, nitrate, nitrite, sulphate, phosphates, calcium, magnesium, sodium, potassium, Iron and dissolved oxygen. On an average, in almost all the samples, one or the other chemical constituent was beyond the permissible limits it was also concluded that water sources in the study area not fit for potability. Sodium absorption ratio (SAR) and water quality (WQI) studies indicate water available from all sources not fit for irrigation also. The study indicates the need for periodic monitoring of ground water in the study area.

Key words: Water quality, Physicochemical analysis, Water quality index, SAR

Introduction

Water is one of the essential components for the sustenance of life on earth. Among the various sources of water, ground water is said to be the safest water for drinking and domestic purposes. The quality of ground water is influenced by the nature of the sub surfaces as well as the environment where recharge takes place. Water used for industries, agricultural and human needs adds continuously contaminants to the ground water. It is reported that two third of all illness in India are related to water born diseases¹⁻².

Tipparthi revenue sub-division located in Nalgonda district, Andhra Pradesh, and the district was well known for endemic fluorosis³. From the literature it was confirmed that no body could study entire physicochemical analysis of all drinking water sources in this particular area⁴. So, in the light of the above, an attempt has been made to study the quality of drinking water from bore well (BW), hand pump (HP) and open well (OW) in and around Tipparthi revenue sub- division.

Geology of the study area

The study area is located approximately 120 km away from the capital of Andhra Pradesh. Tipparthy division falls in the survey of India, toposheet No.56 P/10. The area lies between 16° 40' 30" and 16° 45' 30" latitudes and bounded by 79° 31' 00" and 79° 40' 00" longitudes. It is about 45 km south east of Nalgonda district head quarters of Andhra Pradesh. This area forms part of the past palnad basin and it is contact zone between quartzites of bangnapalli and limestones of narji series of Kurnool formations. The soils of the catchment area can be broadly divided into 5 groups, namely medium block soil (12.0%), deep block soil (29.0%), mixed red and black soil (35.0%), red sandy soil (20.0%) and red loamy soil (4.0%). As per census of 2001 the population of the revenue sub division has been recorded as 46,451.

A water quality index⁵ (WQI) is common with many other indices system transforms a group of water quality parameters to a common scale and combines them to form single number in accordance with a chosen method or model computation. The main objective of the WQI system is to use it as a preliminary means of assessing a water body for compliance with the standards adopted for designated classes of beneficial uses. A WQI is defined as the composite influence of different water quality parameters in the quantity of water⁶.

Experimental

Water samples have been collected manually from all existing sources of drinking water in the study and for the present investigation separate sets of samples were collected for chemical analysis from the source. The bottles for sample collection have been thoroughly cleaned by rinsing with 8 M HNO₃, followed by repeated washing with double distilled water and they are further rinsed with sample water before collection. Physicochemical analysis was done by standard procedure⁷. The results were compared with WHO⁸, USEPA⁹ standards.

Mathematical modeling

Mathematical modeling¹⁰⁻¹¹ offers more attractive studies, though it deviates much from real situations. The statistical parameters mean, minimum (min), maximum (max), sum and standard deviation (SD) were computed by using the experimental data.

Water quality index

WQI has been derived using the following formula:

$$WQI = (Q_i W_i / W_i)$$

Where Q_i is the quality rating/sub index

The ground water quality rating was calculated by applying the formula:

$$Q_i = (M_i - L_i) / (S_i - L_i) \times 100$$

Where M_i is the estimated value of the i^{th} parameter in the laboratory, L_i is the ideal value of the i^{th} parameter and S_i is the standard values of the i^{th} parameter. W_i is the unit weight, which was calculated by the following formula: $W_i = K / S_i$

Where K (constant of proportionality) = $(1 / S_1 + 1 / S_2 + \dots + 1 / S_n)$

S_n is the standard values for different water quality parameters.

Sodium absorption ratio (SAR) studies⁶

SAR and %Na were calculated from following method listed in Richard¹² as follows:

$$SAR = Na^+ / [(Ca^{2+} + Mg^{2+})/2]^{0.5}$$

$$\% Na = [(Na^+ + K^+) / (Ca^{2+} + Mg^{2+} + Na^+ + K^+)] \times 100$$

Results and Discussion

The findings of present investigation are summarized in Tables 1-3 were also made with WHO and USEPA drinking water standards. In the following text three types of waters are discussed in the order of BW, HP and OW respectively.

Table 1. Physicochemical analysis of hand pump water

S.No	Name of the Village	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17
1	Keshiraj pally	7.71	968	563	6	300	2.98	149	0	1	41	0.2	60	60	216	8	1	4
2	A Duppalapally	7.22	2737	1597	0	770	3.02	660	2	3	5	0.4	200	108	199	0	1	7
3	Pathapalle	7.48	1035	1264	2	390	3.01	149	0	3	32	0.4	84	72	208	6	1	2
4	Kankanalapaly	7.35	2300	1340	2	370	2.85	99	1	1	8	0.06	52	96	186	4	0	4
5	Thanedaripally	8.15	3464	2043	2	120	2.82	57	1	1	5	0.15	32	16	246	6	0	8
6	Peddasuraram	7.68	1264	1565	4	126	2.68	71	0	1	6	0.46	32	89	210	5	0	9
7	Chinnasuraram	7.96	2538	1433	2	770	2.09	511	0	2	78	0.38	144	164	148	14	0	3
8	choullagudem	8.43	1286	726	5	350	2.94	213	0	2	12	0.48	52	88	242	2	0	2
9	Pajjur	8.55	1010	576	2	222	1.86	240	2	4	5	0.28	42	96	246	5	0	6
10	Anthagudem	8.02	1267	2656	3	670	1.57	341	1	3	15	0.33	56	212	38	1	1	6
11	Yarragaddala gudem	7.71	1360	784	5	1200	2.69	240	0	0	6	0.37	86	98	147	1	2	3
12	Gaddikodaram	8.15	1357	397	3	1542	2.54	168	0	0	41	0.01	12	123	234	1	1	6
13	Indlur	7.77	6887	3990	6	2240	2.32	334	0	4	82	0.06	329	569	202	6	1	6
14	Gollagudem	7.63	2000	1164	5	850	2.87	355	0	1	28	0.94	108	232	286	18	2	8
15	Mamidala	8.04	2217	1280	3	710	2.65	199	2	1	34	0.24	72	212	184	6	1	8
16	Alligudem	7.83	772	424	2	320	2.36	114	0	2	14	0.12	32	96	248	32	0	2
17	Godorigudem	7.75	1229	699	1	390	2.76	121	0	2	15	0.15	64	92	263	2	0	2
18	Yallammagudem	7.24	1354	1231	2	333	2.34	547	3	4	21	0.26	23	123	235	5	1	3
19	Pavirala gudem	7.34	687	1313	3	1233	2.64	264	1	1	7	0.34	65	24	146	2	1	8
	Sum	148.01	35733	25045	58	12906	48.99	4831	15	41	455	5.63	1548	2574	3884	124	13	97
	Min	7.22	687	397	0	120	1.57	57	0	0	5	0.01	12	16	38	0	0	2
	Max	8.55	6887	3990	6	2240	3.02	660	3	4	82	0.94	329	569	286	32	2	9
	Mean	7.79	1881	1318	3	679	2.58	254	1	2	24	0.3	81	135	204	7	1	5
	SD	0.38	1421	864	2	548	0.4	168	1	1	23	0.21	75	120	56	8	1	2

Table 2. Physicochemical analysis of bore well water

S.No	Name of the Village	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17
1	Pathapalle	7.26	1003	1226	1	570	2.18	213	0.34	1.32	52	0.07	108.2	120.24	160	8	0.42	16
21	Kankanalapaly	7.47	1194	692	3	330	2.3	113	0.16	1.72	20	0.24	68.1	64.12	200	14	0.68	15.9
22	Thanedaripally	7.21	1005	1465	5	370	3.24	213	1.64	2.01	18	0.34	136.2	12.024	222	1	1.02	13.3
23	Peddasuraram	7.19	856	1648	2	570	4.5	269	1.05	3.17	7	0.1	124.2	104.2	198	4	0.42	17.3
24	Chinnasuraram	7.32	956	1355	4	580	4.24	284	0.67	4.21	28	0.42	164.3	68.13	238	20	1.22	17.8

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25	choullagudem	7.26	998	133	8	256	3.02	106	0.12	1.14	10	0.4	30.1	80.26	93	0	1.64	15.6
26	Pajjur	7.94	2992	2322	1	330	2.97	84	0.16	2.02	7	0.24	34.5	86.32	216	2	0.13	19.2
27	Anthaigudem	7.97	2292	1318	6	661	3.02	186	0.8	4.21	32	0.03	54.2	100.23	226	3	0.61	21.5
28	Yarragaddala gudem	7.46	1346	313.6	1	420	1.42	163	0.5	4.02	28	0.08	72.1	96.19	228	6	0.24	18.4
29	Kothagudem	7.6	942	528	3	540	1.86	191	1.8	4.21	44	0.59	84.1	132.26	212	7	0.61	18.4
30	Dacharam	8.28	670.2	370.6	0.8	1233	2.64	400	0.12	0.42	12	0.25	32.3	68.34	268	6	2.88	13.9
31	Madgulapally	7.58	976	556.5	1	1223	2.09	412	0.9	2.02	34	0.34	22.3	96.35	148	8	0.9	15.6
32	Vodderigudem	7.55	6600	3890	8	2210	3.42	1008	0.3	2.02	61	0.14	328.6	557.11	146	12	2.56	19.2
33	Indugala	7.96	735.1	1220	1	470	3.08	92.3	0.5	2.21	23	0.08	72.14	116.23	210	0	0.02	19.4
34	Aregudem	7.46	986	1316	3	650	3.62	281.3	1.23	2.02	4	0.12	52.03	63.02	286	6	0.32	17.8
35	Velmagudem	7.86	1264	1245	2	323	3.26	62.3	1.1	2.42	5	0.12	50.2	102.02	231	2	0.32	16.1
	Sum	121.37	24815	19599	49.8	10736	46.86	4081	11.39	39.14	385	3.62	1434	1867	3282	99	13.99	275.4
	Min	7.2	670	133	0.8	256	1.4	62.3	0.1	0.4	4	0	22.3	12	93	0	0	13.3
	Max	8.3	6600	3890	8	2210	4.5	1008.2	1.8	4.2	61	0.6	328.7	557.1	286	20	2.9	21.5
	Mean	7.6	1551	1225	3.1	671	2.9	255.1	0.7	2.4	24.1	0.2	89.6	116.7	205.1	6.2	0.9	17.2
	S.D	0.3	1474	914.5	2.5	500.4	0.8	226.6	0.5	1.2	17.3	0.2	75.8	120.9	48.4	5.5	0.8	2.2

Table 3. Physicochemical analysis of open well water

S. No	Name of the Village	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17
36	Pajjur	7.26	1527	876	6	380	2.97	220.1	0.56	1.12	42	0.54	36	116	195	2	1.1	6.1
37	Bandavarigudem	7.98	700	331	2	196	1.68	62.48	0	1.7	17	0.1	56	19	69	3	0.4	6.35
38	Gangannapalem	7.36	358	311	5	176	2.6	53.96	1.2	2.7	26	0.02	46	18	43	3	0.2	3.3
39	Indlur	7.68	5226	3060	6	1720	2.44	139.64	0.31	0.82	48	0.042	649	68	24	1	0.14	7.6
40	Marrigudem	7.56	1195	575	3	340	3.02	90.88	0.03	1.2	41	0.08	116	21	100	4	0	2.2
41	Rajupet	7.74	784	372	1	212	1.06	76.68	0.002	0.02	28	0	51	16	63	7	0.2	5.02
42	Malaprajgudem	8.01	1112	534	5	152	1.08	156.2	0.1	0.01	17	0.04	49	13	88	6	0.01	6.2
43	Gavvavarigudem	7.73	1203	579	6	272	1.14	139.16	0.05	0.2	40	0.05	89	16	105	8	0	4.2
	Sum	61.32	12105	6638	34	3448	15.99	939.1	2.25	7.77	259	0.87	1092	287	687	34	2.05	40.97
	Min	7.26	358	311	1	152	1.06	53.96	0	0.01	17	0	36.07	13	24	1	0	2.2
	Max	8.01	5226	3060	6	1720	3.02	220.1	1.2	2.7	48	0.54	649	116	195	8	1.1	7.6
	Mean	7.67	1513	829	4	431	2	117.39	0.28	0.97	32.3	0.11	136	35	85	4.25	0.26	5.12
	SD	0.27	1543	919	1	526.95	0.85	56.6	0.42	0.93	11.9	0.18	208	37	52	2.49	0.37	1.79

*P1- pH, P2 - EC, P3 - TDS, P4 - Turbidity, P5 - TH, P6 - F⁻, P7 - Cl⁻, P8 - NO²⁻, P9 - NO³⁻, P10 - SO₄²⁻, P11 - PO₄³⁻, P12 - Ca²⁺,

P13 - Mg²⁺, P14 - Na⁺, P15 - K⁺, P16 - Fe²⁺, P17 - DO

The pH values vary from 7.20 to 8.30, from 7.22 to 8.55 and from 7.26 to 8.36 in the samples from BW, HP and OW respectively. The higher electrical conductivity (EC) values in samples 26, 27, 32 of bore wells water and in samples 2, 4, 5, 7, 13 of hand pump water and sample 39 of open well water clearly indicate that water is unfit for human consumption. Total dissolved solids (TDS) have varied from 133 to 3890 mg/L, from 396 to 3990 mg/L and from 311 to 3060 mg/L in all three BW, HP and OW sources of drinking water. The results of total dissolved solids indicate that many samples of water from bore wells and hand pump contain high dissolved solids compared with that of open well water. Turbidity gives the water a cloudy appearance or shows up as dirty sediment. It was clearly indicates all the samples collected from study area were with in the permissible limit. Total hardness (TH) is the aesthetic objective is set at a maximum of 800 mg/L.

In the study area, the total hardness of water from all the groundwater resources range between 256 to 2210, 120 to 2240 and 60 to 730.8 as CaCO_3 of samples from BW, HP and OW respectively. The main source of fluoride and their concentrations in water is geological sources¹³⁻¹⁴. A colorless and odorless natural pollutant fluoride (F^-) comes into contact with groundwater from its source of origin, the rock minerals. The maximum permissible limit in drinking water is 1.5 mg/L⁸⁻¹⁵. The concentration of fluoride ion in water samples has been analyzed by SPADNS technique⁷. The concentration of fluoride in all samples of study area has varied from 1.4 to 4.5 mg/L, 1.57 to 3.02 mg/L and 1.06 to 3.02 mg/L of BW, HP and OW respectively. From the analytical study, 14 water samples from bore well, 19 from hand pump, 5 samples from open well water was falling in the range of 1.5 to 4.50 mg/L concentration of fluoride ion, but only 1 from bore well, 3 from open well water samples are within the permissible limit. The USEPA drinking water regulations recommended a maximum concentration of chloride (Cl^-) ions is 250 mg/L. High chloride contents were observed in samples 23,24,30,31,32 and 34 of bore well water and in sample 2,7,10,11,13,14,18 and 19 of hand pump water. The higher concentration is usually indicative of polluted nature of water. The USEPA maximum contamination limit for nitrate is 10 mg/L and for nitrite is 1.0 mg/L. Concentration of nitrate above 4 mg/L can cause methamaglobinemia (blue - baby disease) in children¹⁶. The concentrations of nitrate in all the samples in the study area are ranges from 0.4 to 4.2 mg/L, 0.42 to 4.21 mg/L and 0.01 to 2.7 mg/L in all the three BW, HP and OW sources respectively. The results indicate that the nitrate concentration is within the permissible limit in all water samples. The concentrations of nitrite (NO_2^-) in the study area are fall under the range of 0.1 to 1.8 mg/L, 0.08 to 3.1 mg/L and 0.0 to 1.2 mg/L. The sulphate (SO_4^{2-}) contents in three sources have varied from 4 to 61 mg/L, 5 to 82 mg/L and 17 to 48 mg/L respectively and values are within the permissible limit (250 mg/L). Phosphate (PO_4^{3-}) values are also within the permissible limit.

The concentration of calcium (Ca^{2+}) has varied from 22.3 to 328.7 mg/L, from 12.25 to 328.65 mg/L and 36.07 to 649.29 mg/L. Higher value of calcium may be due to the presence of rock soil in the study area. The concentration of magnesium (Mg^{2+}) is higher in samples of 2, 7, 10, 12, 13, 14, 15 and 18 of hand pump water, 20, 23, 29, 31, 32 and 35 of bore well water and 36 & 39 of open well water. This higher value of magnesium may be from leaching of rocks. The concentration of sodium (Na^+) ranges from 93.0 to 280.0 mg/L in bore well, 38 to 286.0 mg/L in hand pumps and 24 to 195.0 mg/L in open well water respectively. The concentration of potassium (K^+) ranges from 0 to 20.0 mg/L in bore wells, 0.00 to 32.00 mg/L in hand pumps and from 0.0 to 10.00 mg/L in open wells water respectively in the study area. Its concentration however is usually quite lower than that of sodium, calcium and magnesium.

In the present study iron (Fe^{2+}) has varied from 0.0 to 2.9 mg/L, from 0.04 to 2.4 mg/L and from 0.0 to 1.1 mg/L in all the samples. From the results it is concluded that most of the results well bellow the permissible limit⁹. Dissolved oxygen (DO) ranged from 2.20 to 9.20 mg/L, 2.5 to 9.5 mg/L and 2.2 to 7.60 mg/L in three deferent types of samples.

The sodium absorption ratio was calculated in given water samples, which provide a useful index of the sodium hazard present in soil and crops irrigated with such. A high sodium absorption ratio (2 to 10) indicates little danger for sodium; medium hazard are between 7 and 18; high hazard between 11 and 26 and very high hazard above that. Lower the ionic strength of the solution, the greater sodium hazard for a given SAR⁵. The value of SAR in the ground water samples of the study area ranges from 23.18, 22.93 and 11.96 for HP, BW and OW. It was clearly indicates the ground water of the study area falls under the category of very high hazards. The value of sodium percentage in the ground water sample of the study area ranged from 53.21, 54.5 and 44.61 for three different types of samples. Based on this observations it was not quite safe for irrigation and potability¹².

Prescribed water quality rating for drinking purposes is presented in broadly divided into five categories, excellent (0 to 25), good (26 to 50), poor (51 to 75), very poor (76 to 100) and unfit for drinking water (>100). It is observed that the WQI values for present investigation, hand pump water is 139.9, for bore well water it was 130.6 indicating that Physico chemically water quality rated as 'unfit for drinking' purpose, where as for open well water it was rated as very poor for drinking purpose (90.1).

Statistical analysis

Positive correlation is obtained between EC and TH ($r = 0.99, 0.99, 1.0$), Na^+ and Cl^- ($r = 0.72, 0.60, 0.99$) in hand pump, bore well and open well water samples. This indicates that conductivity depends on the salts of chloride of sodium and potassium. Total hardness showed positive correlations with EC, Cl^- ($r = 0.9$) Mg^{2+} ($r = 0.9$) and Na^+ ($r = 0.6, 0.5, 0.9$) in all three types of samples. This indicates that the hardness of water was contributed mainly by the salts of chlorides of Na^+ , Mg^{2+} and careful examination of results of water from study area reveals that a large number of pairs of parameters have high positive correlations ($r > 0.8$). The significant correlations of EC, TDS with TH, SO_4^{2-} , Ca^{2+} and Mg^{2+} indicate the presence of sulphates of calcium and magnesium. Compared with the other water quality parameters, EC and TDS are easily determinable. Hence on knowing this value exactly, we can calculate the other parameters, which are in good agreement with experimental data. So, this correlation determination provides quick monitoring of the quality of ground water.

Conclusion

The result of this study indicates that the quality of ground water varies from place to place. Higher values of certain parameters at certain bore wells open wells and hand pump water samples are not fit for drinking as such. The water quality index, sodium absorption ratio studies and %Na studies indicates poor quality of water for drinking as well as agricultural purpose. Hence, proper care must be taken to avoid any contamination of ground water and its quality be monitored periodically.

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