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WATER QUALITY INDEX OF DUG WELLS IN THE VILLAGES OF DARYAPUR TALUKA, AMRAVATI DISTRICT, MAHARASHTRA, INDIA

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ABSTRACT

In present study water quality index is used to evaluate the seasonal water quality of dug wells from Daryapur Taluka of Amravati district. For calculation of Water Quality Index (WQI) assessment of seasonal water quality has been carried out in terms of physico-chemical parameters such as pH, TDS (Total Dissolved Solids), DO (Dissolved Oxygen), Alkalinity, Total Hardness, Chloride, Sulphate and COD (Chemical Oxygen Demand) and compared with ICMR and WHO standards. The values of water quality index during summer season were reported high (D1= 103.93 & D2=102.45) which indicates that the water is unsuitable for drinking purpose. During rainy seasons the reported values shows moderate decline (D1= 87.81 & D2=85.15) than the summer season indicates very poor water quality where as in winter season the values (D1= 74.34 & D2=73.97) are lower as compared to summer and rainy seasons and rated with poor water quality. Seasonal monitoring of water quality and treatment of water prior supply is needed.

KEYWORDS: Water quality, WQI, dug wells, Daryapur,

1. INTRODUCTION

Water is considered as one of the most indispensable natural resources existed in its different states namely liquid, solid and gas on the spot of the earth. It constitutes about 70% of the body weight of almost all living organisms and acts as media for both biochemical and chemical reactions. No life is possible without water as it tends to be an internal and external media for several organisms as well. It has been estimated that near about 97.2% of water present on earth is salty and 2.8% is fresh water out of which about 20% constitute as ground water. Ground water is of much importance than surface water due to certain characteristics (Goel, 2000). This natural resource has been continuously utilized for different purposes such as domestic, industrial and irrigation on the basis of its intrinsic quality. Therefore it should be evaluated in terms of its quality and quantity.

Ground is the main source of drinking water around the world and is highly valued by the population for their survival (UNESCO).

The deterioration of ground water quality can be due to unplanned urbanization and industrialization (Singh et al., 2002), over use of fertilizers (Shamruk et al. 2001) and certain mining activities (Lin et al., 2003). Thus assessment of water quality is very important. Water Quality Index (WQI) is regarded as most effective tool for the communication of water quality. In present study water quality index is used to evaluate the seasonal water quality of dug wells from Daryapur Taluka of Amravati district. However many researchers (Gupta et al.,2011, Tambekar et al., 2008 and Rajankar et al. 2009) and government agencies like MPCB, CGWB explore Amravati district before for its ground water quality by using water quality index.

2. MATERIAL AND METHODS

2.1 Sampling site

Two villages namely Mahimapur and Shivar of Daryapur Taluka, Amravati District Maharashtra were selected for study. Dug wells in these villages were considered as sampling sites and represented as sampling site D1 for Mahimapur and D2 for Shivar village in present study.

2.2 Collection of Water Samples and Analysis

Water samples for physico-chemical analysis were collected monthly in each season during a year 2012. Water samples collected from sampling sites were analyzed on site and in laboratory as per the guidelines and standard methods prescribed by American Public Health Association (APHA 2005). For calculating the seasonal WQI parameters like pH, Total Dissolved Solids (TDS), Alkalinity, Total Hardness, Chloride, Dissolved Oxygen, Sulphate, and Chemical Oxygen Demand (COD) has been considered.

2.3 Calculation of WQI

For calculation of water quality rating (qn), seasonal mean values of water quality parameters were considered whereas calculation of subindex (qn.Wn), the drinking water standards (Sn) and unit weight (Wn) was taken as per recommended agencies ICMR and WHO (Table 1).The calculation of WQI was carried out using Weighted Arithmetic Index method (Brown et al. 1972) in the following steps.

Table 1: Water quality parameters with their std. values (Sn) and unit weight (Wn) values for Water Quality Index (WQI) calculation.

Parameters	Standards (Sn)	Unit Weights (Wn)
pH	7.0-8.5 (ICMR)	0.218176
TDS	500 mg/l (WHO)	0.003708
Alkalinity	120 mg/l (ICMR)	0.01545
Total Hardness	300 mg/l (ICMR)	0.0061816
Chloride	250 mg/l (ICMR)	0.0074179
DO	5.0 mg/l (ICMR)	0.37089
Sulphate	250 mg/l (WHO)	0.0074179
COD	20 mg/l (ICMR)	0.02507

2.3.1 Calculation of Sub index or Quality Rating (qn)

Let there be n water quality parameters and quality rating or subindex (qn) corresponding to n^{th} parameter is a number reflecting the relative value of this parameter in the polluted water with respect it's standard permissible value. The qn is calculated by using following 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 n^{th} parameter at given sampling site

S_n - standard permissible value of n^{th} parameter.

V_{io} - Ideal value of n^{th} parameter in pure.

All ideal values (V_{io}) are taken as zero for the drinking water except for pH=7.0 and Dissolved Oxygen = 14.6 mg/l

2.3.2 Calculation of Unit Weight (Wn)

The unit weights (Wn) for various water quality· parameters are inversely proportional to the recommended standards for the corresponding parameters.

$$W_n = \frac{K}{S_n}$$

Where, W_n - Unit weight for n^{th} parameter.

S_n - Standard value for nth parameter.

K - Constant for proportionality.

2.3.3 Calculation of WQI

WQI is calculated from the following equation.

$$\text{WQI} = \sum_{n=1}^{n} q_n w_n \Big/ \sum_{n=1}^{n} w_n$$

The suitability of WQI values for human consumption were rated according to Mishra and Patel (2001) as given in table 2.

Table 2.: Water quality rating values for determination of Water Quality Index (WQI), according to Mishra and Patel (2001).

WQI values	Status
0-25	Excellent
26-50	Good
51-75	Poor
76-100	Very Poor
100 & Above	Unsuitable for drinking

2.4 Statistical analysis

The data obtained in triplicate were analyzed by SPSS statistical package (Window version 17) and Microsoft software Excel 2007 and represented as mean values with standard deviation in figures and tables.

3. RESULTS AND DISCUSSION

3.1Seasonal water quality parameters

Seasonal observations on water quality parameters of sampling sites are represented in table 3.

pH is one of the most important parameter that shows acid-base neutralization and water softening. Seasonal mean values of pH during different seasons shows combination of both acidic and alkaline nature of water. However it remains under the prescribed limit value 7.0 – 8.5 of ICMR for drinking water during winter in D1(7.075) and D2(7.07) sampling sites.

TDS is a direct measure of organic and inorganic substances dissolved in waters especially inorganic substances that are dissolved in water. Seasonal variations of TDS values in both sampling sites shows higher concentration during summer (D1= 580 mg/l, D2= 568 mg/l) followed by rainy (D1= 488 mg/l, D2= 533.25 mg/l) and less in winter (D1= 445 mg/l, D2= 437 mg/l) season. Winter season values of both sampling sites favors the desirable limit value 500 mg/l of WHO for drinking water.

Dissolved oxygen is one of the basic parameters in water, important for the metabolic activities of all aerobic aquatic organisms. Seasonal mean values of DO in both sampling sites were increased from summer (D1= 2.425 mg/l, D2= 2.5 mg/l) followed by rainy (D1= 3.75 mg/l, D2= 3.87 mg/l) and higher in winter (D1= 4.25 mg/l, D2= 4.35 mg/l) season. Seasonal values in both sampling sites for DO were below the desirable range 5.0 mg/l of ICMR (Table 4 & Fig.3).

Alkalinity of water is a measure of its capacity to neutralize acids and provides an index for the nature of salts present in the water samples. Seasonal variations in the mean values of Alkalinity were increased from winter (D1= 122.5 mg/l, D2= 138.5 mg/l) followed by rainy (D1= 173.5 mg/l, D2= 140 mg/l) and higher in summer (D1= 226.25 mg/l, D2= 230.75 mg/l) season in both the sampling sites. However none of the seasonal values suggest its suitability for drinking water as the desirable range of ICMR is 120 mg/l.

Total Hardness is most commonly associated with the ability of water to precipitate soap. Chemically, hardness is often defined as the sum of polyvalent cation ($Ca^{++}$and Mg^{++}) concentrations dissolved in the water. A seasonal mean value of Total hardness exceeds the desirable range 300 mg/l of ICMR during all seasons (D1= 556.5 - 685 mg/l, D2= 580 – 695.5 mg/l) in both the sampling sites which is unsuitable for drinking purpose.

Naturally, chlorides occur in all type of waters, chloride in the groundwater contributed by the minerals like, mica, apatite, and hornblende (Das and Malik, 1998). A seasonal mean value of Chloride do not exceeds the desirable range 250 mg/l of ICMR during rainy and winter seasons except summer season (D1= 255.07 mg/l, D2= 243.96 mg/l) in both the sampling sites.

Sulphate is utilized by all living organisms in the form of both mineral and organic sulphates. A seasonal mean values of Sulphate remains in the desirable range 250 mg/l of WHO during all seasons (D1= 164.75 – 223.25 mg/l, D2= 137.5 - 227 mg/l) indicating suitability of water for drinking purpose.

COD is a measure of the oxygen equivalent of the organic matter content of a sample that is susceptible to oxidation by a strong chemical oxidant (WHO, 1984). A seasonal mean variation in values of COD in both sampling sites (D1= 17.12 - 20 mg/l, D2= 17.37- 19.5 mg/l) favors the desirable range 20 mg/l of ICMR indicating the suitability of water for drinking purpose.

Overall seasonal water quality reveals that it is mainly affected during summer followed by rainy season whereas winter season water quality suppose to be the good one up to certain extent. However some of the parameters like Total hardness, Alkalinity which exceeds the desirable limit during all seasons indicates prominent problem as the study area falls under the salinity prone region characterized by the presence of basaltic (Ca-HCO3 & CaCl) and alluvial (Na-HCO3 & NaCl) aquifers (MPCB, 2012-13) and also to the geology and hydrology of the region (Tiwary et al. 1995; Tiwary and Dhar1994). Alkalinity, TDS, pH and DO were reported elevated concentrations in summer season followed by rainy seasons might be due to climatological factors (Kant and Kachroo 1971) as well as anthropogenic activities (Singh, 1992). Similar observations were reported on ground water quality of dug wells by Tambekar and Neware (2012) while assessing the ground water quality of Amravati District, Warhate et al. (2006) on assessment of ground water quality of mining affected areas of Yavatmal District.

3.2 Seasonal Water Quality Index (WQI)

The seasonal water quality rating (qn) values, subindex values (qn Wn) values and calculated seasonal water quality index values are represented in table 4, table 5 and table 6 respectively.

The calculated values of seasonal water quality index (Table 6 & Fig1) significantly differ during each season in both D1 and D2 sampling sites. The values of water quality index during summer season were reported high (D1= 103.93 & D2=102.45) which indicates that the water is unsuitable for drinking purpose. During rainy seasons the reported values shows moderate decline

(D1= 87.81 & D2=85.15) than the summer season indicates very poor water quality where as in winter season the values (D1= 74.34 & D2=73.97) are lower as compared to summer and rainy seasons and rated with poor water quality.

Overall in both the sampling sites water quality index values reveals that the water quality during different seasons is unsuitable for drinking purpose. The governing factor behind deterioration of water quality with respect to the higher seasonal water quality index values might be the hardness and alkalinity as mentioned above. According to the ground water quality survey carried out in the year 2007, 2008 and 2009 by Maharashtra state pollution control board (MPCB Report 2010), the villages Mahimapur (Sampling site D1) and Shivar (Sampling site D2) in present study were reported with 103 (with Fe) and 220 (with Fe) water quality index values respectively and rated with poor water quality. Report also stated exceedences of total hardness, TDS in Amravati region. Gupta et al. (2011) reported higher values of total hardness and poor water quality of Daryapur. Similar findings were also reported on water quality index of adjacent district Akola (Tambekar et al., 2008) and Nagpur (Rajankar et al., 2009) by using CCME and NSF water quality index respectively.

4. CONCLUSION

In both the sampling sites seasonal water quality index values reveals that the water quality during different seasons is unsuitable for drinking purpose. The governing factor behind deterioration of water quality with respect to the higher seasonal water quality index values might be the hardness and alkalinity. Seasonal monitoring of water quality and treatment of water prior supply is needed.

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Table 3: Seasonal mean variation in water quality parameters of sampling site D1 and D2

	Sampling site D1			**Sampling site D2**			
WQP	**Summer**	**Rainy**	**Winter**	**Summer**	**Rainy**	**Winter**	**Water Std.**
pH	6.155 ±0.17	6.425 ±0.31	7.075 ±0.32	6.20 ±0.18	6.47 ±0.26	7.07 ±0.33	**7-8.5(ICMR)**
TDS	580 ±44.8	488 ±24.6	445 ±48.1	568 ±22.6	533.25 ±34.2	437 ±33.5	**500 (WHO)**
DO	2.425 ±0.29	3.75 ±0.46	4.25 ±0.51	2.5 ±0.31	3.87 ±0.42	4.35 ±0.38	**5.00 (ICMR)**
Alk.	226.25 ±7.0	173.5 ±21.4	122.25 ±24.4	230.75 ±8.3	140 ±27.2	138.5 ±53.6	**120 (ICMR)**
TH	685 ±46.7	536.75 ±24.8	556.5 ±22.7	695.5 ±48.1	528 ±15.0	580 ±76.5	**300 (ICMR)**
Chl.	255.07 ±7.9	190.87 ±15.2	183.93 ±15.1	243.96 ±9.4	185.84 ±10.1	191.43 ±25.6	**250 (ICMR)**
Sul.	223.25 ±8.3	164.75 ±9.6	165.25 ±33.9	227 ±13.2	137.5 ±31.3	189.5 ±38.9	**250 (WHO)**
COD	20 ±0.70	19.35 ±2.79	17.12 ±0.94	19.5 ±1.11	18.5 ±0.40	17.37 ±0.47	**20 (ICMR)**

*All values are in mg/l except pH, ±SD n=4,

WQP= Water Quality Parameters, TDS= Total Dissolved Solids, DO= Dissolved Oxygen, Alk.=Alkalinity, TH=Total Hardness, Chl.=Chloride, Sul.=Sulphate, COD=Chemical Oxygen Demand

Table 4: Seasonal Water Quality Rating (q_n) values of water quality parameters of sampling sites.

	Sampling site D1			**Sampling site D2**		
Parameters	**Summer**	**Rainy**	**Winter**	**Summer**	**Rainy**	**Winter**
pH	56.33	38.33	5.0	53.33	35.33	4.66
DO	126.82	113.02	107.81	126.04	111.77	106.77

TDS	116.00	97.60	89.00	113.60	106.60	87.40
Alkalinity	188.54	144.58	188.54	191.66	116.66	191.66
Total Hardness	228.33	178.66	185.50	231.66	176.00	193.33
Chloride	102.02	76.34	73.57	97.58	74.00	76.57
Sulphate	89.30	65.90	66.10	90.80	55.00	75.80
COD	100	96.75	85.60	97.50	92.50	86.85

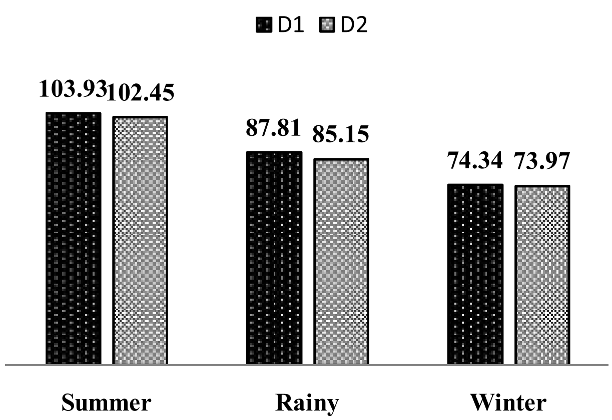
Table 5: Seasonal calculated Subindex (q_n W_n) values of water quality parameters of sampling sites.

	Sampling site D1			**Sampling site D2**		
Parameters	**Summer**	**Rainy**	**Winter**	**Summer**	**Rainy**	**Winter**
pH	12.289	8.362	1.090	11.635	7.708	1.016
DO	47.036	41.917	39.985	46.746	41.454	39.599
TDS	0.430	0.361	0.330	0.421	0.395	0.324
Alkalinity	2.912	2.233	2.912	2.961	1.802	2.961
Total Hardness	1.411	1.104	1.146	1.432	1.087	1.195
Chloride	0.756	0.566	0.545	0.723	0.548	0.567
Sulphate	0.662	0.488	0.490	0.673	0.407	0.562
COD	2.507	2.425	2.145	2.444	2.318	2.177

Table 6: Calculated values for Water Quality Index (WQI) determination (Seasonal)

***Sampling sites**	**Seasons**	$\sum_{n=1}^{n} q_n w_n$	$\sum_{n=1}^{n} w_n$	$\sum_{n=1}^{n} q_n w_n \, / \sum_{n=1}^{n} w_n$	**Status of Water Quality based on WQI (Mishra & Patel, 2001)**
D1	**Summer**	68.003	0.6543114	103.93	Unsuitable for drinking (100 & Above)
	Rainy	57.456		87.81	Very poor (76 - 100)
	Winter	48.643		74.34	Poor (51 - 75)
D2	**Summer**	67.035	0.6543114	102.45	Unsuitable for drinking (100 & Above)
	Rainy	55.719		85.15	Very poor (76 - 100)
	Winter	48.401		73.97	Poor (51 - 75)

Fig.1: Seasonal WQI of sampling sites D1 & D2



The special study carried out by CGWB in Purna River Alluvial basin indicates that in southern parts of Anjangaon and Achalpur talukas and entire Daryapur taluka brackish to saline ground water has been observed with EC ranging from 2000 to more than10000 □ mhos/cm at 25°C. Thus it is inferred that these areas of Purna River Alluvium are affected by inland salinity problem due to diagenetically altered meteoric water having longer residence time, high rate of evapotranspiration and it is restricted to the sandy aquifers inter-layered with clayey beds due to which less recharge of ground water is taking place.