Evaluation of Groundwater Quality Index of the Urban Segments of Surat City, India

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Abstract**—** 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) 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 particularly five groundwater quality parameters pH, TDS, Chlorides, Hardness and Electrical Conductivity(EC) suggested and essentially responsible for groundwater quality degradation in the said area. The Groundwater Quality Index for each sampled location was determined by imparting the relative and proportionate weightage to the involved parameters contributing to overall groundwater quality of the 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 quality Index (GWQI), TDS, Chlorides

I. Introduction

The development of growing regions in developing countries is allied with several social, economical, environmental and technical aspects of concern area alongwith 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.

Thorough analysis and of groundwater quality status is a very comprehensive and complex study required to be supported by long terms data analysis , seasonal variations, temporal development in region, climate change etc. However, with the consideration of time and resources behind such detailed analysis, it is merely feasible for research task while the regional development task needs an approach includes the collective considerations of groundwater quality parameters with their due impacts on overall groundwater quality in the study area rather than equal weightage based traditional approach i.e. if prevailing groundwater quality analysis reflects the contribution of particular groundwater quality parameters greatly towards the groundwater quality degradation than due consideration should be given to monitoring and analysis of such accountable variables and the collective single operand outcome in the form of Index or decision parameter should be produced for the decision making. Such methodology follows many to one line of action where multiple groundwater quality parameters with their due weightage are introduced in system with the supporting data like water quality standard and singe output know as " Groundwater Quality Index " is determined .

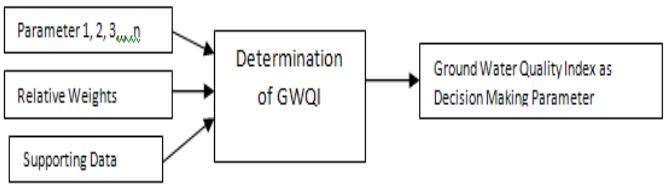

Fig -1 Groundwater Quality Index as Many to One Approach

Generally, the groundwater quality of urban region in vicinity of coastal area is found degraded due to influence of sea water intrusion during tidal and non tidal periods, construction of barrier structures across the river in estuarian zone which may remarkably or partly obstruct the propagation of tidal currents and lead to lateral intrusion of pollutants in urban aquifers. However the overall degradation of groundwater quality in coastal region is the function of prevailing conditions of aquifer, types of aquifer, influence of other sources of pollution like dumping of industrial waste or domestic waste, availability of groundwater in aquifer and yield of recharge water to the aquifer during the year, hydro-geological conditions of aquifer, level of exploitation of groundwater etc.

II. STUDY AREA

Surat, the diamond City of India is located on the left bank of river Tapi in southern zone of Gujarat state, India as shown in figure-1. It is the estuarian region and 16 kms away from Arabian sea. Surat city experiençes a tropical climate with temperature in summer rising well above 40°C and during inter it is around 12 to 15°C. Surat is located at 21°15'N latitude and 72°52'E longitude and bounded by the area 335 Sq.kms with the population of 4-4.5 million. Several industrial establishments of small to big extent have surrounded the city. Study area is mostly covered by alluvial aquifer of medium to coarse sand soil. The elevation of city varies between 10-18 mt with approx average 14.0 mt .above MSL.

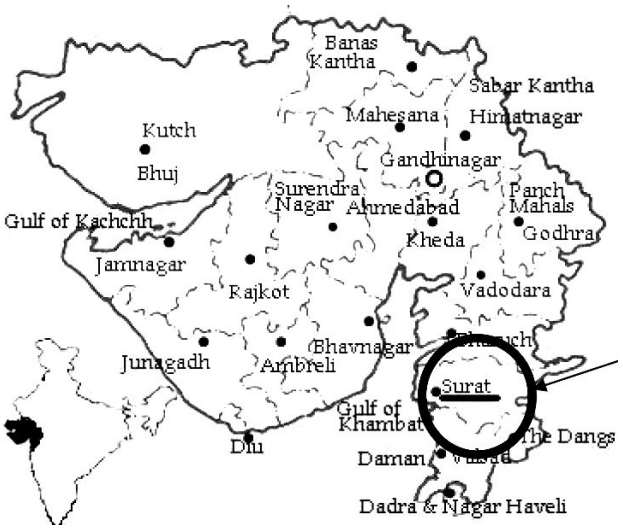

Fig -2 Location Map of Surat City in Gujarat State-India

III. METHODOLOGY

Groundwater samples were collected from 42 locations include the west zone and south west zone urban segments of Surat City during pre-monsoon and post monsoon period of the years 2007,2008 ,2009. Each of the groundwater samples was analyzed for five groundwater quality parameters such as pH, electrical conductivity, TDS, Hardness, chloride, using standard procedures suggested by American Public Health Association (APHA).

Analysis results are used to determine the groundwater quality index to assign the suitability of groundwater for human consumption. The computation of GWQI encompasses the weightage factor of groundwater quality parameter, prescribed groundwater quality standard and analyzed concentration of respective parameter. Flexibility lies with this computation is to give the relative importance to contributing parameters of overall groundwater quality for e.g. laboratory results of groundwater quality parameters in study area indicates the overall quality which is primly affected by pH, TDS/Electrical conductivity (EC), Chlorides, Hardness. Therefore, set of such parameters are considered in the computation of GWQI of study area however, the consideration may include the different set of parameters for the other region.

Computation of Groundwater Quality Index

Evaluation of groundwater quality index includes the following steps:

A. .Assign a weight/ weightage factor (Gwi) to groundwater quality parameter as per its relative significance and Determine Relative Weight (Gwr). The range of such weightage factors may be framed out according; here its scope is set between 1 to 5 where 1 weightage factor can be assigned to least important parameter and 5 weightage factor assigned to most contributive parameters to overall groundwater quality.[8]. Computed relative weights of various parameters are shown in Table-1.

Relative Weight (Gwr) = Gwi / (Gwi + Gwi+1 ….Gwn)

Groundwater Quality Parameter	Indian Standard (BIS-10500)	Weight (Gw_i)	Relative Weight (Gw_r)
pH	6.5-8.5	2	2/15= 0.13
TDS (mg/lit)	500-2000	5	5/15=0.33
TOTAL HARDNESS (mg/lit)	300-600	3	3/15=0.20
CHLORIDES (mg/lit)	250-1000	5	5/15=0.33

Table 1. Relative Weight of Groundwater Quality Parameters

B. Determine Quality Rating (qi) for each parameter:

Quality Rating (qi) = (Ci / DSi) x 100

Where,

qi = quality rating

Ci= concentration of each chemical parameter in each water sample in mg/L,

DSi =Indian drinking water standard for each chemical parameter according to the BIS-10500, 1991.

C. Compute the GWQI

SIi =Gwr x qi

GWQI= ∑ SIi

Where,

SIi = sub-index of i^{th} parameter

Water quality types were determined on the basis of GWQI as per the following:

Table 2. Quality of Water based on GWQI Range

Range of GWQI	Type of water

< 50	Excellent water
50–100	Good water
100–200	Poor water
200–300	Very poor water
> 300	Water unsuitable for drinking purposes

IV. RESULTS AND DISCUSSION

Nos. of samples taken during the year 2007, 2008 and 2009 were 32, 38 and 42. The Groundwater quality of study area including the west zone and south west zone of the city has been analyzed in pre monsoon and post monsoon time at 36-42 locations (each year) during the period of three years (2006-2008) and the summarized statistical outcome of observed analysis are tabulated in Table-3 and Table-4.

Results show that pre monsoon groundwater quality is found with the max TDS range of 2870 mg/lit -3015 mg/lit ,min TDS range of 560 mg/lit –642 mg/lit , average TDS range of 1042 mg/lit – 1266 mg/lit, max Chlorides range of 2444 mg/lit -2340 mg/lit ,min Chlorides range of 371 mg/lit –432 mg/lit , average chlorides range of 906 mg/lit – 1105 mg/lit, max Hardness range of 316 mg/lit -342 mg/lit ,min Hardness range of 140 mg/lit –176 mg/lit , average Hardness range of 214 mg/lit –252 mg/lit, max EC range of 4375 µs/cm- 5118 µs/cm,min EC range of 1057 µs/cm-1312 µs/cm, average EC range of 2002 µs/cm- 2016 µs/cm. The GWQI assessed from the above base data is found with max range of 185- 192, min range of 67-83 and average range of 103-121.

Correspondingly post monsoon groundwater quality is found with the max TDS range of 2145 mg/lit - 2430 mg/lit , min TDS range of 468 mg/lit – 608 mg/lit , average TDS range of 924 mg/lit – 1080 mg/lit, max Chlorides range of 1968 mg/lit -2115 mg/lit ,min Chlorides range of 398 mg/lit – 428 mg/lit , average chlorides range of 957 mg/lit – 1056 mg/lit, max Hardness range of 348 mg/lit -375 mg/lit ,min Hardness range of 145 mg/lit –174 mg/lit , average Hardness range of 212 mg/lit –246 mg/lit, max EC range of 4290 µs/cm-5275 µs/cm,min EC range of 1063 µs/cm-1144 µs/cm, average EC range of 1715 µs/cm- 2051 µs/cm. The GWQI assessed from the above base data is found with max range of 179- 190, min range of 62-78 and average range of 103-124.

Table 3. Typical Statistics of Three years Groundwater Quality Data- Pre Monsoon

Parameter	Year	pH	TDS (mg/lit)	Hardness (mg/Lit)	Chlorides (mg/Lit)	Electrical Conductivity (µs/cm)	GWQI
Maximum	2007	8.6	2884	335	2360	4375	186
	2008	8.1	3015	316	2440	5118	192
	2009	8.3	2870	342	2344	5000	185
Minimum	2007	6.2	642	153	432	1312	83
	2008	6.6	630	176	418	1086	77
	2009	6.8	560	140	371	1057	67
Mean	2007	7.1	1042	252	1105	2002	114
	2008	7.7	1266	248	906	2040	121
	2009	7.4	1181	214	926	2216	103

Table 4. Typical Statistics of Three years Groundwater Quality Data- Post Monsoon

Parameter	Year	pH	TDS (mg/lit)	Hardness (mg/Lit)	Chlorides (mg/Lit)	Electrical Conductivity (µs/cm)	GWQI
Maximum	2007	8.3	2362	348	1986	4540	182
	2008	8.5	2430	365	2115	5275	190
	2009	8.2	2145	375	2050	4290	179
Minimum	2007	6.4	608	174	428	1115	78
	2008	6.7	576	162	398	1144	76
	2009	6.8	468	145	423	1063	62
Mean	2007	7.1	1005	235	1056	1932	124
	2008	7.3	924	246	988	1715	112
	2009	7.5	1080	212	957	2051	103

Above results showing the concise status of all 36 to 42 collected water samples as shown in Figure 3 , among which 45% wells were belongs to south west zone and 55% wells belongs to west zone. Comparatively the groundwater quality index of west zone was found better than south west zone and it is justified because south west zone is in much vicinity of coastal region than west zone however , west zone is also sensibly found with moderate to poor in groundwater quality

index and as per the review of experts the ground water quality of west zone is supposed to degrade due to construction of weir cum cause way across the river which cut off the propagation of tidal waves and allow them to intrude in surrounding aquifers.

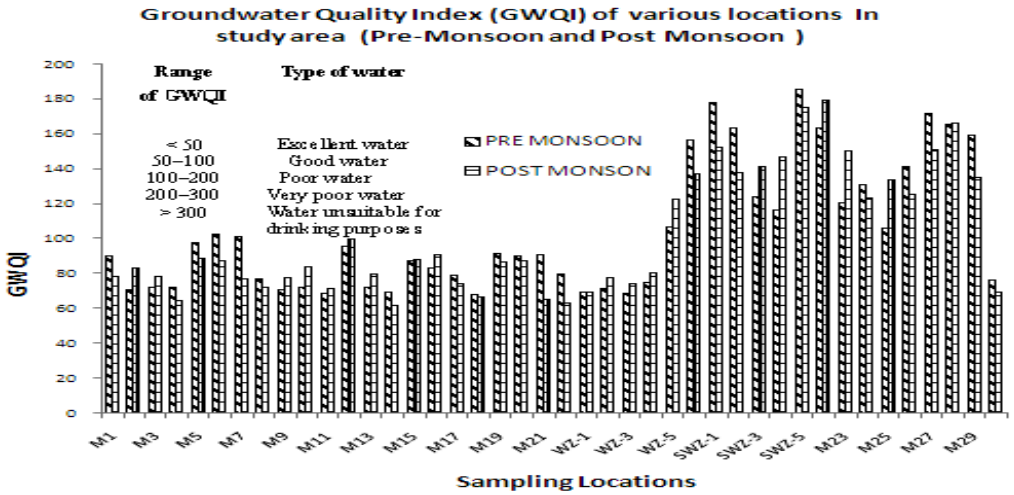

Fig -3 Groundwater Quality Index of Study Area (Pre-Monsoon and Post-Monsoon)

V.CONCLUSION AND FUTURE SCOPE

The obtained GWQI from representative samples of study area shows the groundwater quality 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 . This needs the attention towards the improvement of groundwater quality before further degradation. Literature indicates that artificial recharging of groundwater by recharge well is one of best method confirmed across the world for the improvement of groundwater quality in urban region. Therefore, as a future scope of this study the recharge phenomena can be explored to study area and on the base of available data of rainfall, land use pattern ,topography- (1) Runoff in the study area can be worked out and with the consideration of individual recharge well's recharge rate capacity numbers of well can be computed and proposed . (2) Effect of recharging on groundwater quality can be predicted and the effect of recharging can be correlated with GWQI.

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