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ASSESSMENT OF GROUND WATER QUALITY FOR IRRIGATION PURPOSE, VERAVAL DISTRICT, GUJARAT,INDIA

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Abstract : Water is not only necessary for human life, but also for plants and animals. majority of India's population relies on underground water assets for drinking, residence, industrial, and agricultural purposes. In many areas, increasing high-rise residential, industrial, and irrigation activities have resulted in the degradation of groundwater quality. Groundwater contamination has a detrimental effect on human health. In the present study, 36 groundwater samples were collected from 26 villages from Veraval district. Various physiochemical parameters data such as pH, total dissolved solids (TDS), electrical conductivity (EC), Ca2+, Mg2+, , Cl− , SO_4 2⁻ are collected and compared with BIS standard.The suitability for agriculture use was assessed using sodium absorption ratio (SAR), sodium percentage (Na%), residual sodium concentration (RSC), Kelley's ratio, and magnesium hazard. Results showed that the groundwater quality in the study area is not suitable for irrigation.

KEYWORDS : Ground water quality, Irrigation use, Veraval District

I. INTRODUCTION

Groundwater supplies potable water to an estimated 1.5 billion people per day (Department of International Development (DFID), 2001) and has shown to be the most reliable source of rural water.(Gemechu Beyene,et al.,2019). Due to decrease in surface water resources and pollution of these sources, groundwater is becoming more important for drinking and irrigation purposes (Tadesse et al., 2009). Being naturally filtered in their passage through the ground, they are usually clear, colorless, and have excellent quality, being free from microbial contamination and require minimal treatment (Babiker, et al., 2007). Unfortunately, it seems that we can no longer take high quality groundwater for granted, as a threat is now posed by an ever-increasing number of soluble chemicals from urban development, industrial activities and modern agricultural practices(Ravikumar P,et.al.,2010) In coastal locations, over-exploitation of groundwater resulted in seawater intrusion. Gujarat state has the longest coastal line of 1600 km. The present study deals with the ground water quality in villages of coastal areas of Veraval taluka, saurashtra, Gujarat. Gujarat state has very few perennial rivers namely Narmada, Tapi and Mahi, which are flowing in South Gujarat region. There is no perennial river in "Saurastra" & Kachchh region. Moreover, "Saurashtra" region is also having sea on west and south-west side and hence sources of water in coastal belt districts of Veraval, Bhavnagar, Junagadh, Jamnagar, Porbandar and some part of Rajkot are affected by sea water intrusion, resulting into increase in salinity of ground water beyond permissible limit.

II. STUDY AREA

Veraval is a city in the state of Gujarat, in the district of Junagadh. The town of Veraval has a population of 1,63, 336 people.The Latitude and Longitude of Veraval city are It is situated in between latitude 20°54'57.23"N and longitude 70°21'46.27"E with total area 321.02 km2 . . Veraval has a hot semi-arid climate with warm to hot temperatures throughout the year. Almost all precipitation falls during the summer monsoon season from June to September. Study area is a micro watershed of Veraval taluka. It lies between Latitude 20°55‟ & 21°05‟ North and Longitude 70°25‟& 70°40‟ East. Veraval talukas are made up of 56 villages. Among 56 villages 36 villages from 26 different villages are selected for the study. Majority of people in the study area are engaged in agriculture and animal husbandry occupation.

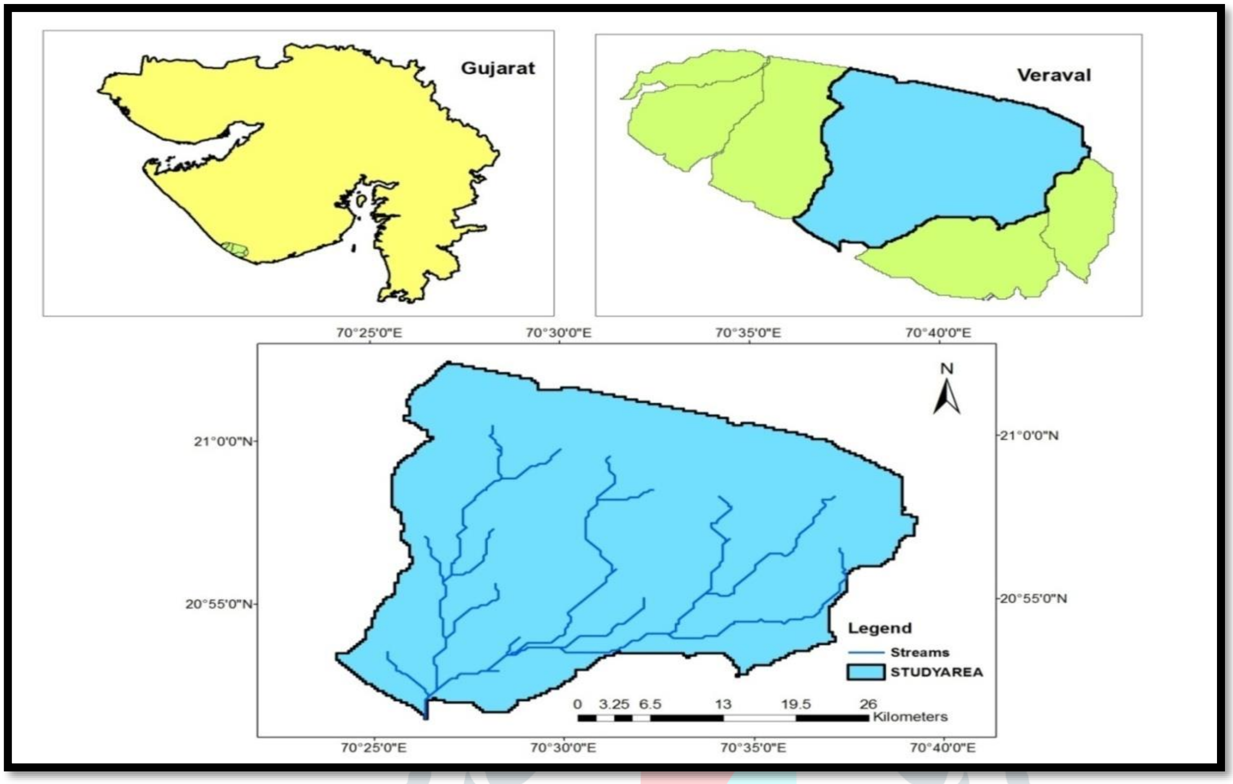

Fig. 2.1 Location Map of Veraval District

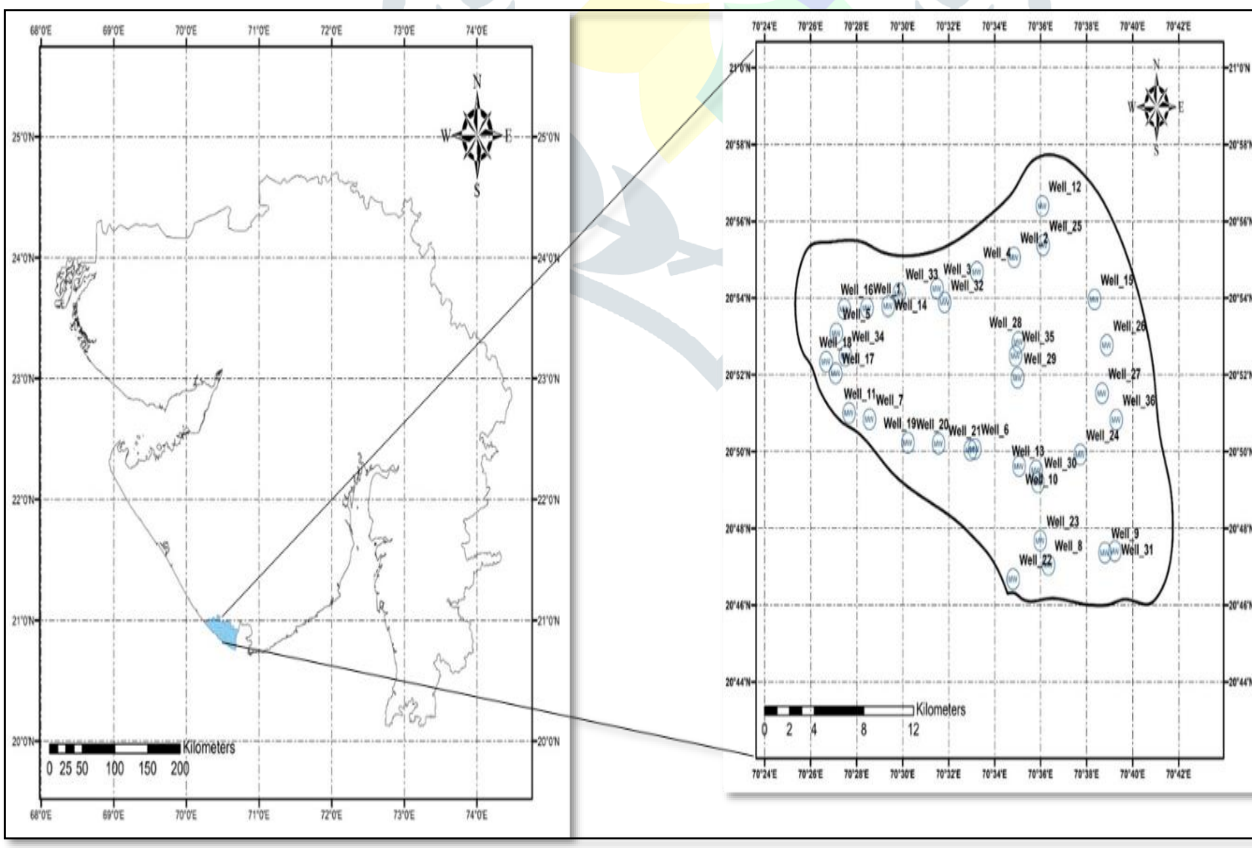

Fig. 2.2 Location Map of 36 wells

Sr. No	Name of the village	Taluka	Latitude	Longitude
1	Ajotha	Veraval	N 200 53.739'	E 700 28.450'
2	Ajotha	Veraval	N 200 55.058'	E 700 34.848'
3	Sunderpura	Veraval	N 200 54.246'	E 700 31.501'
4	Navagam	Veraval	N 200 54.678'	E 700 33.234'
5	Lati	Veraval	N 200 53.080'	E 700 27.117'
6	Pasnawada	Veraval	N 200 50.069'	E 700 33.139'
7	Sutrapada	Veraval	N 200 50.843'	E 700 28.561'
8	Dhamtaj	Veraval	N 200 47.042'	E 700 36.342'
9	Kanjotar	Veraval	N 200 47.366'	E 700 38.800'
10	Lodhva	Veraval	N 200 49.620'	E 700 35.067'
11	Prabhas Patan	Veraval	N 200 51.004'	E 700 27.674'
12	Khambha	Veraval	N 200 56.395'	E 700 36.080'
13	Lodhva	Veraval	N 200 49.508'	E 700 35.810'
14	Ajotha	Veraval	N 200 53.788'	E 700 29.373'
15	Prasli	Veraval	N 200 53.964'	E 700 38.348'
16	Ajotha	Veraval	N 200 53.712'	E 700 27.468'
17	Lati	Veraval	N 200 52.036'	E 700 27.088'
18	Lati	Veraval	N 200 52.341'	E 700 26.672'
19	Sutrapada	Veraval	N 200 50.230'	E 700 30.232'
20	Vadodara	Veraval	N 200 50.208'	E 700 31.564'
21	Pasnawada	Veraval	N 200 50.037'	E 700 32.949'
22	Lodhva	Veraval	N 200 49.679'	E 700 34.806'
23	Dhamlej	Veraval	N 200 47.679'	E 700 35.988'
24	Dhamlej	Veraval	N 200 46.922'	E 700 37.727'
25	Ghantiya	Veraval	N 200 55.375'	E 700 36.110'
26	Kadavasan	Veraval	N 200 52.772'	E 700 38.884'
27	Solaj	Veraval	N 200 51.518'	E 700 38.673'
28	Barrula	Veraval	N 200 52.852'	E 700 35.039'
29	Padtrruka	Veraval	N 200 51.918'	E 700 34.999'
30	Singsak	Veraval	N 200 49.197'	E 700 35.888'
31	Rakhej	Veraval	N 200 47.407'	E 700 39.231'
32	Chaziva	Veraval	N 200 53.888'	E 700 31.829'
33	Borash	Veraval	N 200 54.115'	E 700 29.857'
34	Haransa	Veraval	N 200 52.492'	E 700 27.515'
35	Pasnavada	Veraval	N 200 52.489'	E 700 34.912'
36	Matana	Veraval	N 200 50.828'	E 700 39.295'

Table. 2.1 List of 36 wells from 26 villages

III. Research Methodology

The current study is focused on determining the efficiency of groundwater for agriculture and drinking uses. For this study, 36 samples of groundwater were taken from 36 different wells from Veraval taluka in Gujarat. The water characteristics of irrigational production in the study region were determined using groundwater samples. The groundwater sample prevention was done with great caution to ensure that no biological or chemical reaction speeds were slowed. The samples were collected from an open well.

Groundwater samples are collected in a 2-liter pre-washed polyethylene bottle, and each bottle is labeled name and date of sampling. The amounts of significant ions in water samples were measured in the laboratory using the American Public Health Association's (APHA) suggested analytical methods (2005).The temperature taken for the calculation of water indices is in the range of 29-34℃. Electrical conductivity (EC), Sodium Absorption Ratio (SAR), Residual Sodium Carbonate (RSC), Kelley's Ratio (KR), Magnesium Hazard Ratio (MHR) are several of the main factors that decide irrigation water consistency.

3.1 Indices for Irrigation Purpose

Water Indices	Parameter / Formula	Range	Classification	References
Salinity Hazard (SH)	EC	<250 µS/cm 251-750 µS/cm 751-2250 µS/cm 2251-6000 µS/cm 6001-10000 µS/cm 10001-20000 µS/cm	Low Medium High Very high Extensively high Brines weakly conc.	(Selvam et al., 2014; Barik & Pattanayak, 2019)
Sodium Absorption Ratio (SAR)	$\frac{Na^{+}}{\sqrt{(Ca^{2+} + Mg^{2+})/2}}$	<10 meq/l 10-18 meq/l 18-26 meq/l >26 meq/l	Excellent Good Fair Poor	(Sherif et al., 2011); Srivastava, 2019 ; Ismail et al., 2020)
Kelley Ratio (KR)	$\frac{Na^{+}}{Ca^{2+} + Mg^{2+}}$	<1 >1	Suitable Unsuitable	(Iqbal et al., 2018) ; Srivastava, 2019)
Total Hardness (TH)	$2.497Ca^{2+} + 4.115Mg^{2+}$	0-75 meq/l 75-150 meq/l 150-300 meq/l	Soft Moderately Hard	(Rezaei & Hassani, 2017) ; Beyene et al., 2019)

		>300 meq/l	Very Hard	
Residual Sodium Carbonate (RSC)	$(CO_3^{2+} + HCO_3^-) - (Ca^{2+} + Mg^{2+})$	<1.25 meq/l 1.25-2.5 meq/l >2.5 meq/l	Good Medium Bad	(Raju et al., 2016; Srivastava, 2019)
Magnesium Hazard (MH)	$\frac{(Mg^{2+})}{(Ca^{2+} + Mg^{2+})} * 100$	<50% >50%	Suitable Unsuitable	(Soleimani et al., 2018)

Table 3.1 List of Irrigation Indices

Irrigation water of superior quality maintains optimum crop productivity. The concentration and distribution of dissolved salts provide information about the groundwater and usage for irrigation can be decided. If irrigation usage exceeds acceptable limits, these particular ions can be hazardous to different plant physiological mechanisms or induce nutritional abnormalities in plants. (Raghupathi et al. 2013). Na, Cl, and EC are commonly found in high concentrations in coastal groundwater. The salinity and sodicity indices are significant factors in assessing if groundwater is suitable for irrigation usage. Residual Sodium Carbonate (RSC), Sodium adsorption ratio (SAR), Kelley's Ratio (KR), Magnesium Hazard Ratio (MHR) & Salinity Hazard (SH) are used for the present study area.

3.2 Sodium Absorption Ratio

Sodium concentration is a crucial component in determining the irrigation classification of water. The Sodium Absorption Ratio, an integral water reliability metric, is frequently used to determine the sufficiency of irrigation water and to estimate the alkali hazard to crop growth. (2015) (Arumugam et al.). This measure is quantified using the ratio of sodium to calcium and magnesium. Magnesium and calcium in the soil operate as a buffer against sodium's influence, increasing the permeability of the soil and aiding cultivation. Increased salt depletes soils of calcium and magnesium by hardening and compacting them, resulting in delayed penetration and internal sewage disposal (Karanth 1987). Thus, the appropriateness of wells in the Veraval district is estimated by applying the equation below to calculate the SAR. (1954, Richards) The SAR (sodium adsorption ratio) is calculated using the following equation:

$$\frac{Na^{+}}{\sqrt{(Ca^{2+} + Mg^{2+})/2}} \qquad \text{(Eq.1)}$$

SAR values for samples taken in the Veraval area range from 5.804 to 554.7, with an average of 108.20. The well samples are classified as follows. The higher the SAR value, the greater the possibility that excess Sodium will degrade the crop's quality. As a result, a large proportion of well waters are suitable for irrigation. Classification of irrigation well samples using SAR.

Parameter	Range	Water-Class	No. of samples.
SAR	0-10	Excellent.	1
	10-18	Good.	0
	18-26	Doubtful.	2
	>26	Unsuitable.	33

Table 3.2 SAR-based classification of well samples for irrigation

3.3 Residual Sodium Carbonate

Residual Sodium Carbonate an integral water reliability measure demonstrates the salinity threat for the soil. When carbonate &bicarbonate concentrations surpass calcium and magnesium content, the residual carbonate value is obtained, which can be used to form salts of sodium across calcium and magnesium.(Raju et al, 2009; Siddiqui et al, 2005). As a result, the sodium content of water rises in the manner of sodium carbonate, as shown by the RSC value using the below Equation:(Raghunath 1987).

$$RSC = (CO_3^{2-} + HCO_3^{-}) – (Ca^{2+} + Mg^{2+}) \quad \text{(Eq.2)}$$

The RSC of samples in the present area of study ranges from -486.8 to 217.2, with an average of -42.1666. The samples from the wells are categorized below. There are no carbonates present in any of the tested wells of Veraval district. Almost all of the sampling sites had a negative and low value of RSC, which is attributed to insufficient Ca++ and Mg++ precipitation. The higher the value of RSC, the inferior the reliability of water for agrarian use hence, negative RSC is considered best for agriculture purposes.

Parameter	Range	Water-Class	No. of samples.
RSC	<1.25	Good	16
	1.25- 2.5	Doubtful	0
	>2.5	Unsuitable	20

Table 3.3. RSC-based classification of well samples for irrigation.

3.4 Kelly's Ratio

Kelly Ratio is another important criterion to classify the irrigation water.Kelley's scale, which is used to assess irrigation waters, is the amount of sodium weighed against magnesium &calcium.(Kelley, 1946; Paliwal, 1967;Patel et al., 2020) Kelley's Ratio is employed to determine the alkali hazard of water.(Handa 1981;Patel et al., 2020) Excessive amounts of sodium in water has a negative impact on the soil's properties and permeability. (Kelly,1951) The Kelley's Ratio is determined using the following formula:

$$\frac{Na^{+}}{Mg^{2+} + Ca^{2+}}$$

The KR of samples of the Veraval region varies between 0.183 to 51.28 with an average of 8.306255. The well samples are classified in the table below. For irrigation purposes, Kelley's ratio must be less than one. Here, the majority of samples surpass the suitability requirements, indicating that perhaps the significant number of well water is unsuitable for cultivation.

Parameter	Range	Water-Class	No. of samples.
KR	<1	Suitable	2
	>1	Unsuitable	34

Table 3.4 KR-based classification of well samples for irrigation

3.5 Magnesium Hazard Ratio

Magnesium(Mg2+) &Calcium(Ca2+), both minerals are in equilibrium in the majority of waters; an elevated amount of magnesium is typically caused by the involvement of exchangeable sodium in irrigated soils. Magnesium has a great significant impact on crop production than calcium. The excess Magnesium Soil to become alkaline, resulting in lower crop yields and poor agricultural production results. Magnesium Hazard Ratio can be computed through following equation :(Paliwal1972).

$$\frac{Mg^{2+}}{Ca^{2+}+Mg^{2+}} * 100$$

The MHR of samples for the Veraval region varies between 16.107 to 100 meq/L, with an average of 68.8897 meq/L. The well samples are classified in the table below. Here, 91% of well samples surpass the 50% suitability limit for irrigation use.

Parameter	Range	Water Class	No. of samples.
MHR	<50%	Suitable	13
	50%	Unsuitable	23

Table 3.5 MHR-based classification of well samples for irrigation.

3.6 Salinity Hazard

Salinity indices for water samples are derived using measured EC values, which are proportional to TDS. Water's salinity is defined by its total salt content. Excessive salinity reduces the osmotic activity of plants, obstructing water and nutrient absorption from the soil. Additionally, the salts that contribute to this salinity determine the appropriateness of the water for its intended use. (1999; Saleh et al.). The EC of Veraval region samples ranges from 979 to 10235 mho/cm, with an average of 4089.055 mho/cm. The well samples are classified in the table below. TDS levels in irrigation water are excessively high, which might increase the quantity of salt in the soil, so affecting plant salt uptake.

Parameter	Range	Water-Class	No. of samples.
EC	<250	Excellent	0
	250-750	Good	0
	750-2250	Permissible	16
	>2250	Doubtful	20

Table 3.6 SH-based classification of well samples for irrigation.

IV.RESULTS & DISCUSSION

As per the investigation, sodium rate and overall concentrations, show that samples from the present analysed area are not suitable for irrigation purposes. Agricultural materials, for the most part, are exceptionally poor in the section of groundwater due to an overabundance of sodium salts. This has an effect on the soil-plant system through osmotic effects. Issues with high salt presence occur when irrigation occurs in poorly drained agrarian soils and, however, when waterlogging permits the water table to increase near the root vicinity of vegetation resulting in the accumulation of sodium salts within the soil system from capillary rise just after surface evaporation. High quantities of undesirable cations may degrade the soil fertility because of the de-flocculation (distribution of clay particles) method. Farmers are compelled to use this water for farming practices regardless of the basic state of water quality in the Veraval region under consideration. As a result, implantation of plants that are highly tolerant of the salinity and sodicity in the area is one method of crop production here. Additionally, groundwater quality here is not completely safe for drinking utilization and could be harmful to the well-being of people. The uniform management of groundwater assets for irrigation and drinking by public authorities may be one of the most appropriate approaches to resolving water quality issues in the Veraval coastal area.

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