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Analysis of Drinking Water Quality through Water Quality Index (WQI) Calculated from Ahmedabad City

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Abstract: ***According to UNDP World Urbanization Prospect Data Set, nearly 4.2 billion of World's human population lives in towns and cities. After independence, the urban population of India has grown nearly five times during last 75 years. Gujarat has more than 37 % people living in cities and towns, higher than the average of India. Ahmedabad is the largest city of Gujarat and sixth largest city in India with a population of almost 5 million. It is located at 23.03^0 N 72.58^0 E. The present study was carried out to find water quality index (WQI) of drinking water from the data of 36 samples from 18 areas of Ahmedabad city studied in the year 2004. Water quality index is one of the most effective ways to communicate water quality information to the public and administrators. The data of total hardness, calcium hardness, magnesium hardness, chlorinity and salinity were subjected to WQI. The WQI was calculated by taking the weighted arithmetic mean of the quality rating using Gujarat Pollution Control Board (GPCB) drinking water standards. The present data indicate that most of samples are not suitable for drinking purpose. However, they can be used for drinking after proper treatment or else for other purposes.***
Keywords: WQI, Physico-chemical Parameters, Drinking water, Ahmedabad

I. INTRODUCTION

A water quality index (WQI) provides a single number (like a grade) that expresses overall water quality at a certain location and time based on several water quality parameters. The objective of an index is to turn complex water quality data into information that is understandable and useable by the public. This type of index is similar to the index developed for air quality that shows if it's a red or blue air quality day. The use of an index to "grade" water quality is a controversial issue among water quality scientists and institutes (Kankal et al., 2008; Shah et al., 2008; Suthar and Mesariya, 2012; Suthar and Suthar, 2010). A single number cannot tell the whole story of water quality; there are many other water quality parameters that are not included in the Water Quality Index. The index presented here is not specifically aimed at human health or aquatic life regulations. However, a water index (numerical value) based on some very important parameters can provide a simple indicator of water quality. It gives the public a general idea the possible problems with the water in the region (Khandwala and Suthar, 2007). Our previous studies (Suthar et al., 2008a-d; Suthar et al.,) showed that various areas of Ahmedabad city have poor quality of drinking water. Hence, the present study was carried out as a part of continuous monitoring.

II. MATERIALS AND METHODS

The present study is associated with water quality evaluated from 18 areas of Ahmedabad city of Gujarat state. Ahmedabad is the largest city in Gujarat state located on the bank of Sabarmati River. It is located at 23.03°N and 72.58°E. Total 36 tap water samples were collected from municipal and tube well sources in the morning and labelled appropriately (Suthar et al., 2008a-d). Samples were analysed for various physico-chemical characteristics by standard methods (Sunilkumar & Ravindranath, 1998). The chemical parameters analysed were total hardness, calcium hardness, magnesium hardness, chlorides and salinity for WQI calculation.

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The data were compared with Gujarat Pollution Control Board (GPCB) drinking water standards as mentioned by Kapila & Mehta (2006). These standards are same as IS: 10500 of Bureau of Indian Standards for parameters studied (Shankar & Balasubramanya, 2008). The data were analysed bio-statistically by calculating mean, range (minimum and maximum values) and Student's t-test. Water quality index (WQI) was calculated based on GPCB standards.

A. Water Quality Index (WQI)

Water quality index (WQI) is a very useful and efficient method for assessing and communicating the information on overall quality of water. To determine suitability of water for drinking purposes, WQI is computed as per various researchers (Sinha and Saxena, 2006; Asadi et al., 2007; Dwivedi & Pathak, 2007). Five physicochemical parameters, viz. total hardness, calcium hardness, magnesium hardness, chlorinity, and salinity values of 2004 data were used to calculate WQI (Suthar et al., 2008a-d).

1) Calculation of unit weight (Wi)

For a given pollutant or component of water (i^{th} parameter), if it is more harmful then its recommended standard (Si) for drinking water will have smaller magnitude. So, the unit weight (Wi) for the i^{th} parameter is assumed to be inversely proportional to its recommended standard (Si) for the i^{th} parameter. Where, i = 1, 2, 3…, n and n = number of parameters considered for WQI (n = 5 as five parameters studied in the present study).

Thus, $Wi = K/Si$

Where, K = Proportionality constant, Wi = Unit weight for i^{th} parameter, Si = Drinking water standard (i.e. highest desirable limit) prescribed by GPCB (or BIS) for i^{th} parameter].

The proportionality constant (K) was derived from

$$\sum_{i=1}^{n} K = [1/\sum 1/Si]$$

These assumed unit weights (Wi) for all five water quality parameters used here as given in the last column of Table 1.

2) Calculation of quality rating (qi)

The quality rating (qi) was calculated for the i^{th} parameter using the following formula.

$$qi = [(V_{actual} - V_{ideal})/(V_{standard} - V_{ideal})] \times 100$$

Where, qi = Quality rating of i^{th} parameter; V_{actual} = Actual value of the i^{th} parameter obtained from laboratory analysis; V_{ideal} = Ideal value of ith parameter which can be obtained from the standard tables (here, for all parameters, V_{ideal} is equivalent to zero) $V_{standard}$ = GPCB standard value of i^{th} parameter (i.e., highest desirable value of i^{th} parameter as per GPCB standards)

3) Calculation of subindex

The subindex (qiWi) has been calculated by multiplying quality rating (qi) and unit weight (Wi) of i^{th} parameter.

4) Calculation of Water Quality Index (WQI)

The water quality index was calculated by taking the weighted arithmetic mean of the quality rating using following formula adopted by various investigators (Swarnalatha et al. 2007, Dwivedi & Pathak 2007, Shankar & Balasubramanya, 2008; Suthar et al., 2010).

$$WQI = [\sum qiWi] / [\sum Wi]$$

Here, $\sum Wi = 1$ was considered. Both the summations were taken from i = 1 to i = n = 5 (i.e., the total number of parameters considered in the present study). The status of water quality based on WQI was evaluated as per classification adopted by various investigators (Asadi et al., 2007; Suthar et al., 2010; Shah et al., 2008) as given in Table 1.

III. RESULTS

The water quality index (WQI) showed that almost 29 samples (80%) were having the index value more than 100. Only 7 samples were having WQI value less than 100. Both Municipality and Tubewell sources do not have any significant difference in mean WQI values. The calculated WQI data suggests that drinking water is unsafe as per GPCB standards adopted in present study.

Table: 1 Water Quality Parameters, Their GPCB Standards, Bureau Of Indian Standards (BIS:2003) Standards and assign unit weights

Name of Parameters	Standard Value (Si) (Highest Desirable Limit) (HDL)	Maximum Permissible limits (MPL)	Unit weights used for WQI values (Wi)
Total Hardness	300	600	0.0592898
Calcium Hardness	75	200	0.2371592
Magnesium Hardness	30	90	0.5938982
Chlorinity	250	1000	0.0711477
Salinity	--(450#)	1800	0.0395265
∑Wi			1

GPCB = Gujarat Pollution Control Board standard values (as adopted by Kapila and Mehta, 2006)
#Salinity values were calculated from chlorinity value;
Double Dash '--' represents there is no standards prescribed by GPCB (Kapila and Mehta, 2006).

Table: 2 Status of Water Quality Based on Water Quality Index (WQI) By

WQI value	Status	Number of samples in the present study	Percentage (%)
0-25	Excellent	00	0.00%
26-50	Good	01	2.78%
51-75	Poor	01	2.78%
76-100	Very poor	05	13.89%
Above 100	Unsuitable for drinking	29	80.55%
	Total	36	

Weighted arithmetic mean of the quality rating (inversely proportion) using formula adopted by investigator (Please refer Swarnalatha et al., 2007; Dwivedi & Pathak, 2007; Shankar & Balasubramanya, 2008; Suthar et al., 2010).

Table: 3 Sample and Area -wise Water Quality Index (WQI) of Ahmedabad City (For Actual Value Of Each Parameter Please refer Suthar et al., 2008-b).

Sample Number (S-1 to S-33)	Area	Sample Source	WQI Calculated
S-3	Amraiwadi	Tubewell	202
S-33	Amraiwadi	Tubewell	447
S-10	Bapunagar	Tubewell	48
S-13	Bapunagar	Tubewell	169
S-14	Bapunagar	Municipality	101
S-27	Bapunagar	Municipality	128
S-31	Bapunagar	Municipality	59
S-8	CTM	Municipality	155
S-12	CTM	Tubewell	314
S-35	CTM	Tubewell	88

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S-25	Ellisbridge	Tubewell	93
S-36	Shah-e-alam	Tubewell	118
S-23	Ghodasar	Municipality	194
S-26	Ghodasar	Municipality	261
S-19	Hatkeshvar	Municipality	178
S-1	Isanpur	Municipality	109
S-15	Kankaria	Municipality	352
S-30	Kankaria	Municipality	550
S-6	Maninagar	Municipality	306
S-7	Maninagar	Tubewell	162
S-20	Maninagar	Municipality	95
S-32	Maninagar	Tubewell	111
S-2	Meganinagar	Tubewell	78
S-18	Narayan Nagar	Municipality	128
S-5	Naroda	Municipality	106
S-4	Narol	Tubewell	296
S-17	Narol	Municipality	136
S-34	Nikol	Municipality	94
S-9	Odhav	Tubewell	325
S-11	Odhav	Tubewell	380
S-16	Rakhial	Municipality	205
S-22	Rakhial	Municipality	110
S-21	Vastral	Tubewell	225
S-24	Vastral	Municipality	223
S-28	Vastral	Tubewell	451
S-29	Vastral	Tubewell	178

Table : 4 water quality index (WQI) as per sample source.

Source	Total Number of Samples Studied and Used for Analysis	Water Quality Index -WQI Value (Mean ± SEM)	Minimum Value Recorded	Maximum Value Recorded
Municipality	19	183.68 ± 27.049 ^{NS}	59	550
Tubewell	17	219.19 ± 32.420 ^{NS}	48	451
Total	36	199.31 ± 20.503 ^{NS}	48	550

Bio-statistical Method Used: Student's t-test; two-tailed; Unequal Variance;
SEM= Standard Error of Mean; NS= Not Significant.

IV. DISCUSSION

Water quality index is one of the most effective ways to communicate water quality information to the public and policy makers. A water quality index (WQI) may be defined as a rating reflecting the composite influence of a number of water quality parameters on the overall quality of water (Shankar & Balasubramanya, 2008). The numerical value of the water quality index implies that the water under consideration is fit for human consumption if its WQI is less than 100. Moreover, the larger the WQI value, the water is considered to be more polluted. In the present study, WQI values exceeded 100 in all samples collected. It is considered that the water samples studied were unfit for drinking purpose without suitable treatment. In the present study, the major factor for higher WQI values in most of the samples may be the higher due to calcium and magnesium hardnesses (Suthar et al., 2011; Suthar et al., 2013; Suthar et al., 2017; Suthar et al., 2022).

V. CONCLUSION

Water Quality Index (WQI) can be used to calculate and analyse on the bases on the number of physico-chemical parameters of drinking water studied and best analyzed on the basis of mathematical / statistical procedures.

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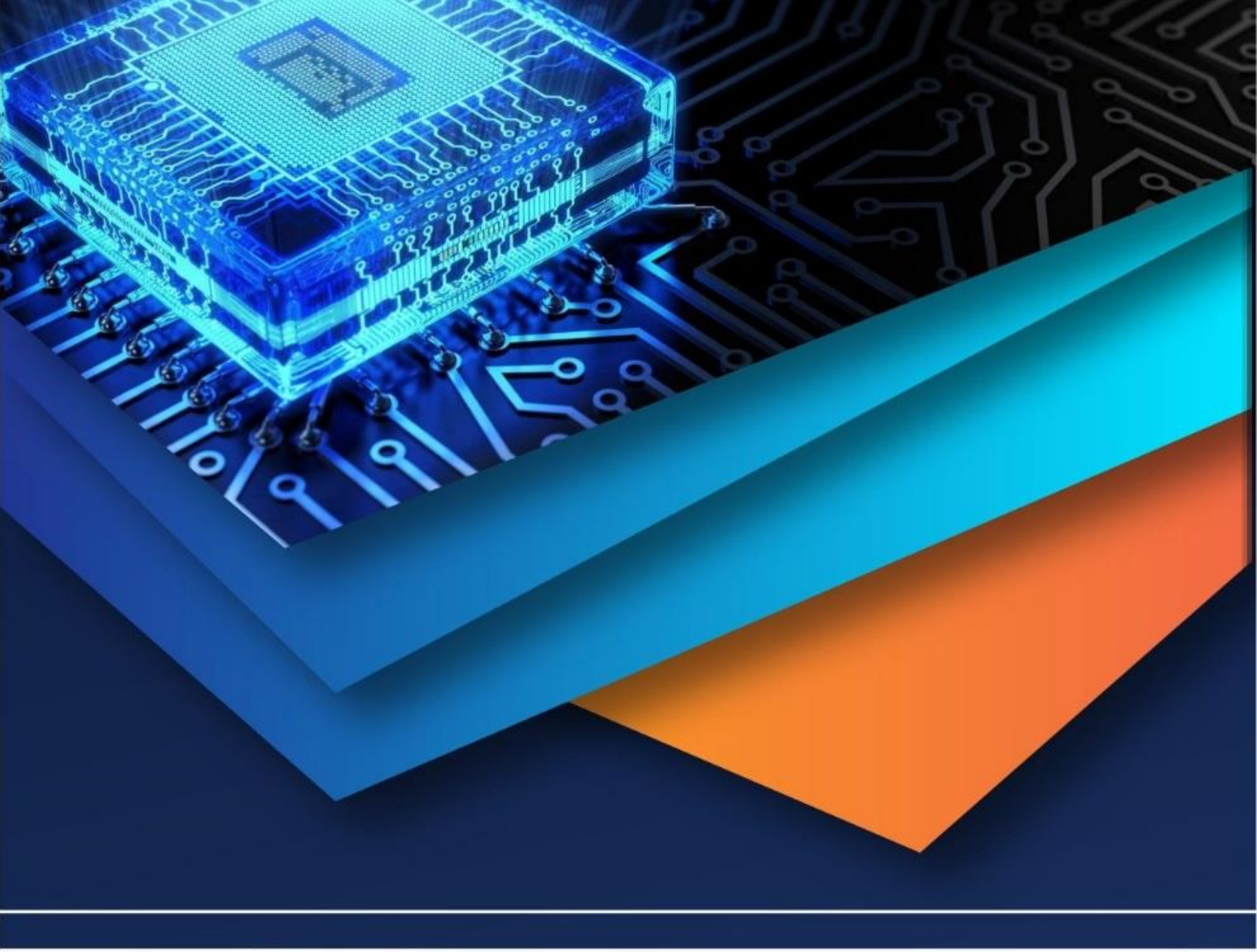
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