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Study of groundwater quality of Valsad District of South Gujarat for irrigation purpose

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ABSTRACT

Groundwater samples were collected from five talukas of Valsad district for two years (from August 2008 to July 2009) and were analyzed to find out the suitability of irrigation purpose. Hence parameters like pH, EC (Electrical Conductance), Calcium, Magnesium, Sodium were determined in present investigation. Groundwater of the study area was classified according to sodium absorption ratio (SAR), EC, US Salinity laboratory classification. The value of SAR indicates that majority of samples fall in low sodium hazard category. On the basis of EC, groundwater of Dhamdachi village is not found suitable for irrigation purpose.

Key words: Groundwater, sodium absorption ratio, Valsad District, Gujarat.

INTRODUCTION

Due to rapid growth in population, industrialization and increasing agricultural demand, the future requirement of water will be enormous. Groundwater is an important source of water supply throughout the world [1]. Groundwater is used for domestic, agriculture and industrial purpose in most parts of the world [2].

Water quality plays an important role in irrigated agriculture. Many problems arise during inefficient management of water for agriculture use. The concentration and composition of dissolved constituents in water determine its quality for irrigation use. Quality of water is an important consideration in any appraisal of salinity or alkali conditions in an irrigated area [3].

India is a predominantly agricultural country. Its rural economy completely depends on agriculture. The sources of water irrigation to agricultural land for irrigating are rainwater, surface and groundwater. In Gujarat due to lack of perennial river stream and other surface water resources, the groundwater is an important source for irrigation purpose. Surface water contains low salinity with low concentration of various ions while groundwater contains a variety of minerals in higher concentration with greater salinity. The water used for irrigation purpose should be of such quality, which dose not harms the soil and gives maximum crop yields. Therefore, suitability of water for irrigation purpose is evaluated by its effect on soil and crops [4]. Various classifications based on Electrical conductivity (EC), Sodium absorption ratio (SAR) etc, have been proposed to classify water for irrigation purpose. On the basis of this, several researches have analyzed and classified the water suitable for irrigation purpose [5-7].

Valsad district is laid between 20^0 8' to 21^0 9' N latitudes, and 62^0 39' to 73^0 30' E longitudes. It has main four rivers named Auranga, Par, Damanganga and Kolak. Farming is one of the major sources of earning. The district is famous for its mango, chickoo trees. The other major crops are Rice[*Oryzasativa*], Sugarcane[*Saccharum*], Pigeon pea[*Cajanus cajan*] and vegetables.

MATERIALS AND METHODS

Groundwater samples were collected from 15 sampling stations for finding suitability for irrigation purpose. The sampling stations designated S_1 to S_{15}. The location of sampling stations is Table 1.

Table 1: Sampling stations, locations and type of ground water sources

Sampling Station	Location	Type of groundwater source
S_1	Tithal	Bore well
S_2	Dhamdachi	Bore well
S_3	Haria	Hand pump
S_4	Pardi	Hand pump
S_5	Khadki	Hand pump
S_6	Vapi	Bore well
S_7	Valvada	Hand pump
S_8	Bhilad	Hand pump
S_9	Sarigam	Well
S_{10}	Nanapondha	Bore well
S_{11}	Kaprada	Well
S_{12}	Sutharpada	Hand pump
S_{13}	Dharmpur	Bore well
S_{14}	Barumal	Hand pump
S_{15}	Kakadkua	Hand pump

The samples were collected and preserve in two litre polythene bottles which were thoroughly washed twice with the water to be analyzed. The parameters like pH, EC, Calcium, Magnesium, Sodium were estimated as per APHA [8].

The suitability of groundwater for irrigation depends upon its mineral constituents. Kelley pointed out the importance of considering the concentration of Na^+ ions in assessing the suitability of water for irrigation. According to him, excess of Na^+ ions in irrigation water reacts with soil to reduce its permeability as a result of clogging of particles. High values of SAR imply a hazard of Na^+ ions which replace absorbed Ca^{+2} ions and Mg^{+2} ions and leads to a situation which ultimately damages the soil structure.

Sodium is the most important element, which influences the soil quality and plant growth either by affecting the permeability of soil by clogging or replacing other cations. The extent of replacement of other cation by sodium is denoted by SAR [3].

Sodium adsorption ratio is calculated by using following formula [3].

$$SAR = \frac{Na^+}{\sqrt{\left(\frac{Ca^{+2} + Mg^{+2}}{2}\right)}}$$

The salts present in the water, besides affecting the growth of the plants directly also affect the soil structure, permeability and aeration, which indirectly affect the plant growth. The sodium hazard of irrigation water can be well understood by knowing SAR. High sodium in water leads to the development of alkali soil, which has unfavorable structure and restricts aeration [9].

RESULTS AND DISCUSSION

On the basis of EC and SAR, the groundwater quality of Valsad district is described on the basis of EC and SAR:

Electrical Conductance (EC):
The most expedient procedure to evaluate salinity of water is to measure its EC. It influences the quality of water for irrigation purpose due to its relation with ionic constituents of water. The high EC value is harmful for the plant growth physically by reducing the uptake of water through modification of osmotic pressure or chemically by metabolic reaction caused by toxic constituents. Besides these effects, water with high EC change the soil structure, permeability and aeration, which ultimately affects plant growth and crop yield considerably. Such adverse effects are called salinity hazard [3]. The results of groundwater analysis is reported in Table 2. Classification of groundwater according to electrical conductance given in Table 3.

Table 2: Results of Groundwater Analysis

	Sampling Stations														
Parameters	**S_1**	**S_2**	**S_3**	**S_4**	**S_5**	**S_6**	**S_7**	**S_8**	**S_9**	**S_{10}**	**S_{11}**	**S_{12}**	**S_{13}**	**S_{14}**	**S_{15}**
Ph	7.1	7.4	7.8	7.4	7.4	7.5	7.7	7.3	7.8	6.6	7.1	7.8	7.1	7.5	7.1
EC	2.214	2.848	0.331	0.854	0.758	0.997	0.664	0.527	0.91	0.876	0.238	0.284	0.603	0.28	0.314
Ca	243	113	40.1	107	81	85	73	65	103	137	27	29	86	37	48
Mg	83	94	23	33	45	40	33	27	44	39	9	8	34	12	16
Na	370	710	55	108	96	146	94	46	68	35	13	61	38	21	21
SAR	5.24	11.99	1.**75**	2.34	2.12	3.25	2.28	1.21	1.42	0.68	0.57	2.64	0.88	0.76	0.67

(Results are expressed in mg/l except for pH, SAR. EC in mmho/cm)

Table 3: Classification of groundwater according to electrical conductance (Salinity hazard)

	Class	**EC mmho/cm**	**Category of water**	**Suitability**	**Representing stations**	**% Distribution**
Low Salinity	C1	<0.25	Excellent	It can be used for irrigation with most crops on most soils with little likelihood that soil salinity will develop. Some leaching is required, but this occurs under normal irrigation practices expect in soil of extremely low permeability.	S_{11} Kaprada	6.7
Medium Salinity	C2	0.25-0.75	Good	It can be used if a moderate amount of leaching occurs. Plants with moderate tolerance can be grown in most cases without special practices for salinity control.	S_3:Haria, S_7:Valvada, S_8:Bhilad, S_{12}:Sutharpada, S_{13}:Dharampur, S_{14}:Barumal, S_{15}: Kakadkuva	46.6
High Salinity	C3	0.75-2.25	Fair	It cannot be used on soil with restricted drainage. Even with adequate drainage, special management for salinity control may be required and plants with good tolerance should be selected.	S_1:Titahl, S_4: Pardi, S_5:Khadki, S_6: Vapi, S_9: Sarigam, S_{10}: Nanapondha	40
Very high Salinity	C4	>2.25	Poor	It is not suitable for irrigation under ordinary conditions but may be used occasionally under very special circumstances.	S_2 Dhamdachi	6.7

The frequency distribution of groundwater samples among the stations with respect to EC shows that about 6.7% fall under EC less than 0.25 mmhos/cm, while 46.6% have an EC value between 0.25 to 0.75 mmhos/cm, 40% have an EC value between 0.75 to 2.25 mmhos/cm and 6.7% fall under very high EC class (C4) in Valsad district. According to above classification, groundwater of Dhamdachi station is not suitable for irrigation under ordinary conditions. Groundwater quality is found 'Fair' at S_1 (Tithal), S_4 (Pardi), S_5 (Khadki), S_6 (Vapi), S_9 (Sarigam), S_{10} (Nanapondha) with respect to EC and hence special management of salinity control required before when used for irrigation. Kaprada has 'Excellent' category of groundwater, rest stations have 'Good' category of groundwater and hence can be used for irrigation.

Sodium Absorption Ratio (SAR):

Salinity Laboratory of Agriculture recommended the water classification according to the value of SAR [3] as presented in Table 4.

The frequency distribution of groundwater samples among the stations with respect to SAR shows that none of samples had SAR value greater than 26.0. The groundwater quality is good to excellent with respect to SAR and suitable for irrigation purpose.

Table 4: Classification of groundwater according to SAR (alkali hazard)

Grade	Class	SAR range	Category of water	Suitability	Representing stations	% Distribution
Low sodium	S1	<10	Excellent	It can be used for irrigation on almost all soil with little danger of the development of harmful levels of exchangeable sodium. However, sodium-sensitive crops such as stone-fruit trees and avocado may accumulate injurious concentrations of sodium.	All except Dhamdachi (S_2)	93.3
Medium sodium	S2	10 to 18	Good	It will present an appreciable sodium hazard in fine-textured soils having high CES, especially under low leaching conditions, unless gypsum is present in soil. This water may be used on coarse-textured or organic soils with good permeability.	Dhamdachi (S_2)	6.7
High sodium	S3	18 to 26	Fair	It may produce harmful levels of exchangeable sodium in most soils and will require special soil management, good drainage, high leaching and organic matter additions. Gypsiferous soils may not develop harmful levels of exchangeable sodium from such waters.	None	0.0
Very high sodium	S4	>26	Poor	It is generally unsatisfactory for irrigation purposes except at low and perhaps medium salinity, where the solution of calcium form the soil or use of gypsum or other amendments may make the use of these waters feasible.	None	0.0

U.S. Salinity Laboratory Classification:

EC and SAR are responsible for salinity and sodium hazard respectively. Therefore, U.S. Salinity Laboratory proposed a classification [10] with reference to SAR as an index for sodium hazard S and electrical conductivity (EC) as an index of salinity hazard C. This classification categorizes for water into 16 classes. The chemical analysis data of groundwater of the study area has been processed as per U.S. salinity laboratory classification and findings have been submitted in Table 5.

Table 5: U.S. Salinity laboratory classification

Station	EC	SAR	Class	Classification
1	2.214	5.24	C3S1	high salinity low sodium hazard water
2	2.848	11.99	C4S2	very high salinity medium sodium hazard water
3	0.331	1.75	C2S1	medium salinity low sodium hazard water
4	0.854	2.34	C3S1	High salinity low sodium hazard water
5	0.758	2.12	C3S1	high salinity low sodium hazard water
6	0.997	3.25	C3S1	High salinity low sodium hazard water
7	0.664	2.28	C2S1	medium salinity low sodium hazard water
8	0.527	1.21	C2S1	medium salinity low sodium hazard water
9	0.91	1.42	C3S1	High salinity low sodium hazard water
10	0.876	0.68	C3S1	High salinity low sodium hazard water
11	0.238	0.57	C1S1	Low salinity low sodium hazard water
12	0.284	2.64	C2S1	medium salinity low sodium hazard water
13	0.603	0.88	C2S1	medium salinity low sodium hazard water
14	0.28	0.76	C2S1	medium salinity low sodium hazard water
15	0.314	0.67	C2S1	medium salinity low sodium hazard water

In present study only five classes are observed as below:

1. Very high salinity and medium sodium hazard water (C4S2):

Only one station, i.e. S_2 (Dhamdachi) has such type of groundwater. Medium SAR of this groundwater indicates dominance of calcium and magnesium ions. This type of water is not suitable for irrigation in ordinary conditions, though It may be used occasionally under very special circumstances.

2. Medium salinity low sodium hazard water (C2S1):
Total 7 stations have such type of groundwater namely S_3, S_7, S_8, S_{12}, S_{13}, S_{14} and S_{15}. The use of this type of water groundwater for irrigation purpose requires proper management practices.

3. High salinity low sodium hazard water (C3S1):
Total 6 stations have such type of groundwater namely S_1, S_4, S_5, S_6, S_9, and S_{10}. The groundwater could be used for irrigating semi-tolerant crops without any harmful sodic effect.

4. Low salinity low sodium hazard water (C1S1):
Only one station, i.e. S_{11} (Kaprada) falls in this category. It is suitable for irrigation purpose.

CONCLUSION

On the basis of above discussion, it may be concluded that the groundwater of Valsad district was having high to very high salinity at 47% location. SAR value indicates that no location fall under the category of high sodium hazard. While on the basis of US salinity classification, it may be summarized that groundwater at one sampling station i.e. Dhamdachi (S2) is not suitable for irrigation in ordinary conditions.

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