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Original Research Paper

An Appraisal of the Groundwater Quality Status of Bangalore South District, Karnataka, India

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ABSTRACT

The study aims to appraise water quality status of some selected areas of Bangalore south district. This has been done by collecting 90 groundwater samples, 30 samples from each of the three selected areas of Bangalore south, and subjecting them to a comprehensive physico-chemical analysis and interpreting the results as per the criteria laid down by the Bureau of Indian Standards for potability. The study indicated that 64.44 % of the water samples tested from the entire study area are nonpotable due the presence in excess of nitrates, total hardness, total dissolved solids and chlorides.

INTRODUCTION

Bangalore is rated as the fastest growing city in the entire South East Asia. This growth has taken toll of the geological resources in the city of which the groundwater is primarily one such important resource. With the surface water supplies being no longer able to satiate the needs of the city, groundwater becomes the only alternate source of good quality water. But it is learnt that there are problems aplenty of groundwater contamination in certain parts of the city, particularly the industrial belts. A good number of industries of different types have been established in the conurbation of Bangalore, which have been loading the environment with ever-increasing levels of pollutants. These pollutants may enter the soil/water and degrade the quality of groundwater. Industrial effluents, if not treated and properly controlled, can pollute groundwaters (Olayinka 2004). The flow of groundwater and pollutants that it may contain is very slow as compared with flow on land surface. As a result, it may take considerable time for the contaminants to move away from the source of pollution and degradation in the groundwater quality may remain undetected for years (Purandara & Varadarajan 2003). Once the groundwater is contaminated, it may remain in an unusable or even hazardous condition for decades or even centuries (Mishra et al. 2005).

Groundwater pollution risk and susceptibility to overexploitation can be assessed and protection measures prioritized and initiated. There is an urgent need for rapid surveys of groundwater utilization, aquifer pollution vulnerability and subsurface contaminant load, to be undertaken. Also there is need to study all aspects of pollution of groundwater resources and constantly monitor the levels of pollution for the benefit of users so as to guard them against the hazards of polluted waters. The present work assumes importance in this context.

STUDY AREA

The details of the three areas of Bangalore south, from where the groundwater samples have been collected for quality monitoring, have been presented below as three zones.

Zone I: Bommasandra industrial area: The Bommasandra industrial area lies to the left of Bommasandra village on the Bangalore-Hosur Road at a distance of about 12 kms from the City. It covers an area of about 3.84 sq. km and lies between 12°47' 52" to 12°49' 12" E latitude and 77°4' 20" to 77°42'20" N longitude, and is covered under Survey of India toposheet number 57 H/9. The area has a network of nearly 600 industries over an extent of 3.84 sq km. The drinking water need of the area is met with by about 180 borewells drilled in and around the area.

Zone II: Bommanahalli industrial area: The Bommanahalli City Municipal Corporation (CMC) is a cluster of villages located between Sarjapur road and Kanakapura road. The area covers 43.57 sq. km and has a population of around 3.5 lakh. Lying adjacent to the west of the Bangalore-Hosur road and adjacent to the IT corridor, the area has a number of industries, corporate offices of leading software companies and a few upscale residential layouts. The area has 31 wards, and though 60 borewells are supposed to be functioning in each ward, only five to ten are actually working. Drinking water from the CMC borewells has become a scarcity and there is a thriving private market for water, with the people paying huge amount to private borewell owners to meet their needs. There are several areas where the sewage and drainage have merged and the huge number of industries in the area is blatantly disposing off their untreated/improperly treated effluents, which have been steadily making their way into the already depleted and contaminated groundwaters of the area. There are repeated complaints of children falling sick, at least once a week, due to the consumption of poor quality water.

Zone III: Bellandur: Bellandur is the area to the south of Bangalore covering 23 sq. km and the catchment area comprises of Bellandur, Challaghatta, Yamalur, Agara, Madiwala, Puttenahalli and Yelachenahalli. The area lies between latitude 12°53'30" to 12°56'50" east and longitude 77°34' to 77°41'40" north.

The area comprising of Madiwala, Agara, Koramangala, Challaghatta and Bellandur come under the existing sewerage zone, that is, sewage from Koramangala, Madiwala and Agara all drain into a tank and treated wastewater from Challaghatta treatment plant also drains into this Bellandur tank which extends to about 3.84 km^2. At present there is no catchment for these tanks as the nallas on the upstream side are converted into settlements. Since the tank is dry, they have become a store house for the sewage coming from different parts of the city. The Bangalore Water Supply and Sewerage Board, BWSSB is also conveniently directing the raw sewage through storm water drains into Bellandur tank, and irrigation in the command areas of these tanks is ruled out.

MATERIALS AND METHODS

Thirty water samples from each zone (total 90 samples) were collected from both the borewells and open wells in and around the industrial areas during May 2007 in 2-litre PVC containers, sealed and were analysed for 20 major physico-chemical parameters in the laboratory. The physical parameters such as pH and electrical conductivity were determined in the field at the time of sample collection. The chemical characteristics including metals were determined as per the standard methods (APHA 2002). The results obtained were evaluated in accordance with the standards prescribed under IS: 10500 (BIS 2003).

RESULTS AND DISCUSSION

The results of the physico-chemical analysis of the three zones are presented in Tables 1a, 1b and 1c, while Tables 2 and 3 give some mathematical interpretations of the results. The diagrammatic interpretations of the results are presented in Figs. 1 and 2.

Out of the thirty samples analysed in zone I, 22 samples (73.33%) were found to be nonpotable as per Bureau of Indian Standards. The main causative constituents for the nonpotability of the samples were total hardness and nitrates, which accounted for 63.33% and 60% of unsafe samples respectively, followed by magnesium and calcium, as a result of which 53.33% and 36.67% of the samples were found to be unsafe. Total dissolved solids accounted for 30%, while chlorides and chromium rendered 20% of the water samples unfit. Iron contributed to the nonpotability of 10% of the samples.

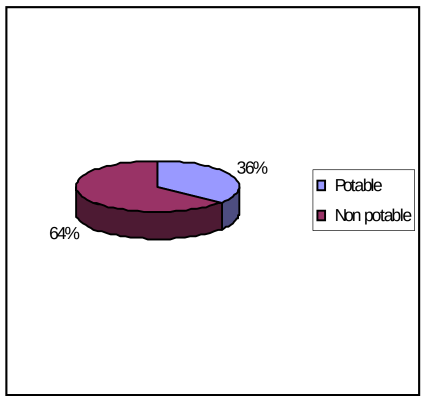

Fig. 1: Overall potability of groundwater samples.

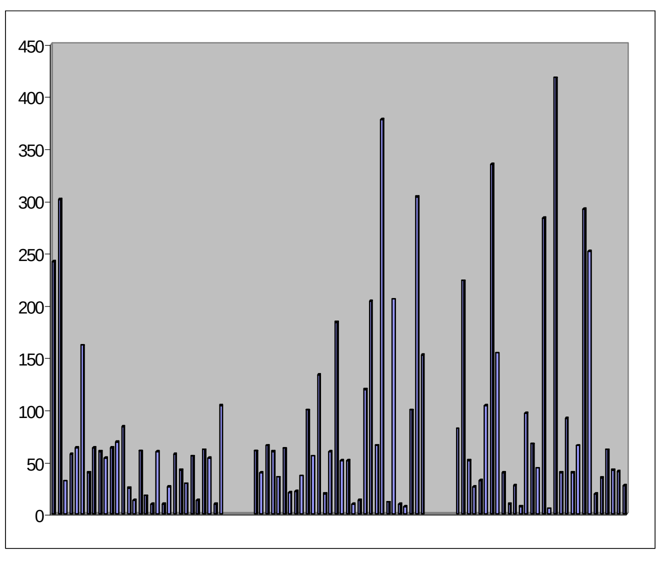

Fig. 2: Variation of nitrates (mg/L) in the groundwaters of the three zones of Bangalore South.

Table 1a: Results of physico-chemical analysis of groundwater samples of Zone I.

SN	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	7.29	nil	720	196	56	40	0.7	0.05	204	10	280	242	34	1.1	972	1520	nil	nil	nil	nil
2	6.90	0.2	1402	400	102	60	0.9	0.10	183	nil	1012	302	180	0.5	2120	3390	0.04	nil	nil	nil
3	6.92	nil	540	128	54	20	1.2	0.8	275	16	272	32	54	01	724	1190	nil	nil	nil	nil
4	7.10	nil	610	148	59	52	1.1	nil	327	nil	300	58	84	02	1056	1710	nil	nil	nil	nil
5	7.18	0.2	958	280	41	324	15	0.14	550	nil	740	64	226	0.8	2020	3580	0.2	nil	nil	nil
6	7.32	2.6	648	204	34	172	6.0	0.22	360	nil	404	162	40	0.6	1202	2070	nil	nil	nil	nil
7	6.50	0.1	370	92	34	20	1.0	nil	153	nil	60	40	75	0.6	226	390	0.19	nil	nil	nil
8	7.01	nil	520	128	49	34	1.2	0.14	275	18	280	64	290	1.0	760	1200	0.24	nil	nil	nil
9	7.06	nil	1438	336	146	212	6.0	0.5	348	nil	1012	60	210	0.6	2160	3560	0.6	nil	nil	nil
10	7.47	1.4	1122	252	120	90	4.0	0.24	420	06	508	54	174	0.8	1420	2350	0.22	nil	nil	nil
11	7.20	nil	1650	376	173	40	0.8	0.06	346	04	1020	64	290	1.0	2125	3710	0.28	nil	nil	0.1
12	7.50	4.0	1240	268	139	22	0.7	1.6	324	10	1010	70	404	nil	2080	3260	nil	nil	nil	nil
13	7.31	2.1	1100	256	112	26	0.8	0.3	488	18	700	84	402	1.4	1860	3150	nil	nil	nil	0.12
14	7.90	0.4	1090	280	122	274	4.0	0.12	608	40	640	26	240	0.6	2015	3180	0.22	nil	nil	0.10
15	7.10	nil	310	100	15	42	1.4	0.04	275	nil	130	14	40	2.5	480	700	0.11	nil	nil	nil
16	6.48	26	520	152	34	25	3.1	24	113	nil	200	61	288	6.0	844	1420	0.71	0.2	.08	0.40
17	7.40	0.2	370	96	32	30	0.5	nil	214	nil	190	18	33	nil	510	830	nil	nil	nil	0.02
18	7.61	0.5	550	172	29	26	2.8	0.2	336	06	200	10	189	2.5	820	1200	0.15	nil	nil	nil
19	7.30	0.1	730	240	32	90	8.0	0.4	519	32	410	60	238	nil	1385	1980	nil	nil	nil	nil
20	7.32	nil	670	240	15	200	6.0	0.16	380	nil	450	10	180	nil	1320	2280	0.1	nil	nil	nil
21	7.52	0.4	456	148	21	88	3.0	0.24	340	nil	272	27	40	nil	800	1440	0.08	nil	nil	nil
22	7.48	0.3	1060	304	73	54	0.8	0.20	516	39	610	58	30	nil	1446	2760	0.23	nil	nil	0.1
23	7.62	nil	576	126	57	185	6.0	0.18	370	nil	508	42	140	nil	1360	2050	0.08	nil	nil	nil
24	7.71	2.6	760	132	85	240	15	1.02	398	nil	530	30	152	nil	1400	2460	0.12	nil	nil	nil
25	7.80	0.9	1500	336	161	72	0.8	nil	458	nil	1044	56	350	nil	2248	3740	nil	nil	nil	nil
26	8.02	1.0	1920	440	200	100	0.8	0.2	396	04	1440	14	220	nil	2622	4190	nil	nil	nil	nil
27	8.22	nil	370	100	30	58	3.0	0.14	358	nil	104	62	40	nil	636	1080	0.34	nil	nil	nil
28	7.46	3.2	1400	358	128	100	0.8	0.12	472	nil	682	54	176	0.2	1790	3080	0.12	0.14	nil	0.18
29	7.1	nil	400	104	34	78	0.6	nil	244	nil	200	10	30	nil	580	880	nil	nil	nil	0.02
30	7.42	0.2	1350	308	141	80	2.0	0.24	488	nil	770	104	360	1.2	2021	3290	0.15	nil	nil	0.01

SN-Sample No.; 1-pH; 2-Turbidity (NTU), 3-Total hardness; 4-Ca; 5-Mg; 6-Na; 7-K; 8-Fe; 9-HCO_3; 10-CO_3; 11-Cl; 12-NO_3; 13-SO_4; 14-PO_4; 15-TDS; 16-EC (micromho/cm); 17-F; 18-Cu; 19-Pb; 20-Cr. Values in mg/L or stated.

Table 1b: Results of physico-chemical analysis of groundwater samples of Zone II.

SN	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	7.1	0.5	440	116	37	20	2.0	0.2	396	nil	260	61	91	0.8	760	1030	2.5	nil
2	7.4	0.3	560	112	68	16	2.2	0.28	402	10	230	40	103	0.8	800	1320	nil	nil
3	7.3	1.4	434	96	47	40	1.9	nil	366	nil	320	66	113	1.0	860	1340	2.0	nil
4	7.42	0.5	376	100	30	80	4.0	0.16	324	nil	120	60	60	1.2	628	1060	0.22	nil
5	6.98	nil	170	50	10	72	2.0	0.1	200	04	64	36	26	0.2	380	610	0.34	nil
6	7.72	1.3	350	96	27	40	1.4	0.16	335	nil	240	63	150	0.8	770	1290	2.6	nil
7	7.53	2.0	250	48	32	30	1.1	0.22	332	08	130	21	50	0.1	480	770	1.3	0.02
8	6.82	0.6	338	90	28	98	02	0.10	336	nil	162	22	64	0.8	682	1180	0.22	nil
9	7.21	nil	140	40	10	62	04	0.04	180	nil	70	37	40	0.6	390	580	0.18	nil
10	7.82	2.4	622	160	54	162	18	0.12	260	nil	274	100	220	1.6	1124	1810	0.38	nil
11	7.62	2.0	240	52	27	40	1.2	nil	335	14	110	56	136	0.6	596	990	2.6	0.01
12	8.20	0.2	190	48	17	34	1.0	nil	244	nil	100	134	50	1.1	506	810	1.6	0.8
13	7.82	3.6	290	52	39	56	1.8	0.08	305	nil	160	20	45	0.2	530	850	0.28	.005
14	6.88	1.8	405	110	32	100	30	0.36	340	08	170	60	80	1.2	708	1210	0.25	nil
15	7.0	0.6	688	208	44	150	66	0.2	460	14	340	184	150	1.4	1410	2260	0.12	nil
16	7.12	0.1	620	110	84	75	1.7	1.42	488	16	470	52	23	1.2	1080	1650	4.8	nil

Table Cont...

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17	7.52	0.2	430	84	53	70	1.0	nil	518	08	420	52	80	0.8	1030	1630	4.92	nil
18	8.2	1.1	340	96	25	30	1.1	0.08	335	nil	190	10	50	0.1	590	950	1.2	0.005
19	7.8	4.0	510	96	66	52	1.4	0.1	396	nil	400	14	20	0.2	850	1360	2.82	nil
20	8.3	1.2	1530	260	214	90	6.0	nil	183	nil	1508	120	80	2.0	2452	4020	6.4	nil
21	7.8	1.0	810	156	102	80	8.0	0.14	300	nil	1020	204	280	4.2	2012	3260	4.1	nil
22	7.12	5.2	250	60	24	60	2.3	nil	274	nil	140	66	40	0.1	580	1000	3.2	nil
23	6.86	1.8	522	140	42	264	82	1.12	396	20	412	378	270	3.6	2180	3100	0.88	nil
24	6.44	1.0	1202	312	102	204	10	2.6	250	nil	1014	12	260	1.7	2080	3450	0.12	nil
25	7.42	2.8	456	128	34	202	2.0	0.16	238	nil	224	206	180	1.4	1124	1760	0.60	nil
26	7.52	0.2	280	76	22	88	2.2	nil	374	40	150	10	35	0.2	640	1020	nil	nil
27	8.2	1.3	160	46	11	46	0.2	nil	152	nil	40	08	40	0.1	270	460	nil	nil
28	7.9	0.1	390	100	34	20	1.2	nil	374	20	320	100	166	0.2	950	1560	2.4	nil
29	6.52	3.8	880	308	46	292	04	0.44	426	12	468	304	160	03	2028	3270	0.68	nil
30	7.32	1.2	540	162	34	130	06	0.12	251	nil	266	153	76	1.8	990	1650	0.44	0.01

SN-Sample No.; 1-pH; 2-Turbidity (NTU), 3-Total hardness; 4-Ca; 5-Mg; 6-Na; 7-K; 8-Fe; 9-HCO_3; 10-CO_3; 11-Cl; 12-NO_3; 13-SO_4; 14-PO_4; 15-TDS; 16-EC (micromho/cm); 17-F; 18-Cr. Values in mg/L or stated.

Table 1c: Results of physico-chemical analysis of groundwater samples of Zone III.

SN	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	7.97	0.8	896	135	140	446	8.0	0.1	1318	88	1272	82	252	1.2	3484	6500	0.6	nil	nil	nil
2	6.70	0.8	1064	301	78	301	28	1.29	608	nil	582	224	265	1.8	2120	3550	0.5	nil	nil	nil
3	7.03	0.2	620	174	46	234	16	0.12	436	nil	330	52	270	3.0	1370	2300	0.6	nil	nil	nil
4	7.01	0.5	312	75	31	72	1.0	0.16	265	nil	112	27	74	0.2	550	940	0.1	nil	nil	nil
5	7.47	1.4	448	192	25	183	4.0	0.91	373	nil	240	33	60	0.4	965	1270	0.5	nil	nil	nil
6	7.26	3.6	1236	298	115	119	24	1.12	456	10	760	104	76	5.2	2456	3400	Nil	nil	nil	nil
7	6.81	4.0	1272	374	84	309	1.2	1.16	440	nil	764	335	233	14	2330	3900	0.4	nil	nil	nil
8	7.65	4.8	460	134	31	188	4.0	0.12	382	nil	246	155	90	3.4	1065	1660	0.36	nil	nil	nil
9	6.95	0.4	120	32	10	25	2.0	0.94	116	nil	31	40	10	0.2	240	350	0.12	nil	nil	nil
10	7.67	1.8	160	51	8.0	102	4.0	0.05	190	nil	110	10	68	0.8	480	770	0.7	nil	nil	nil
11	6.8	Nil	320	68	36	46	2.0	Nil	244	nil	195	28	45	0.9	525	900	0.3	nil	nil	nil
12	7.53	1.0	392	104	33	100	2.0	0.83	294	26	224	08	70	1.0	720	1260	0.12	nil	nil	nil
13	7.42	2.2	1288	411	65	370	26	0.12	440	nil	1086	97	176	2.2	2490	4000	0.8	0.12	nil	nil
14	7.65	1.2	424	112	36	152	5.0	21	343	nil	290	68	60	1.2	920	1440	0.36	nil	nil	0.42
15	7.1	0.6	144	42	10	47	0.6	0.7	147	nil	70	44	52	1.6	407	1550	0.3	nil	nil	nil
16	6.82	0.2	1012	270	82	560	8.0	1.36	376	nil	552	284	32	1.1	2015	2900	0.22	nil	nil	nil
17	6.99	Nil	92	26	7	60	6.0	0.71	161	nil	30	6	14	0.2	310	460	0.72	nil	nil	nil
18	7.90	5.2	1092	339	61	260	24	1.92	505	4.0	557	418	172	6.6	2115	3300	0.88	0.02	nil	0.36
19	7.5	2.5	340	84	32	65	2.0	Nil	336	nil	200	40	49	1.4	725	1250	0.3	nil	nil	nil
20	7.2	1.2	520	168	25	188	20	0.1	294	nil	339	92	159	2.0	1170	1910	0.54	nil	nil	nil
21	7.77	1.3	468	126	38	74	2.0	0.3	260	nil	224	40	77	2.0	735	1150	0.22	nil	nil	nil
22	7.67	2.8	528	170	26	141	4.0	0.1	348	nil	238	66	69	1.1	910	1420	0.4	nil	nil	nil
23	7.19	2.0	864	250	60	309	7.0	3.12	568	nil	496	292	147	3.8	1880	3000	0.56	nil	nil	nil
24	7.22	1.6	888	276	48	440	14	2.8	584	6.0	412	252	142	6.1	2008	2950	0.46	nil	nil	nil
25	7.41	0.8	200	62	11	97	2.0	0.35	226	14	115	20	38	1.8	500	820	0.38	nil	nil	nil
26	8.00	1.5	488	112	52	59	1.0	0.3	343	nil	196	35	36	3.0	685	1080	0.6	nil	nil	nil
27	7.55	0.9	452	114	42	92	4.0	0.7	364	nil	196	62	41	2.6	755	1180	0.65	nil	nil	nil
28	7.05	0.1	424	94	47	100	7.0	0.2	373	nil	190	42	45	3.1	740	1160	0.22	nil	nil	nil
29	7.80	0.8	180	53	12	58	1.0	0.4	211	nil	31	41	64	0.9	390	620	0.4	nil	nil	nil
30	7.44	1.9	304	88	21	460	11	2.6	361	nil	214	28	68	1.8	804	1320	0.38	nil	nil	nil

SN-Sample No.; 1-pH; 2-Turbidity (NTU), 3-Total hardness; 4-Ca; 5-Mg; 6-Na; 7-K; 8-Fe; 9-HCO_3; 10-CO_3; 11-Cl; 12-NO_3; 13-SO_4; 14-PO_4; 15-TDS; 16-EC (micromho/cm); 17-F; 18-Cu; 19-Pb; 20-Cr. Values in mg/L or stated.

Table 2: Maximum, minimum and average concentrations (mg/L) of critical parameters in the groundwaters of Bangalore south and BIS permissible limits.

Sl. No.	Parameter	Maximum	Minimum	Average	BIS limits (Maximum)
1	Chlorides	1508	30	400.8	1000
2	TDS	3484	240	1181.62	2000
3	Total Hardness	1920	92	641.9	600
4	Calcium	440	26	166.08	200
5	Magnesium	214	07	55.94	100
6	Nitrate	418	06	84.73	45

Table 3: Critical water quality parameters exceeding the overall permissible limits.

Sl no	Parameter	Number exceeding the permissible limits	Percentage of samples exceeding the permissible limits
1	Chlorides	11	12.22
2	TDS	22	24.44
3	Total Hardness	36	40.00
4	Calcium	28	31.11
5	Magnesium	16	17.78
6	Nitrate	52	57.78

Out of the thirty samples analysed in zone II, 20 samples (66.67%) were found to be nonpotable, mainly due to nitrates, fluorides and total hardness, which accounted for 63.33%, 40% and 23.33% of unsafe samples respectively followed by total dissolved solids, as a result of which 16.67% of the samples were found to be unsafe. Calcium accounted for 13.33% of the samples being nonpotable. Chlorides, magnesium and iron each rendered 10% of the samples nonpotable.

Out of the thirty samples analysed in zone III, 16 samples (53.33%) were found to be nonpotable, mainly due to nitrates which accounted for 50% of unsafe samples followed by total hardness and iron, as a result of which 33.33% of the samples were unsafe. Total dissolved solids and calcium, each accounted for 26.67% of the samples being nonpotable. Chlorides and magnesium each rendered 6.67% of the samples nonpotable.

From the results, it is quite clear that nitrates and total hardness have been two main and common parameters, affecting all the three zones. The maximum, minimum and mean concentrations of nitrates in the three zones were found to be 302 mg/L, 10 mg/L, 65.07mg/L; 378 mg/L, 08 mg/L, 88.30 mg/L, and 418 mg/L, 06 mg/L, 100.83 mg/L respectively. In the study areas, organic origin is probably the cause for most of such occurrences such as drainage of water through soil containing domestic and industrial wastes, vegetable and animal matter. Septic tanks and garbage dump disposal may also be responsible for the high nitrate content in the study area. Beyond 45 mg/L, this may cause methaemoglobinaemia or blue baby disease in infants. It may also be carcinogenic in adults (Basappa Reddy 2003).

The maximum, minimum and mean concentrations of total hardness in the three zones were found to be 1920mg/L, 310mg/L, 878.33 mg/L; 1530 mg/L, 140 mg/L, 480.43 mg/L, and 1288 mg/L, 92 mg/L, 566.94 mg/L respectively. The high degree of hardness in the study area is definitely attributed to the disposal of untreated/improperly treated sewage and industrial wastes (Ramasesha 2005). The calcium and magnesium salts, which impart hardness, are also obviously higher in these areas.

Total dissolved solids (TDS) were also found be other parameter contributing substantially to the nonpotability of the samples in all the zones. The TDS concentrations in the three zones varied from 226 mg/L to 2622 mg/L, 390 mg/L to 2452 mg/L and 240 mg/L to 3484 mg/L respectively. TDS in groundwater originate from natural sources, sewage, urban run-off and industrial wastes. Waters with high TDS (> 2000mg/L) are of inferior palatability and may induce an unfavourable physiological reaction in the transient consumer and gastrointestinal irritation (Ranjit Singh & Ajith Kumar 2004).

Chlorides, which have contributed to 20, 10 and 6.67% of nonpotability in the three zones, have peak values of 1440, 1508 and 1272 mg/L respectively. The high value can definitely be attributed to the discharge of industrial effluents in the area.

In Bommanahalli, the fluoride has a peak value of 6.4 mg/L, which is more than four times the BIS permissible value of 1.5 mg/L. The fluorides account for the nonpotability of 40% of the samples in this area. Apart from the natural processes, considerable amount of fluorides may have been contributed to man-made reasons, such as the use of fluoride salts in the large number of industries in the study area, which are using it in steel, aluminium, brick and tile industries. Fluorides in excess of 1.5 mg/L may lead to a crippling and painful disease called fluorosis, which may be in the form of dental fluorosis, skeletal fluorosis and nonskeletal fluorosis (Lakshmanan & Rao 1994).

Thus, out of the 90 samples covering the entire study area of Bangalore south, 58 samples exceeded the BIS permissible limits for potable water. That is, 64.44% of the groundwater samples in Bangalore south are nonpotable.

CONCLUSIONS

The findings of the physico-chemical analysis of the groundwaters reveal that an alarmingly high percentage (64.44%) of the groundwater is contaminated due to the presence in excess of various contaminants. This calls for some urgent and immediate measures to be taken to protect the groundwater resources of Bangalore south district. The wastewater generated from various sources should be properly treated and disposed off and strict legislation for industries setting up and operating their effluent treatment plants should be enforced mandatorily. Replacement of damaged pipelines and lining of sewer drains is to be must. Augmenting the groundwater resources by recharging the groundwater aquifer through rain water harvesting, and thus, reducing high concentration of pollutants is an important measure. Public awareness programmes should be initiated to create a sense of awareness in people to safeguard against the perils of water-borne diseases.

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