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An Assessment of Groundwater Quality in the Selected Sites of Anand City, Gujarat, India

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Abstract-The adverse effects of growing population is recognized by shortage of resources and one such major resource is groundwater which is mainly used for drinking purpose. Scarcity of groundwater is observed in the area with declining water level, frequent pressure on recharge and contamination in water. Moreover, increasing amount in pollution magnifies the issues related to groundwater. Present study gives the scenario of groundwater pollution in various areas of Anand city viz. municipal, agricultural and industrial zones. Selection of sites and sampling were carried out to analyze the status of groundwater owing to the anthropogenic pressures present there over that particular site. Physico- chemical parameters were analyzed from selected sites during the post monsoon season. Parameters considered for the present study were pH, Total dissolved solids, Fluoride, Nitrate and dissolved oxygen using standard methods. Results of the study clearly showed the negative effects of the anthropogenic activities on the ground water which aggregates health issues, too. Clustered column graphs for each site present the scenario of the groundwater. Also, water quality index of selected areas shows groundwater with poor quality.

Index Terms-Groundwater, Municipal zone, Agricultural zone, Industrial zone, Physico-chemical parameters, Water Quality Index

INTRODUCTION

Life cycle is mainly contingent by water and its several sources like ocean, river, clouds, and groundwater and so on. Groundwater is very important resource that profoundly affects living organisms (Gorde et. al., 2013). The water beneath mountains, hills, plains cannot be reachable every time from which groundwater is stored and moves slowly through aquifers. Groundwater is the largest source of fresh water available for mankind. It comprises of diversified chemical constituents such as sulphates, nitrates, total dissolved solids etc. The quantity and quality of groundwater mainly depends upon chemicals present in water sample. Geographical areas are also an important factor which gives diverse quality to groundwater (Daxa K. Ghevariyaa et. al., 2017)

Archeologically, human settlements have been always found in the surroundings of accessibility of water and many of civilization have developed around rivers called as River Valley Civilization. Ground water establishes 97% of global fresh water and in many regions, ground water sources are the only supply for drinking purpose. Moreover, for many of the populations it may be the only economically viable possibility for drinking. Thus, the availability of clean ground water is most essential, as it serves as the basic and critical constituent in different spheres of human life for a large number of habitations. (Shirahatti et. al., 2017) Groundwater is globally important, valuable and renewable resource and it also acts as a large reservoir of freshwater that provides "buffer storage" during periods of drought. It is important to know the quality of groundwater as it is used mainly for drinking purpose. (RupalMangukiya et. al., 2012)

In last few years, the demand of groundwater has increased due to ever increasing population and level of growing industrialization. Once groundwater is contaminated, its quality cannot be refurbished easily and it can cause various diseases in human beings. Furthermore, it has been observed that many areas have become polluted due to discharge of contaminated industrial water, domestic water, urbanization, agricultural run-off. Waterborne diseases also spread from contaminated drinking water, therefore, WHO has given drinking water standards as water is an essential need of living organisms. Similarly groundwater quality is also important as it serves the main purpose of irrigation. (Khanna et. al., 2016)

SITE SELECTION

Gujarat ranks 5th in country as far as sewage production is concerned. The Anand district with the tropical climatic conditions has crops such as tobacco, banana, papaya and potato being cultivated as major crops. It has been categorized into different zones i.e. industrial, chemical and petrochemical, agro processing, engineering and ceramics, cement and dairy. The district of Anand has got main three zones namely municipal, agricultural and industrial area. Based on agro climatic zonation, Anand falls in Middle Gujarat Zone i.e. Zone III.

Anand is located at 22.51°N & 72.88°E and 22.52°N, 72.88°E longitude and latitude respectively. After preliminary survey of district, six sites were selected in Anand city. The study included collection of groundwater with mixed sampling method using standard methodology (Charles Teddlie and Fen Yu, 2007).

Sampling:

From three major categories which includes municipal areas, agricultural areas and industrial areas, two sampling sites were identified in category. The samples were collected from six zones which were named as MGWS1 (Municipal Ground Water Site 1), MGWS2 (Municipal Ground Water Site 2), AGWS1 (Agricultural Ground Water Site 1), AGWS2 (Agricultural Ground Water Site 2), IGWS1 (Industrial Ground Water Site 1) and IGWS2 (Industrial Ground Water Site 2). Figure 1 (a), (b) shows selected sites for sampling. The physico-chemical parameters such as pH and Dissolved Oxygen were assessed on site. To perform DO, glass bottles were used of 300 ml. The samples were brought to the laboratory using plastic container with the 5L capacity and were collected from groundwater – bore well water and hand-pump water. Along with Total Dissolved Solids (TDS), Nitrate and Fluoride were also measured in laboratory.

As it was a pre monsoon condition the selection of site was carried out from various zones with the survey of local region. For municipal sites water samples were collected from waste dumping and from the areas which were closer to villages which were inclined to groundwater pollution. For agricultural sites two zones were selected on the bases of crop yielding with usage level of groundwater, pesticides and chemical materials in fields. Water samples were collected in the nearby area of industrial zone of Anand to measure pollution level nearby areas. It includes areas nearer to GIDC in which groundwater aquifers acquires contamination very rapidly. For the appropriate results samples were collected in triplicates and outcomes are discussed in results.

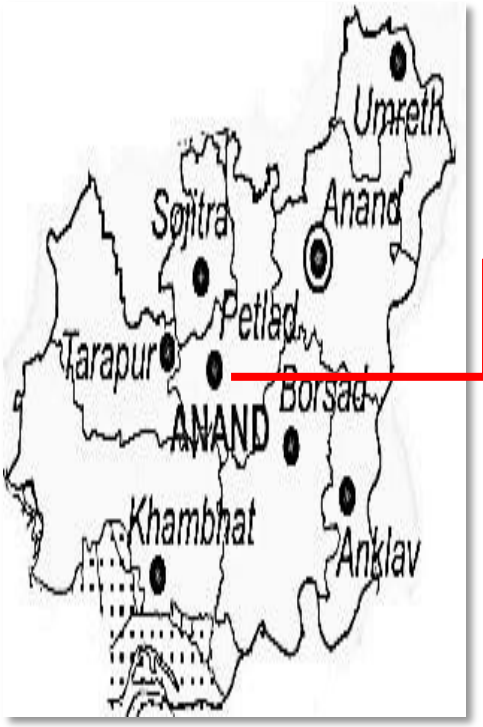

Figure 1: (a) district map of Anand

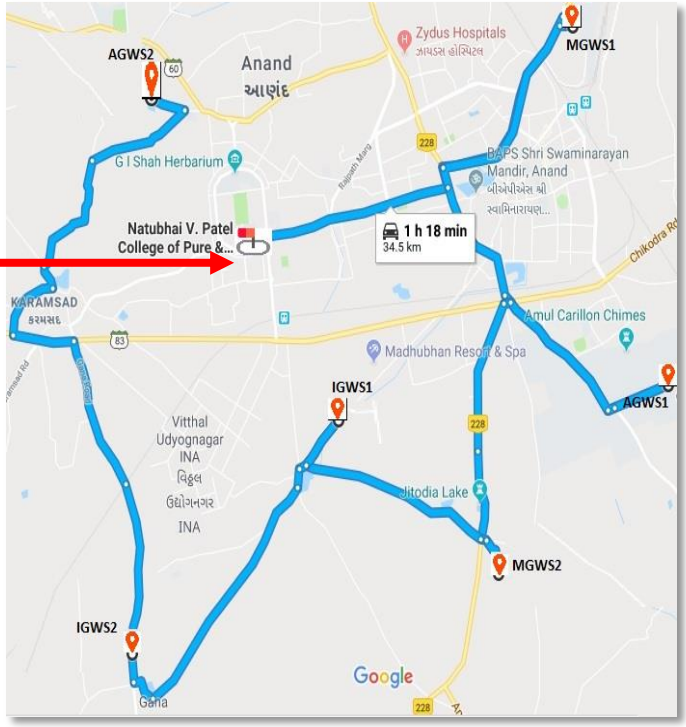

Figure 1: (b) points indicates selected sampling points

ANALYTICAL TECHNIQUES

The pH was measured using digital pH meter. The Dissolved Oxygen was estimated by azide modified Winkler method. By using filtration method TDS in groundwater samples was worked out. Nitrate estimatiation was carried out by Phenol Disulphonic Acid method. Fluoride content of water was tested with the help of SPANDS method. The methodologies were performed following standard methods as given by APHA. (American Public Health Association, 2005)

Water Quality Index:

It is a composite influence of different water quality parameters on the overall quality of water. Water quality index (WQI) is helpful to turn the complex water quality data into information which is easily understandable and usable. It is an important tool to provide information about quality of water and its usage to community

WQI is helpful to give aggregate rating for selected water samples which has a scale from zero to hundred. Higher WQI values shows good quality of water on other hand lower values shows reduced level in quality of water. The calculation of WQI was done by assigning of weight (wi) to the selected water parameters, computation of a relative weight (Wi) of the chemical parameter and by assigning of a quality rating scale (qi) for each parameter (Table-1).

Table 1: Relative weight (Wi) of each parameter

Parameters	Weight (wi)	Relative weight (Wi)
pH	4	0.210
DO(ppm)	2	0.105
TDS(ppm)	4	0.210
Nitrate(ppm)	5	0.263
Fluoride(ppm)	4	0.210

Furthermore, quality rating is calculated with the help of standards given by BIS IS: 10500 and results are multiplied with 100. (Eq. 1) To calculate WQI, SIi is calculated with the help of Wi and qi.(Eq. 2) Finally, WQI is calculated by SIi.(Eq. 3)

$$qi = \left(\frac{ci}{si}\right) \times 100 \quad \text{(Eq. 1)}$$

$$SIi = Wi \times qi \quad \text{(Eq. 2)}$$

$$WQI = \sum SIi \quad \text{(Eq. 3)}$$

RESULT & DISCUSSION

1. ***Municipal Area:***

- Two nominated zones were observed with high amount of nitrate and fluoride content with other physico-chemical parameters viz. DO, pH, TDS level in ground water which were labelled as MGWS1 and MGWS2.

Table 2: Municipal Areas

Parameter/site	pH	DO(ppm)	TDS(ppm)	Nitrate(ppm)	Fluoride(ppm)
MGWS1	6.5	4.4	720	53	1.3
MGWS2	6.3	3.9	768	49	0.9

MGWS1 and MGWS2 sites exhibited the high amount of contamination as the level of pH, DO, TDS, Nitrate and Fluoride and some of them were not in the permissible limits by Indian standards of drinking water IS: 10500.

2. ***Agricultural Area:***

- The selected two zonesAGWS1 and AGWS2 showed high amount of TDS and nitrate.

Table 3: results- Agricultural Areas

Parameter/site	pH	DO(ppm)	TDS(ppm)	Nitrate(ppm)	Fluoride(ppm)
AGWS1	7.3	4.7	625	63	0.9
AGWS2	7.2	4.1	710	52	1.2

As per Indian drinking water standard the pH of drinking water should range between 6.5 to 8.5. Both the agricultural zones fall within the range. The values of DO were less than the prescribed values. The prescribed limit for TDS is less than 500 ppm, which was found exceeding in both the zones. The nitrate content was also found higher in both the zones. The level of fluoride should not exceed than 1.0 ppm for drinking purpose, however, AGWS2 recorded higher values.

3. ***Industrial groundwater:***
   - Samples which showed high amount of groundwater effluence are listed below

Table 4: Industrial Areas

Parameter/site	pH	DO(ppm)	TDS (ppm)	Nitrate(ppm)	Fluoride(ppm)
IGWS1	6.1	2.3	830	84	1.3
IGWS2	6.4	1.9	880	68	1.4

In the selected zones from industrial areas, the results for all parameters were recorded higher than the prescribed limits of Indian standards.

Comparative evaluation of all selected zones:

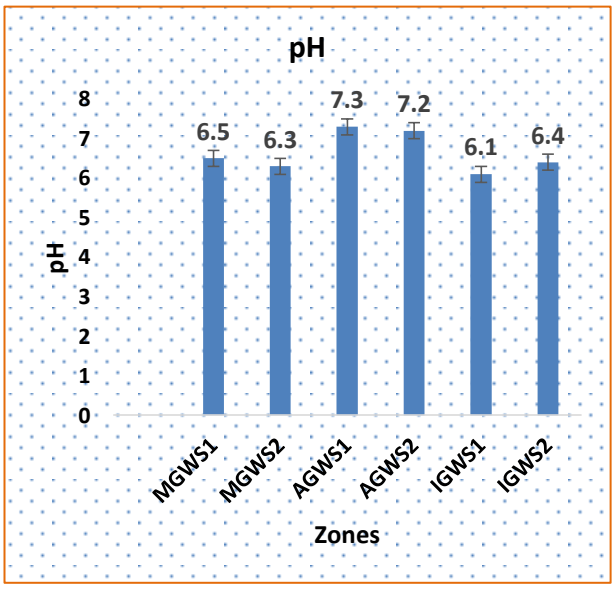

Figure 2: pH of selected zones

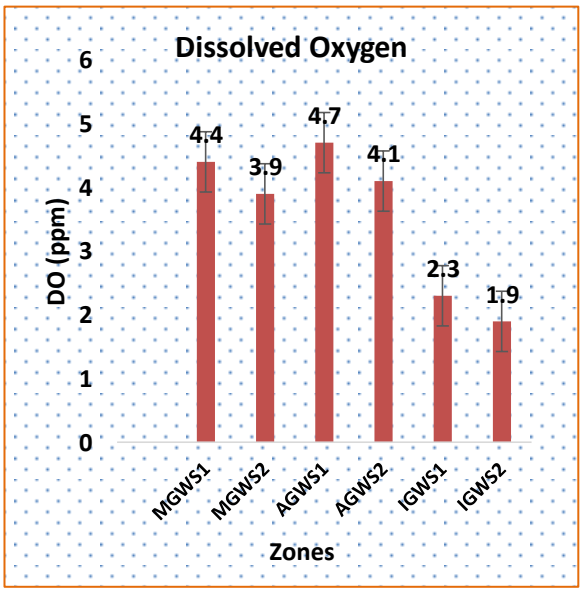

Figure 3: DO of selected zones

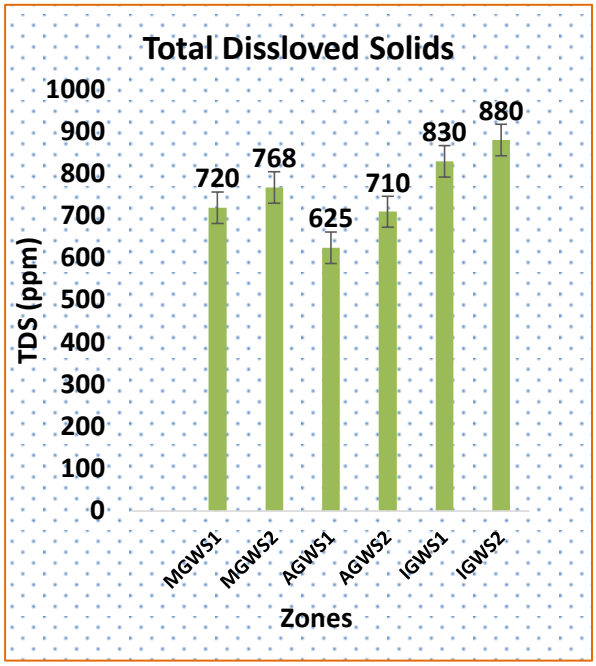

Figure 4: TDS of selected zones

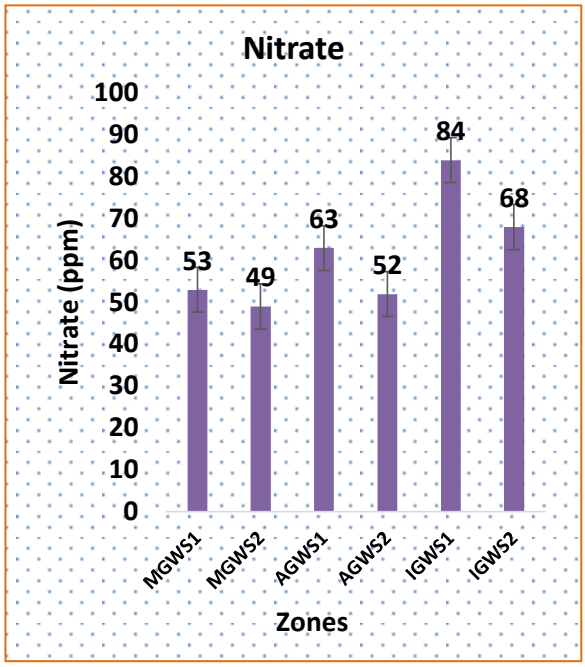

Figure 5: Nitrate of selected zones

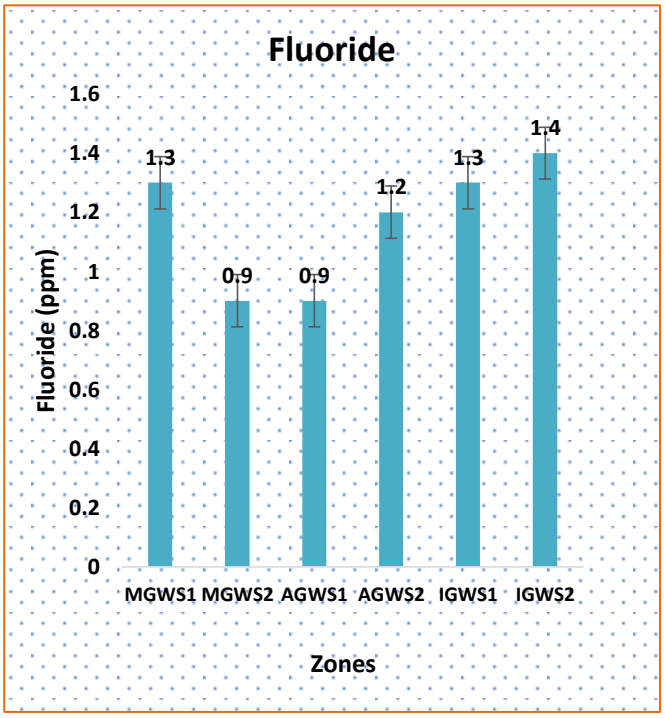

Figure 6: Fluoride of selected zones

The pH values were found slightly acidic for municipal and industrial areas whereas the agricultural areas recorded alkaline pH which may be due to use of various pesticides. The lowest pH value of 6.1and the highest of 7.3 were recorded for IGWS1 and AGWS1 respectively. The acidic condition in the area nearer to industrial zones was also recorded by Narsimha Adimalla et.al, (2018).

In general condition DO values reach to 8 or 7 at 25^0C and 350C respectively at one atmospheric pressure. The DO content recorded for all sites was less than 5ppm which indicates that it is not suitable for drinking purpose. J. R. Prajapati and B. V. Raol, (2007) also reported declined values of DO in groundwater of Kalol city. Level of TDS for the drinking purpose is established by IS: 10500 viz. 500 ppm. All the selected sites showed the TDS values in range of 625 to 880 ppm which were found exceeding than the prescribed standards. It can lead to gastrointestinal problems as reported by Mubin Chopda & .A. M .Malek (2018) in Erode city , Tamil Nadu. Figure 5 shows results acquired for nitrate content. The prescribed limit for Nitrate content is 45 ppm as given by IS: 10500. The findings from all the sites represented values of nitrate between 49 ppm to 84 ppm. The MGWS2 site recorded the lowest value of 49 ppm whereas IGWS1 site showed the highest value of 84 ppm. Daxa K. Ghevariya et. al. (2017) also found alike values for nitrate in Ghogha Taluka, Bhavnagar District. High value of fluoride can lead to Fluorosis. From figure 6 it is observed that water samples MGWS1, IGWS1 and IGWS2 showed high level of fluoride content which is not suitable for drinking purpose. Findings from Salve, P. R. et. al. (2008) also showed the same scenario of fluoride in Mahesana district.

Table 5: Groundwater quality comparison with drinking water standards by BIS IS: 10500

Parameter	Indian Standard	qi value (Percentage observance)			SIi value		
		MGWS	AGWS	IGWS	MGWS	AGWS	IGWS
pH	6.5-8.5	98.46	111.5	96.5	20.67	23.41	20.19
DO(ppm)	6	69.1	73.3	35	7.25	7.69	3.67
TDS (ppm)	500	148.8	133.5	171	31.24	28.03	35.91
Nitrate(ppm)	45	113.3	127.7	168.8	29.79	33.58	44.39
Fluoride(ppm)	1	110	105	135	23.1	22.05	28.35

The above table displays values of all the parameters with comparison to the standards for drinking water. For MGWS qi values ranged from 69.1 to 148.8. The qi for AGWS was from 73.3 to 127.7 and for IGWS it was observed from 35 to 171. SIi counted for MGWS was within range of 7.25 to 31.24, for AGWS 7.69 to 33.58 and for IGWS it was observed within 3.67 to 44.39. From the collective measure of qi and SIi, WQI for the three sites were measured. The values obtained were 112.05, 114.76 and 132.51 for MGWS, AGWS and IGWS respectively.

Table 6: Water quality classification based on WQI value

WQI	Value Water Quality	Percent of groundwater sample
<50	Excellent	0.0
50-100	Good water	0.0
100-200	**Poor water**	**100.0**
200-300	Very poor water	0.0
>300	Water unsuitable for drinking	0.0

The WQI for all three sites were in range of 100 to 200 which indicates Poor quality of water. These waters cannot be directly utilized for drinking purpose without any pretreatment as it may cause gastrointestinal irritation. It can also disturb functioning of mucous membrane and may also lead to methaemoglobina and fluorosis

Correlation coefficient matrix of physico-chemical parameters:

	pH	DO(ppm)	TDS (ppm)	Nitrate(ppm)	Fluoride(ppm)
pH	1				
DO(ppm)	0.905957809	1			
TDS (ppm)	-0.763722989	-0.942545638	1		
Nitrate(ppm)	-0.654271313	-0.703953511	0.476970677	1	
Fluoride(ppm)	-0.545108115	-0.653149777	0.651883041	0.421238507	1

The correlation coefficient matrix for all the physico-chemical parameters as shown above illustrates the positive correlation between pH and DO .Also it proves that TDS has positive correlation with Nitrate and Fluoride. On other hand, total dissolved solids, nitrate and fluoride has negative correlation with pH.

Statistics of water quality parameters of selected groundwater samples:

Parameters	MIN	MAX	AM	MEDIAN	SD
pH	6.00	6.40	6.22	6.25	0.15
DO(ppm)	1.90	4.70	3.55	4.00	1.16
TDS (ppm)	625.00	880.00	755.50	744.00	91.18
Nitrate(ppm)	49.00	84.00	61.50	58.00	13.19
Fluoride(ppm)	0.90	1.40	1.17	1.25	0.22

Min-Minimum, Max-Maximum, AM-Arithmetic mean, SD-Standard deviation

CONCLUSION

As WQI for all the samples ranges from 112.05 to 132.51 which shows all the samples exceed the percent value 100 which should not be used for drinking purpose. The analysis also reveals that groundwater of the selected sites needs to be treated first before consuming. It should be protected from various contaminations by anthropogenic activities. Continuous monitoring and checkup may help to investigate the issues related to health due to contaminated water.

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