Research Paper

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Laboratory studies on water quality assessment of groundwater of open dug wells and surface water of Lake Waddepally in Warangal city, India

Environment

KEYWORDS : Groundwater, lake, dug wells, chemical oxygen demand

Pritanjali Shende	Post Graduate Student, Department of Civil Engineering, National Institute of Technology, Warangal-506 004, Andhra Pradesh, India.
Tarun Kandpal	Post Graduate Student, Department of Civil Engineering, National Institute of Technology, Warangal-506 004, Andhra Pradesh, India.
Anoop C.K	PhD Student, Department of Civil Engineering, National Institute of Technology, Warangal-506 004, Andhra Pradesh, India.
E. Venkata Rathnam	Associate Professor, Department of Civil Engineering, National Institute of Technology, Warangal-506 004, Andhra Pradesh, India.
K.V. Jayakumar	Professor, Department of Civil Engineering, National Institute of Technology, Warangal-506 004, Andhra Pradesh, India.

ABSTRACT

The water from lakes and reservoirs are collected, treated and supplied for public distribution by Government agencies in India. Water from open dug wells (Groundwater) is one of the major resources for individual residents. Studies on physicochemical parameters of groundwater of open dug wells and surface water of Waddepally Lake in Warangal district of Andhra Pradesh State are carried out and the results are presented in this paper. The groundwater samples were collected from 15 open dug wells in an area of 4 km from the lake. The lake water samples from 4 different locations were taken from top surface, 1m and 2m depth wise. Laboratory tests were conducted for determining (i) physical parameters: Temperature, pH and Electrical Conductivity, (ii) chemical parameters: Total Alkalinity, Dissolved Oxygen, Total Hardness, Chlorides, Fluorides, Total Solids, Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Carbonate (CO_3^-), Bicarbonate (HCO_3^-), and Chemical oxygen demand.

Surface water supply from dams, reservoirs, canals and lakes were constructed for multi-purpose projects by irrigation and municipal authorities in India. The water from open dug wells and bore wells are alternative source to individual residents in urban areas. Water quality standards have been set for different uses at the national level (Government of India, 2007). The study of different water quality parameters is important for understanding the metabolic events in aquatic ecosystem. An excellent review of various works carried out on lakes in India has been presented by Khobragade, (2008). Vembanad Lake in Kerala was analyzed for surface and bottom water and it was found that south west monsoon and the river inflows have a profound effect on distribution of dissolved oxygen (Batcha, 2002). The response of hydro-biological parameters and accumulation of nitrogen in three lakes of Bhopal was reported (Garg et. al 2002). Studies also been carried out on the water quality deterioration of Bhopal lakes and suggested some policy measures to improve the water quality. The analysis of various physicochemical parameters of Tiveni Lake resulted that significant seasonal variation in some parameters and indicted better quality of lake (Khan et. al 2006). Construction of Harsool-Savangi dam resulted that the parameters like water temperature, turbidity, pH was consistently lower than conductivity, total solids (TS), total dissolve solids (TDS), atmospheric temperature (Shinde et al., 2011).

The water quality of Manasbal Lake in Kashmir indicated that the concentration of major ions in the water samples in winter was higher than in summer (Sarah et al. 2006). In Jimeta-Yola, Nigeria; water samples from dug wells shown that electrical conductivity, chlorides, nitrates, and dissolved oxygen exceeded World Health Organization (WHO) standards in dry season whereas chlorides, nitrate, dissolved oxygen, total hardness, chromium Hexavalant exceeded WHO standards in rainy season (Ishaku, 2011). Further works on various other aspects of lake have been carried by many researchers; Kumar et al.,(2006), Prakash et al., (2004) and Gurunadha Rao (2004).

Study Area

Waddepally lake is one of the drinking water supply source for Warangal city in Andhra Pradesh. The surface area of the lake is 2.95 km2 and storage capacity is 3.82 Mm3. Average depth of water in the lake is about 4m. The lake has its own catchment area of 44 km2 and its elevation ranges from 275 to 300m above mean sea level (MSL). The region receives an average rainfall about 900 mm. The lake, in addition to its own catchment, is filled with water from river Godavari which is carried from Lower Manair dam through the Kakatiya Canal, flowing over a distance of almost 80 km.

A water treatment plant of 15 MLD capacity was constructed on the bank of Waddepally lake by Municipal Corporation of Warangal for the supply of treated water for the part of Kazipet and Hanamkonda region of Warangal city. The Warangal city is located between 79o 32' 4'' E to 79o25'13''E longitude and 17o59'10'' N to 17o55'11'' N latitude. The geological formations of the region include granites and granite gneisses with intrusion of dolerite dykes, shales and sandstones with intermittent coal formations. The lake surface boundary and locations of 15 open dug wells are shown in the Fig. 1. Fig.2 shows the location details like latitudes and longitudes open dug wells around the Waddepally lake. Water level surface in the open dug wells is found in the range of 4-8m below from natural ground surface in the study area. Water samples from the lake and surrounding open dug wells were collected on a monthly basis to observe the spatial and temporal variations of physicochemical parameters.



Figure 1: Lake Waddepally in Warangal District, Andhra Pradesh, India

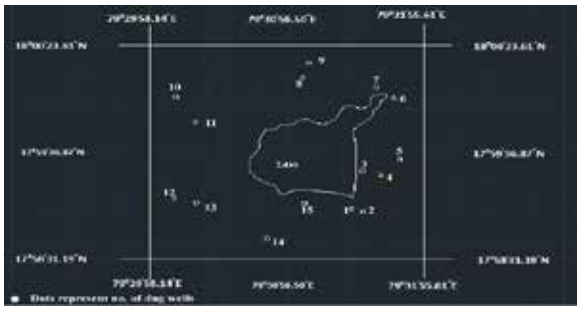

Figure 2: Latitudes and Longitudes of Open Dug Wells around Lake Waddepally

Laboratory Analysis

14 water quality parameters were analyzed during the study period of pre monsoon (April-May),monsoon (August-September) and post monsoon season of (November-December) 2012. The parameters analyzed are: pH, Electrical conductivity, Total Alkalinity, Total suspended solids, Total hardness, Dissolved Oxygen (DO),Chlorides, Calcium, Magnesium, Bicarbonates, Carbonated and Chemical Oxygen Demand (COD). Table 1 presents the list of test procedure followed for determination of different parameters. pH and Electrical conductivity were determined using the pH meter and EC electrodes respectively where as the temperature is measured using a thermometer. Standard Titration methods (APHA, 1980), Standard Analytical procedures for water analysis, 1999.) are used to determine Alkalinity (with sulphuric acid), Hardness (with 0.01 EDTA), Chlorides (with silver nitrate), Dissolved Oxygen (with sodium thiosulphate), COD (closed refluxed), Calcium (with EDTA).

Magnesium (Mg2+), carbonate (CO32-) and Bicarbonate (HCO3-) are estimated using following formulas.

1. Bicarbonate was calculated from pH and Alkalinity

$$HCO3\text{-}\ (mg/L) = \frac{T - 5\times10^{(pH-10)}}{1+0.94\times10^{(pH-10)}}$$

Where, T= Total Alkalinity

2. Carbonate was determined from pH and bicarbonate concentration

$$CO32\text{-}\ (mg/L) = 0.94 \times HCO3 \times 10^{(pH-10)}$$

3. Magnesium was estimated using the values of Total Hardness and Calcium

$$Mg2+ = \{(TH - Ca)x0.243$$

Where TH= Total Hardness.

Table 1: Methods Employed for Laboratory Analysis

Parameter	Method
pH	pH meter
Electrical Conductivity (EC)	Conductometer
Temperature	Thermometer
Total Alkalinity (TA)	Titrometric
Total Hardness (TH)	Titrometric
Chloride (Cl^-)	Titrometric
Fluoride	Spectrophotometer
Calcium (Ca^{2+})	Titrometric
Total Solids (TS)	Gravity Method

Results and Discussion

From laboratory tests various physicochemical parameters were analyzed. The test results for groundwater samples of open dug wells are shown in Table2. Table3 shows the laboratory results of Surface water of Waddepally lake. Permissible standards for drinking water stated by various international and national agencies are provided in Table 4. The water quality analysis results were compared with standard values recommended by World Health Organization (WHO) and Bureau of Indian Standards (BIS) for drinking purposes The following is the discussion of individual water quality parameters.

Water temperature in the open dug wells ranged between 28.2–31.2oC in the pre-monsoon, while 24.2- 28.2oC in the monsoon and 25- 29oC in the Post-monsoon seasons. In lake, the water temperature is decreasing with depth indicating thermal stratification with depth.

Table 2: Range of Physicochemical Parameters of Open Dug Wells

Parameters	Pre-Monsoon		Monsoon		Post-Monsoon	
	April	May	August	September	November	December
pH	7.03 - 8.01	7.01 - 7.87	7.25 - 8.03	7.28 - 8.01	7.69 - 8.21	7.83 - 8.27
Temperature (^{0}C)	28.2 - 31.2	28.2 - 31.4	24.2 - 28.2	24.4 - 28	25 - 28.4	25 - 29
Dissolved Oxygen	5 - 7.2	5 - 6.9	5.2 - 7.8	5.4 - 7.5	5.9 - 7.9	6.1 - 7.9
Chlorides	87 – 1110	94 - 1132	56 - 1021	54 - 1012	154 – 1113	124 - 1120
Alkalinity	200 – 490	242 - 498	150 - 450	170 - 460	254 – 494	284 - 540
Hardness	104 – 474	146 - 480	86 - 462	89 - 454	66 – 530	72 - 510
Electrical Conductivity #	204 – 2342	198 - 2165	242 - 2564	252 - 2420	383 – 2820	421 - 2895
Fluorides	0.4 - 0.87	0.41 - 0.72	0.56 - 0.9	0.67 - 0.95	0.67 - 0.91	0.54 - 0.98
Calcium	5 - 153	41 - 123	50 - 178	52 - 158	34 – 152	36 - 228
Carbonate	0.3 - 2.1	0.3 - 1.4	0.3 - 2.0	0.4 - 1.9	0.1 - 2.0	0.1 - 0.9
Bi Carbonate	199 – 488	241 - 496	150 - 450	170 - 460	109 – 374	199 - 539
Magnesium	10 – 90	9 - 85	4 - 93	1 - 92	6 – 114	2 – 106
Chemical Oxygen Demand	6 – 50	17 - 42	9 - 54	8 - 48	8 – 50	11 – 59
* All units in mg/l except pH, # Unit in micromhos/cm						

Table No 3: Physicochemical Parameters of Waddepally Lake

Parameter	Pre-Monsoon			Monsoon			Post-Monsoon		
	Top Surface	1 Meter	2 Meter	Top Surface	1 Meter	2 Meter	Top Surface	1 Meter	2 Meter
Temperature (^{0}C)	30.4	29.8	28.2	27.8	26.4	25.6	26.4	25.8	25.4
pH	7.61	7.44	7.20	7.92	7.79	7.77	7.92	7.27	7.28
EC #	476.38	511.9	528.1	443.50	444	447.3	586.38	596.1	605.38

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Alkalinity	156.63	163.88	180.2	145.00	145.	173.75	150	152.5	155.5
DO	5.76	6.08	5.45	5.45	6.3	5.15	6.05	6.48	5.44
Hardness	92.88	101.13	114.25	113	113.8	116.3	115.75	116.5	118
Chlorides	97.38	104.50	111.50	79.29	75.54	74.29	76.79	83.03	80.54
Fluorides	1.39	1.38	1.26	1.42	1.37	1.27	1.29	1.27	1.27
TS	43.25	43.13	49.00	39.81	38.31	56.81	63.63	93.81	120.38
Ca^{2+}	23.83	26.33	25.91	25.6	26.0	26.6	27.4	25.9	25.8
Mg^{2+}	16.8	18.2	21.5	21.9	21.2	21.2	21.5	22.0	22.4
CO_3^{2-}	1.1	0.5	0.3	1.0	0.9	1.1	0.4	0.3	0.4
HCO_3^-	155.5	163.3	180.1	139.2	141.8	186.4	155.0	150.0	152.5
COD	64	71.175	78.8	63.6	90	110.8	48.8	57.2	66
* All units in mg/l except pH, # Unit in micromhos/cm									

Table4: Drinking Water Quality Standards (Source: EPA 1979, WHO 1984, BIS 1991)

S.No.	Parameters	BIS 10500, 1991	MUD	EPA,1979 Secondary standards	WHO, 1984	Cause for rejection
1	pH	6.5-8.5	7.0-8.5	6.5-8.5	6.5-8.5	<6.5 and >9.2
2	Temperature (^{0}C)	N.M	N.M	N.M	N.M	<4 and >32
3	Total Solids (mg/l)	500	500	500	N.M	>1500
4	Dissolved Oxygen (mg/l)	8	N.M	6	8	<4
5	Chlorides (mg/l)	250	200	250	250	>1000
6	Total Alkalinity (mg/l)	200	N.M	N.M	250	>250
7	Total Hardness (mg/l)	300	200	N.M	500	>600
8	Electrical Conductivity (μ**mhos/cm)**	750-2250	N.M	N.M	500	>2250
9	Fluorides	1.0	1.0	2.0	1.0	>1.5
10	Calcium	75	75	N.M	75	200
11	Magnesium	30	30	N.M	30	0.5
12	Chemical Oxygen Demand	10	N.M	N.M	10	>10
BIS: Bureau of Indian Standards; EPA: Environmental Protection Agency; MUD: Ministry of Urban Development; WHO: World Health Organisation, NM: Not Mentioned.						

pH of the water samples of dug wells for the post monsoon were higher to monsoon followed by pre monsoon season. The values of the pH of the lake water varied with depth and seasons. The pH values were found decreasing with depth. The highest values of pH were found in monsoon season followed by winter and summer season.

The dissolved oxygen content of the groundwater in the wells ranged between 5- 7.2 mg/l in pre monsoon season, 5.2- 7.8 mg/l in monsoon and 5.9- 7.9 mg/l in the post monsoon period. The values of post monsoon season were greater than monsoon season followed by pre monsoon period. The values of dissolved oxygen of lake water were observed to be maximum at a depth of 1 meter in comparison with top surface and at a depth of 2 meter. Highest values were found during winter season. This may be due to dilution due to rainfall on lake directly.

The alkalinity content of the groundwater in the wells were observed to be higher in the post monsoon followed by pre monsoon and monsoon. The values are found increasing with depth. The maximum value was observed during the summer season followed by monsoon and winter season.

The hardness of the dug well water ranged between 104- 480 mg/l in pre monsoon periods, 86- 462 mg/l in monsoon and 66-530 mg/l in the post monsoon period. The greater values observed in post monsoon followed by pre monsoon and monsoon period. Hardness values of Lake water were observed to be increasing as we are increasing the depth in all the three seasons. Higher values were recorded during post monsoon season followed by monsoon and pre monsoon.

The chloride concentration in the groundwater dug well varied between 87- 1132 mg/l in the pre monsoon season, 54-1021 mg/l in monsoons and 124-1 120 mg/l in post monsoon period. The maximum value of chloride was in winter season followed by summer and rainy season. In Lake water, higher values of chloride were found at a depth of 2 meters during pre monsoon season and during monsoon season top surface has maximum chloride content whereas during post monsoon season, 1meter depth recorded the highest value.

The electrical conductivity of the dug wells was recorded as highest in the winter season followed by monsoon and summer season. The EC values are increasing depth wise. The highest values of EC were found in the winter season followed by summer and monsoon season.

The fluoride concentration in the groundwater (dug wells) varied between 0.4-0.87 mg/l in pre monsoon, 0.56-0.95 mg/l in monsoons and 0.67-0.98 mg/l in post monsoon period. The highest fluoride content was observed winter season followed by monsoon and summer season. Top surface of lake water has maximum fluoride concentration during all the three seasons and also found to be decreasing with depth.

The highest values of calcium were observed in the dug wells during monsoons followed by summer and winter. The maximum value of calcium in lake water was observed at a depth of 1 meter during pre-monsoon season and during monsoon season higher value was observed at 2 meters depth whereas during post-monsoon top surface was recorded the maximum value.

The COD of the groundwater wells varied between 6-50 mg/l in pre monsoon, 8-54 mg/l in monsoons and 8-59 mg/l in the post monsoon season. The highest COD values were observed in winter season followed by monsoon and summer season. The COD of the lake water were found to be increasing with depth during all the three seasons.

The magnesium content of the groundwater is varied between 9-90 mg/l in pre-monsoon, 1-93 mg/l in monsoon and 2-114 mg/l in post monsoon season. The highest magnesium content was observed in winter followed by monsoon and summer season. The magnesium concentration of the lake water was found to be increasing with depth and among all the three seasons, post-monsoon season recorded the maximum value.

Conclusions

The present study is an investigation on the physicochemical properties of the Waddepally lake and surrounding wells in Warangal city. The results show that quality of lake water samples are within the permissible limits of national standards, which requires minimum treatment before public distribution. From the analysis of the dug wells it was found that, the well no. 13 and well no. 14 are in the critical conditions and needed to be maintained in order to improve the quality of the well. Well no. 8, 9 and 15 has high concentration of chloride (>250). Well no. 1 has high Magnesium content and the bicarbonate content of this well is also very high, as a result the well water is very hard in comparision to other wells. In overall it can be concluded that 55% of the wells around Waddepally lake are having water quality within national standards whereas the remaining 45% of the wells are needed to be maintained to avoid future pollution. It is also advisable to boil the dug well water before human consumption.

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