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Evaluation of Groundwater quality by using Water Quality Index (WQI) method and it's Case study

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Abstract— Groundwater is a natural resource for drinking water. Like other natural resources, it should be assessed regularly and people should be made aware of the quality of drinking water. The development of urban regions in developing country needs the multifaceted study of qualitative and quantitative stresses on available natural resources there within. In this type of multifaceted study, the emphasize should be focused on relative weightage of concern parameters allied with issue rather than traditional identical weightage system. The present study is intended with similar type of multifaceted approach to determine the Groundwater Quality Index (GWQI) and also the case studies for the urban pockets of Surat city situated in Gujarat state-India. Under this study the various seasonal groundwater samples were collected for some consecutive years and the respective physiochemical analysis was carried out for groundwater quality parameters like pH, TDS, Chlorides, Hardness, Turbidity, Nitrates, Calcium, Magnesium, Sulphates Alkalinity, COD and Electrical Conductivity (EC) and essentially responsible for groundwater quality degradation in the said area. The outcome of this study indicates that the groundwater of the study area needs respective degree of quality improvement by the most feasible approach like Artificial Groundwater Recharging.

Keywords- Groundwater, Water Quality Index, Water Standards, Water Parameters, Weightage base method

I. INTRODUCTION

The development of growing regions in developing countries is allied with several social, economical, environmental and technical aspects of concern area along with the study of available sustainable resources for civilization. Among all, Groundwater is one of the vital resources confirmed everlastingly. In context of quality and quantity, groundwater fluctuates invariably in its own which reflects the time to time status of groundwater as a whole for the region [10]. Water quality shows water-rock interaction and indicates residence time and recharge zone confirmation. Thus, water quality indicators must reflect mineralization process, integrate reservoir properties and be sensitive to ground water recharge rate and flow direction. The concept of ground water quality seems to be clear, but the way of how to study and evaluate it still remains tricky. The chemical composition of ground water is controlled by many factors that include the composition of precipitation, mineralogy of the watershed and aquifers, climate and topography. These factors can combine to create diverse water types that change in composition spatially and temporally [10].

Human health is threatened by most of the agricultural development activities particularly in relation to excessive application of fertilizers and unsanitary conditions. Rapid urbanization, especially in developing countries like India, has affected the availability and quality of groundwater due to its overexploitation and improper waste disposal, especially in urban areas. According to WHO organization, about 80% of all the diseases in human beings are caused by water [6]. Once the groundwater is contaminated, its quality cannot be restored by stopping the pollutants from the source. It therefore becomes imperative to regularly monitor the quality of groundwater and to device ways and means to protect it. Water quality index is one of the most effective tools to communicate information on the quality of water to the concerned citizens and policy makers [5]. It, thus, becomes an important parameter for the assessment and management of groundwater. WQI is defined as a rating reflecting the composite influence of different water quality parameters. WQI is calculated from the point of view of the suitability of groundwater for human consumption. The objective of the present work is to discuss the suitability of groundwater for human consumption based on computed Water Quality Index values. [3]

II. MATERIAL AND METHODS

Groundwater samples were collected from urban segments of Surat City. Each of the groundwater samples was analyzed for groundwater quality parameters such as pH, electrical conductivity, TDS, Hardness, chloride, using pH, TDS, Chlorides, Hardness, Turbidity, Nitrates, Calcium, Magnesium, Sulphates Alkalinity, COD and Electrical Conductivity(EC) standard procedures suggested by American Public Health Association (APHA) [2].

A. Computation of Ground Water Quality Index:

For computing WQI three steps are followed. In the first step, each of the all parameters has been assigned a weight (w_i) according to its relative importance in the overall quality of water for drinking purposes. The maximum weight of 5 has been assigned to the parameter nitrate due to its major importance in water quality assessment. Magnesium which is given the minimum weight of 2 as magnesium by itself may not be harmful. In the second step, the relative weight (W_i) is computed from the following equation [8]:

Second step, Relative weight (W_i) is computed from the following equation:

$$\mathbf{W_i = w_i / \sum w_n}$$

Where (W_i) is the Relative Weight, (w_i) is the Weight of each parameter and 'n' is the number of parameters.

In the third step, a quality rating scale (q_i) for each parameter is assigned by dividing its concentration in each water sample by its respective standard according to the guidelines laid down in the **IS:10500, 2012** and the result is multiplied by 100:

$$\mathbf{q_i = (C_i/S_i) \times 100}$$

Where q_i is the quality rating, C_i is the concentration of each chemical parameter in each water sample in mg/*l*, and S_i is the BIS (Bureau of Indian standards) water standard for each chemical parameter in mg/*l* according to the guidelines of the IS-10500, 2012.

For computing the Water Quality Index (**WQI)**, the $\mathbf{SI_i}$ is first determined for each chemical parameter, which is then used to determine the **WQI** as per the following equation.

$$\mathbf{SI_i = W_i \times q_i}$$
$$\mathbf{WQI = \sum SI_i}$$

Where $\mathbf{SI_i}$ is the Sub Index of I^{th} parameter, $\mathbf{q_i}$ is the rating based on concentration of i^{th} parameter and **n** is the number of parameter. The computed WQI values are classified into five types "excellent water", "good water", "poor water" "very poor water" and "water unsuitable for drinking" as shown in Table–1.

Table – 1 Water quality classification based on WQI value

Water quality classification based on WQI value		
WQI Value	**Class**	**Water quality**
< 50	I	Excellent
50-100	II	good water
100-200	III	poor water
200-300	IV	very poor water
> 300	V	Water unsuitable for drinking

III. CASE STUDY

A. Case study – 1: Groundwater water quality characterization by Water Quality Index (GWQI) method in Surat, Gujarat, India

125 water samples were collected from Borewell of thirty nine area of Surat City. Samples were collected in polythene bottles and analyzed for various water quality parameters as per standard APHA procedures. The experimental values were compared with standard values recommended by World Health Organization (WHO) and Indian standards for drinking purposes. The calculation of Water Quality Index (WQI) was done by Weighted Arithmetic Index method.

For those 125 samples, Author had found Ground Water Quality Index and also established that water is suitable for drinking or not. They have shown in their study that Index is useful to turn multifaceted water quality data into simple information that is comprehensible and useable by the public. It is one of the aggregate indices that have been accepted as a rating that reflects the composite influence on the overall quality of numbers of precise water quality characteristics. Water quality index provide information on a rating scale from zero to hundred. Lower value of WQI indicates better quality of water and higher value shows poor water quality [8].

B. Results & Discussion for Case Study – 1:

The pH of the groundwater samples are neutral or close to it as they all range from 7 to 7.5 which are within the permissible limits 6.5- 8.5 given by Indian Standards. The Conductivity of the ground water in Surat ranges from 1.40 - 744.7µs. Sulphate concentration in collected groundwater samples is ranged from 5-7 mg/l as in the permissible limit of 200mg/l as per Indian standards and 250mg/L as per WHO Standards. The levels of Flouride in the groundwater samples ranged from 0.35-7.62 mg/L which exceeds the permissible limit of 1 mg/L as per Indian standards as well as WHO Standards.

Table – 2 Classification of based on Hardness by Sawyer & McCarthy

Water quality classification based on WQI value		
WQI Value	**Water quality**	**Percentage**
0-75	Soft	10.26
75-150	Moderately Soft	33.33
150-300	Hard	28.21

Above 300	Very Hard	28.21

Iron concentration in the groundwater samples are varies from 0 to 7.17 mg/L which exceeds the permissible limit of 0.3 mg/L as per Indian standards and 0.1 mg/L as per WHO Standards. Total Hardness varies from 16-2630 mg/L as CaCO3. The hardness values for the study area are found to be high for almost all locations and determined to fall above the desirable limit of WHO specification and Indian standards. Alkalinity of the samples are in the range of 8-176 mg/L. Maximum concentration is found in ground water sample collected from Udhna is 176 mg/L. Dissolved Oxygen level in ground water is 2.06-3.7mg/L, Maximum concentration is found in ground water sample collected from Ved Road is 3.7mg/L

Table – 3 Water quality classification based on WQI value

Water quality classification based on WQI value		
WQI Value	**Water Quality**	**Percentage**
< 50	Excellent	10.3
50-100	good water	56.4
100-200	poor water	30.8
200-300	very poor water	2.4
> 300	Water unsuitable for drinking	0

Results indicate that Surat City lies in the range of poor to tolerable good but the temporally analysis indicates that such quality fluctuates in its own and even in some of the area it has been found within the range of very poor water. Similarly in 2009 research carried out on water quality index (WQI) of ground water of Surat City, India, they have exposed that out of ten only four sampling spots are in fare condition and not a single spot is having good or excellent WQI and it is not consumable and should not be consumed. [8]

C. Assessment of Groundwater Quality Index of Tumkur Taluka, Karnataka, India

Groundwater samples were collected from 269 locations of Tumkur Taluka, Karnataka during pre-monsoon period (February 2006). Each of the groundwater samples was analyzed for 17 parameters such as pH, Electrical conductivity, TDS, Total hardness, Bicarbonate, Carbonate, Chloride, Sulphate, Phosphate, Nitrate, Fluoride, Calcium, Magnesium, Sodium, Potassium, Iron and Manganese using standard procedures recommended by APHA and computed Water Quality Index as per Weightage method. [2]

D. Results & Discussion for Case Study – 2:

In this study, the computed WQI values ranges from 89.21 to 660.56 and therefore, can be categorized into five types “excellent water” to “water unsuitable for drinking”. Table – 4 shows the percentage of water samples that falls under different quality. The high value of WQI at these stations has been found to be mainly from the higher values of iron, nitrate, total dissolved solids, hardness, fluorides, bicarbonate and manganese in the groundwater.

Table – 4 Water quality classification based on WQI value

Water quality classification based on WQI value

WQI Value	Water Quality	Percentage
< 50	Excellent	00
50-100	good water	1.5
100-200	poor water	63.5
200-300	very poor water	22.0
> 300	Water unsuitable for drinking	13.0

IV. CONCLUSION

For Case Study-1, The WQI for 125 Ground water samples ranges from 22.55 to 247.17 almost 33.3 percent of the samples exceeded 100, the upper limit for drinking water. The high value of WQI at these stations has been found to be mainly from the higher values of iron, total dissolved solids, hardness, chloride and manganese in the groundwater. About 30.8% of water samples are poor in quality and 2.6 percent of water samples are of very poor quality and should not use directly for drinking purpose. As per the classification based on water quality index 66.7% of ground water samples are of good quality and suitable for drinking purpose in which 56.4% ground water samples shows good quality of water and 10.3% sample shows excellent quality of ground water. In this part, the groundwater quality may improve due to inflow of freshwater of good quality during rainy season. Calcium and chloride are significantly interrelated and indicates that the hardness of the water is permanent in nature.

For Case Study-2, The WQI for 269 samples ranges from 89.21 to 660.56. Almost ninety nine percent of the samples exceeded 100, the upper limit for drinking water. The high value of WQI at these stations has been found to be mainly from the higher values of iron, nitrate, total dissolved solids, hardness, fluorides, bicarbonate, chloride and manganese in the groundwater. About 63.5% of water samples are poor in quality. In this part, the groundwater quality may improve due to inflow of freshwater of good quality during rainy season. Magnesium and chloride are significantly interrelated and indicates that the hardness of the water is permanent in nature. The analysis reveals that the groundwater of the area needs some degree of treatment before consumption, and it also needs to be protected from the perils of contamination.

REFERENCES

[1] Aarti Avalkar, Dr. S. M. Yadav, and Dr. P. R. Mehta, “A study of Ground water quality evaluation of coastal region, Navsari & Valsad district”, Global Research Analysis, Vol.:2, Issue 4, April 2013
[2] C. R. Ramakrishnaiah,C. Sadashivaiah,And G. Ranganna (2009) “Assessment Of Water Quality Index for The Groundwater in TumkurTaluk, Karnataka State, India” E-Journal of Chemistry,page no:523-530
[3] Dr.C.Gajendran, S.Jayapriya, Diana Yohannan, Oshin Victor, Christina Jacob (2013), Assessment of groundwater quality in Tirunelveli District, Tamil Nadu, India, ISSN 0976 – 4402, International Journal Of Environmental Sciences Volume 3, No.: 6, 2013
[4] D. R. Pathak, R. Yatabe, and N. P. Bhandary (2013), “Statistical analysis of factors affecting groundwater quality in shallow aquifer of Kathmandu, Nepal” International Journal of Water Research,Vol1(1),pageno: 12-20.
[5] Gunvant H. Sonawane and Vinod S. Shrivastava (2010) “Ground Water Quality Assessment Nearer to the Dye user Industry” Archives of Applied Science Research, Vol: 2 (6),page no: 126-130.
[6] Hemant Pathak and S.N.Limaye “Study of Seasonal Variation in Groundwater Quality of Sagar City (India) by Principal Component Analysis” E-Journal of Chemistry 2011, 8(4), page no 2000-2009.

[7] Hemangi Desai, Tasneem Anandwala, and H. Desai, TIFAC-CORE in Environmental Engineering, Surat, (INDIA) 2008, Evaluation of Underground Water Quality Of Surat City (India), Journal of Environmental Research And Development Vol. 3 No. 1, July-September 2008

[8] Mangukiya Rupal, Bhattacharya Tanushree, and Chakraborty Sukalyan, "Quality characterization of groundwater using water quality index in Surat city, Gujarat, India", International Research Journal of Environment Sciences, ISSN 2319–1414, Vol. 1(4), 14-23, November (2012)

[9] N. SubbaRao, "Seasonal variation of groundwater quality in a part of Guntur District, Andhra Pradesh, India" Environ Geol page no: 413–429, 2006

[10] Neeraj D. Sharma, Dr. J.N.Patel, "Evaluation of Ground Water Quality index of urban segments of Surat city, India", INTERNATIONAL JOURNAL OF GEOLOGY Issue 1, Volume 4, 2010

