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Ground water quality evaluation in Beed city, Maharashtra, India

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The development activities cause depletion and degradation of ground water. A survey was undertaken to assess the quality of ground water in Beed district of Maharashtra taking both physico-chemical and bacteriological parameters into consideration. The present investigation is aimed to calculate Water Quality Index (WQI) of ground water and to assess the impact of pollutants due to agriculture and human activities on its quality. The WQI varied from 329.27 (winter) to 141.56 (monsoon) indicating level of nutrient load and pollution in the handpumps and borewells. The existing results revealed that water from handpumps and borewells are not safe for human use.

Key words: Ground water, pollution, water quality index, Seasonal analysis.

INTRODUCTION

Of all natural resources, water is unarguably the most essential and precious. Life began in water, and life is nurtured with water. There are organisms, such as anaerobes witch can survive without oxygen. But no organism can survive for any length of time without water. The crucial role of water as the trigger and sustained of civilizations has been witnessed throughout the human history it is common knowledge that our planet is faced with a major problem in the available water resources (Gleick, 2008; Witkowski et al., 2007). This problem has two dimensions:

1. The first is with respect to the quantity of water available. With increasing population, the demand for water, both for human consumption and agriculture, has been steadily increasing. Also, the melting of glaciers, deforestation and general environmental degradation, in particular, of rivers, has cut the retentivity, flow and availability of water on the planet.
2. The not so obvious problem, which is perhaps more serious, has to do with the quality of water, which has deteriorated over the last 50th years, so as to render most of it is unfit for drinking. How has this happened?

Excessive urban migration has inflated cities beyond manageable limits, to produce such quantities of effluents so as to render both the local groundwater and rivers flowing by cities to be criminally polluted. This has happened mostly due to leaching of contaminants from landfills, indiscriminately disposed anthropogenic toxic waste, unplanned application of agrichemicals and surface run-off from farm lands (Datta, 1999).

At presents, it is estimated that almost half the world's population has no access to good drinking water (Soni et al., 2009). But, uptill as late as 1960s, the overriding interest in water has been *vis-a-vis* its quantity. Except in mamfestly undesirable situations, the available water was automatically deemed utilizable water. Only during the last three decades of the twentieth century the concern of water quality has been exceedingly felt so that, by now, water quality has acquired as much importance as water quality.

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Table 1. Water Quality Index (WQI) range.

WQI	Status
0 - 25	Excellent
26 - 50	Good
51 - 75	Poor
76 - 100	Very poor
100 and above	Unsuitable for drinking

Source: Mishra and Patel, 2001

A water quality index is an indicator of the quality of water. It is useful for a variety of purposes, such as:

a) Planning tool for managing water resources use,
b) Assessing changes in the quality of the water at different times, places and seasons,
c) Evaluating the performance of pollution control programmes, and- communicating water quality information to the public and to decision makers.

MATERIALS AND METHODS

The present investigation is aimed to calculate Water Quality Index (WQI) in Beed city. For this reason, ten physic-chemical parameters such as DO (Dissolved Oxygen), BOD (Biochemical Oxygen Demand), pH, Cl (Chlorides), NO_3 (Nitrate), Total Alkalinity, Total Hardness, COD (Chemical Oxygen Demand), and TC (Total Coliform) were selected and analyzed as per standard procedure of APHA (1998); Trivedy and Goel (1986); Kodarkar et al. (1998).

Water samples were collected for physico-chemical analysis from 12 sampling station of handpumps and borewells, from November, 2005 - October, 2006. Water samples were collected in one litre plastic bottles. Sample collection was usually completed during morning hours between 8 - 11:00 am every time. pH and dissolved oxygen were monitored at the sampling spots, while other parameters were analyzed in the laboratory.

Water quality index (WQI)

Water quality Index is an important parameter for the assessment and management of ground water. Water Quality Index is a single number (like a grade) that expresses the overall water quality at a certain location based on several water quality parameters. The concept of indices to represent by Horon (1965). It is defined as a rating reflecting the composite influence of different of water quality parameters on the overall quality of water. For calculaton of WQI, selection of parameters has great importance. Since selection of too many parameters might widen the quality index and importance of various parameters depends on the intended use of water (Table 1).

Weighted arithmetic index has been used for calculation of WQI, in the following steps:

Calculation of sub index or quality retting (q_n)

Let there be n water quality parameters and quality rating or sub-index (q_n) corresponding to n^{th} parameter is a number of reflecting the relative value of this parameter in the polluted water with respect to its standard permissible value. The q_n is calculated using expression:

$$q_n = 100[(V_n - V_{io})/(S_n - V_{io})]$$

Where, q_n = quality rating for the n^{th} water quality parameter, V_n = estimated value of the n^{th} parameter at a given sampling station, S_n= standard permissible value of n^{th} parameter, and V_{io} = ideal value of n^{th} parameter in pure water.

All ideal value s (Vio) are taken as zero for the drinking water except for pH = 7.0 and dissolved oxygen = 14.6 mg/L.

Calculation of quality rating for pH

For pH, ideal value is 7.0 (for neutral water) and permissible value is 8.5 (for polluted water). Therefore, quality rating for pH is calculated from the following relation:

$$q_{pH} = 100[V_{pH} - 7.0)] / [(8.5 - 7.0)]$$

Where, VpH = observe value of pH.

Calculation of quality rating for dissolved oxygen

The ideal value (V_{Do}) for dissolved oxygen in 14.6 mg/L and standard permissible value for drinking water is 5 mg/L. Therefore, quality rating is calculated from following relation:

$$q_{Do} = 100[V_{Do} - 14.6)]/[(5 - 14.6)]$$

Where V_{Do} = measured value of dissolved oxygen.

Calculation of unit weight (W_n)

The unit weights (W_n) for various water quality parameters are inversely proportional to the recommended standards for the corresponding parameters:

$$W_n = K / S_n$$

Where W_n = unit weight for n^{th} parameter, S_n = standard value for n^{th} parameter, and K = constant for proportionality.

WQI is calculated from the following equation:

$$WQI = \sum_{n=1}^{n} qn\ wn / \sum_{n=1}^{n} wn$$

RESULTS AND DISCUSSION

The physico-chemical and bacteriological quality of drinking water totally depends of the geological condition of the soil and ground water pollution of the area. The physico-chemical parameters value and total coliform count are presented in Table 2. The seasonal average values of various physico-chemical parameters, drinking water standards, unit weights (W_i), quality rating (q_i), Subindex value (q_iW_i) and WQI value of handpumps and borwells are calculated during different seasons are recorded in Tables 3 to 5.

The pH value of handpumps and borewell water sample was found on 7.19 (winter) to 7.32 (monsoon). The pH of all water samples were within the normal range (WHO, 1984). High TSS values in surface water might be due to mixing of sewage and industrial effluents (Chatterjee and Raziuddin, 2002).

Table 2. Seasonal values of some water quality parameters of Handpumps and borewells at twelve sampling stations (S_1 - S_{12}) during different seasons (all values are mg/L except pH).

Parameter	Season	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
DO	Win.	4.4	5.8	4.2	8.2	8.2	6.4	6.2	10.1	5.8	8.1	12.8	4.8
	Sum.	2.4	3	4.2	5.4	4.8	3	4.4	5.6	2.4	4.4	5.8	3
	Mon.	7.7	7.2	7.5	7.1	6.5	6.1	6.8	6.9	5.1	6.6	7.3	5.8
BOD	Win.	10.8	12.8	12.2	9.8	7.5	12.8	11.8	14.4	8.5	8.3	14.6	8.37
	Sum.	4.1	3.5	4.2	2.9	3.1	5.1	3.2	4.5	2.8	3.2	4.8	3.3
	Mon.	7.5	7.8	8	5.6	5.4	8.7	6.5	7.8	5.6	6.4	8.1	5.4
pH	Win.	6.97	6.9	8.08	8.79	6.9	7.08	7.24	6.84	6.94	6.72	6.94	6.88
	Sum.	7.19	7.19	7.36	7.7	7.59	7.37	7.44	7.1	7.17	7.02	7.14	7.13
	Mon.	7.1	7.11	8.1	8.5	7.62	7.1	7.2	6.9	7.11	6.92	7.1	7.11
Cl.	Win.	355	497	248.5	426	497	603.5	461.5	674.5	887.5	532.5	497	461.53
	Sum.	525.4	440.2	511.2	426	553.8	383.4	468.6	497	468.6	568	894.6	908.8
	Mon.	504	469	416	409	524	584	465	529	612	537	678	599
NO_3	Win.	0.62	0.71	0.81	0.92	0.76	0.63	0.86	0.72	0.68	0.82	0.92	0.97
	Sum.	0.72	0.63	0.73	0.86	0.91	0.74	0.81	0.65	0.93	0.95	0.88	0.97
	Mon.	0.43	0.52	0.53	0.73	0.81	0.48	0.78	0.59	0.84	0.76	0.82	0.87
T. Alk.	Win.	180	186	245	360	348	220	270	358	290	275	285	192
	Sum.	380	409	306	484	356	304	288	400	486	348	404	322
	Mon.	183	185	228	356	309	199	197	336	276	268	244	188
TH	Win.	610	744.2	554.6	488	793	610	671	866.2	744.2	427	585.6	512.4
	Sum.	418	663	609	367	360	437	379	547	534	399	573	508
	Mon.	605	752	588	492	402	572	617	718	651	414	581	509
TSS	Win.	45	37	47	62	50	51	84	48	38	41	82	88
	Sum.	48	52	42	47	40	37	46	55	62	54	48	58
	Mon.	75	62	70	64	58	72	92	82	91	66	88	77
COD	Win.	40	43.2	32	46.4	36.2	28.2	36.4	43.2	32.9	40.1	44.2	44.4
	Sum.	27.2	26.5	21.8	19.6	21.0	22.5	18.8	28.1	18.9	21.7	25.5	23.5
	Mon.	6.2	5.5	6.5	5.8	6.2	6.8	5.6	7.5	6.7	7.2	8.5	6.0
TC	Win.	143	410	625	180	216	420	325	32	82	212	440	390
	Sum.	120	402	392	140	160	220	150	40	90	490	320	260
	Mon.	160	460	670	196	230	435	340	40	102	222	460	392

Table 3. WQI of Handpumps and Borewells during in water season.

Parameter	Unit weight W_n)	ICMR (S_n)	Observed values (V_{io})	Quality rating (q_n)	Sub-index value (q_n W_n)
DO	0.2000	5	7.08	78.33	15.67
BOD	0.2000	5	11.02	220.4	44.08
pH	0.0040	7.0 - 8.5	7.19	12.67	0.05
Cl	0.0040	250	511.79	204.72	0.82
T.Alk.	0.0083	120	267.42	222.85	1.85
TH	0.0033	300	633.85	211.28	0.69
TSS	0.0020	500	56.08	11.22	0.02
COD	0.2000	5	38.89	777.8	155.56
TC	0.1000	1	290.08	351.31	35.13
SUM	0.7716	1206.00	1824.19	2094.53	254.07
Average	0.08	134.00	182.41	209.45	25.40
Water quality index = 329.27					

Table 4. WQI of Handpumps and Borewells during summer season.

Parameter	Unit weight (W_n)	ICMR (S_n)	Observed values (V_{io})	Quality rating (q_n)	Subindex value (q_n W_n)
DO	0.2000	5	4.03	110.10	22.02
BOD	0.2000	5	3.73	74.6	14.92
pH	0.0040	7.0 - 8.5	7.28	18.67	0.07
Cl.	0.0040	250	553.80	221.52	0.89
NO_3	0.0500	20	0.82	4.1	0.21
T.Alk.	0.0083	120	373.92	311.6	2.59
TH	0.0033	300	482.83	160.94	0.53
TSS	0.0020	500	49.80	9.82	0.01
COD	0.2000	5	22.93	458.6	91.72
TC	0.1000	1	207.00	321.36	321.13
SUM	0.7716	1206.00	1705.42	1691.31	32.13
AVERAGE	0.08	134.00	170.54	169.13	3.21
Water quality index = 213.95					

Table 5. WQI of Handpumps and Borewells during monsoon season.

Parameter	Unit weight (W_n)	ICMR (S_n)	Observed values (V_{io})	Quality rating (q_n)	Subindex value (q_n W_n)
DO	0.2000	5	6.72	82.08	16.42
BOD	0.2000	5	6.90	138.00	27.60
pH	0.0040	7.0 - 8.5	7.32	21.33	0.09
Cl	0.0040	250	527.17	210.87	0.84
NO_3	0.0500	20	0.68	3.4	0.17
T.Alk.	0.0083	120	247.42	206.18	1.71
TH	0.0033	300	575.08	191.69	0.63
TSS	0.0020	500	74.75	14.95	0.03
COD	0.2000	5	6.55	131.0	26.20
TC	0.1000	1	308.92	355.41	35.54
SUM	0.7716	1206.00	1761.51	1354.91	51.96
AVERAGE	0.08	134.00	176.15	135.49	5.19
Water quality index = 141.56					

The observed values of total alkalinity were found in the range of 247.42 mg/L (rainy) to 373.92 mg/L (summer). Harish et al. (2006) reported total alkalinity in the ground water between 62 and 140 mg/L. Harish et al. (1991) recorded alkalinity values in the range of 200 - 610 mg/L in city side from handpump water. The BIS (1998) accepted limit for total alkalinity is 1000 mg/L. Observed values are well within the permissible limit.

Total Hardness in handpump and borwell water samples were recorded in the rang of 482.83 mg/L (summer) to 633.85 mg/L (winter) High values of hardness can be attributed low water level and high rate of evaporation. Finding of present study is in harmony with the study of Harish et al. (1991) and Garg et al. (1990) with little variation. According to Kannan (1991), water with hardness more than 180 mg/L is very hard; in this respect, water of these sources are very hard.

Content of chlorides were noted as 511.79 mg/L (winter) to 553.80 mg/L (summer) in all above sources. Nalina and Puttaiah (2005) observed the maximum and minimum values of chloride in summer, rainy and winter season, respectively, from ground water.

Concentration of nitrate were found to vary within 0.68 mg/L (monsoon) to 0.82 mg/L (summer), and also value of nitrates in these sources are well within limits of ICMR standards (ICMR, 1975).

The level of DO varied within 4.03 mg/L (summer) to 7.08mg/L (winter); BOD ranged from 3.73 mg/L (summer) to 11.02 mg/L (winter); COD observed within 6.55 mg/L (monsoon) to 38.89 mg/L (winter); and TC count is very high in all the three seasons. Kaur et al. (1992), Rajmohan et al. (1997) and Singh et al. (2000) reported seasonal as well as yearly changes in the ground water quality. Pradhan et al. (2003) noted BOD as 1.1 mg/L (summer), 1.2 mg/L (rainy) and 1.0 (winter) in tubewell water at Rimuli, district keonjar (Orissa) India. The upper limit for BOD in drinking water is 3 mg/L, but when BOD values reach 5 mg/L, the water is doubtful in purity (Hari, 2002).

A considerable increase in COD values in some sampling stations near those locality which has poor sanitation and filthy water accumulation. Pathak (1994) reported COD values varied from 4 mg/L (rain) to 46 mg/L (winter) from handpump sample in Rewa region (M.P), India. Sharma, (2003) observed COD values 12.0 to 14.1) mg/L from tubewell water samples of Matsya Industrial area Alwar. Pathak (1994) noted t coliform high in number than the standard from handpump water samples during different seasons at Rewa region (M.P.) India. Rawat (2003) calculated MPN (coliform) per 100 ml in tubewell from 4 - 10 ml and 4 to 6/100 ml in handpumps. Fokmare (2002) also recorded increased number of coliform/100 ml in hand pumps at Akola city (M.S) India.

Application of WQI is a useful method in assessing the water quality of hand- pump and borewells. The WQI values in all three seasons are much above 100 indicating unsuitability for drinking purpose (Tables 1, 3, 4 and 5). The WQI values are maximum because for the continuous discharge of municipal sewage and industrial effluents near to the sources of water which may percolate in the ground water.

From the present observation, it can be concluded that water quality of hand pumps and borewells is under stress of severe pollution. The Beed district water is not suitable for drinking, bathing, swimming and pisciculture. In order to save these sources from further deterioration, effective pollution control measures must be taken in to consideration.

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