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Assessment of groundwater quality in Jaisamand catchment for drinking purpose using geographical information system

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■ **ABSTRACT :** The present study focuses on a GIS-based assessment and characterization of groundwater quality using pre monsoon and post monsoon groundwater quality data. Spatio-temporal variations of water quality parameters in the study area were analysed by using GIS techniques. Maximum area of Jaisamand catchment showed the drinking water quality within permissible limit. EC somewhat extent within permissible limit during pre monsoon period. Sulphate content also exceeded from permissible limit some extent in pre monsoon period but in post monsoon period it was within permissible range. The maximum total dissolved solids were found in western site of study area during pre monsoon period whereas in post monsoon period maximum area showed total dissolved solids within permissible range.

■ **KEY WORDS :** Water quality, GIS, Assessment, Spatio-temporal

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Water is essential to the existence of man and all living things. Man's activities such as food production, nutrition are dependent on water availability in adequate quantities and good quality. Groundwater has become the major source of water supply for domestic, industrial and agricultural sectors of many countries. It is estimated that approximately one-third of the world's population use groundwater for development, industrial and agricultural activities directly or indirectly affect groundwater quality (Singh and Chandel, 2006; Gupta *et al.*, 2008 and Srinivasamoorthy *et al.*, 2008). On the earth 37 Mkm^3 of fresh water estimated to be present, about 22 per cent exists as groundwater, which constitutes about 97 per cent of all liquid freshwater potentially available for human use (Foster, 1998). However, the worldwide groundwater overdraft, declining well yields, drying up of springs, stream flow depletion and land subsidence due to over exploitation of groundwater as well as the growing degradation of groundwater quality by natural and/or anthropogenic pollutants, are threatening our ecosystems and even the lives of our future generations (Bouwer, 2000; Shah *et al*., 2000; Zektser, 2000 and Evans and Sadler, 2008). The quality of groundwater is critical in the regions that are characterized by a semi-arid/arid climate and dominated by agricultural activities; the water quality is generally affected by diffuse contamination originating from intensive irrigated agriculture (Saidi *et al*., 2009). Scarcity in several parts of the country, especially in arid and semi-arid regions. The over dependence on groundwater to meet ever-increasing demands of domestic, agriculture and industry sectors has resulted in overexploitation of groundwater resources in several states of India such as Gujarat, Rajasthan,

Punjab, Haryana, Uttar Pradesh, Tamil Nadu, among others (CGWB, 2006; Garg and Hassan, 2007 and Rodell *et al*., 1991). Geographic information system (GIS) has emerged as a powerful tool for storing, analysing and displaying spatial data and using these data for decision making in several areas including engineering and environmental field (Stafford, 1991; Goodchild *et al*., 1993; Burrough and McDonnell, 1998 and Lo and Yeung, 2003). It allows for swift organization, quantification, and interpretation of a large volume of spatial data, providing an efficient environment. The main intent of the present study was to evaluate groundwater quality and characterize its spatial and temporal variations in a Jaisamand catchment of Udaipur district in Rajasthan (India).

METHODOLOGY

Study area :

The Jaisamand lake catchment is located in the Udaipur district which falls semi-arid region of Rajasthan bounded by Longitude $73^0$45' E to $74^0$25'E and Latitude $24^0$10' N to $24^0$35' N. The lake is also a prime source supply drinking water for the city of Udaipur located at a distance of about 52 km from the lake. The Jaisamand lake with a gross capacity of 414.6 Mm^3 and live storage of 296.14 Mm^3, is Asia's second largest artificial water storage reservoir built across the Gomati river. In Jaisamand catchment Gomati, Thavaria, Siroli, Vagurwa, Jhamri, Sukhali, Godi, Makradi and Bhangar are the major rivers. The total catchment of Jaisamand lake is 1857.87 km^2 with highest elevation is 693m above mean sea level.

The location map of Jaisamand catchment as shown in Fig. A.

Data collection :

For the analysis of groundwater quality of the catchment, pre and post monsoon groundwater samples were collected in sampling bottles by dividing the entire basin into 6km x 6km grid. Fig. B shows the location map of groundwater sampling sites. The groundwater samples were collected in plastic bottles thoroughly cleaned and sterilized. The samples were collected using rope and bucket. These samples were analysed in the laboratory to find out different water quality parameters such as pH, EC, TDS, CO_3, HCO_3, SO_4, Cl, Ca, Mg, Na and K. On the basis of the results of the analysis the

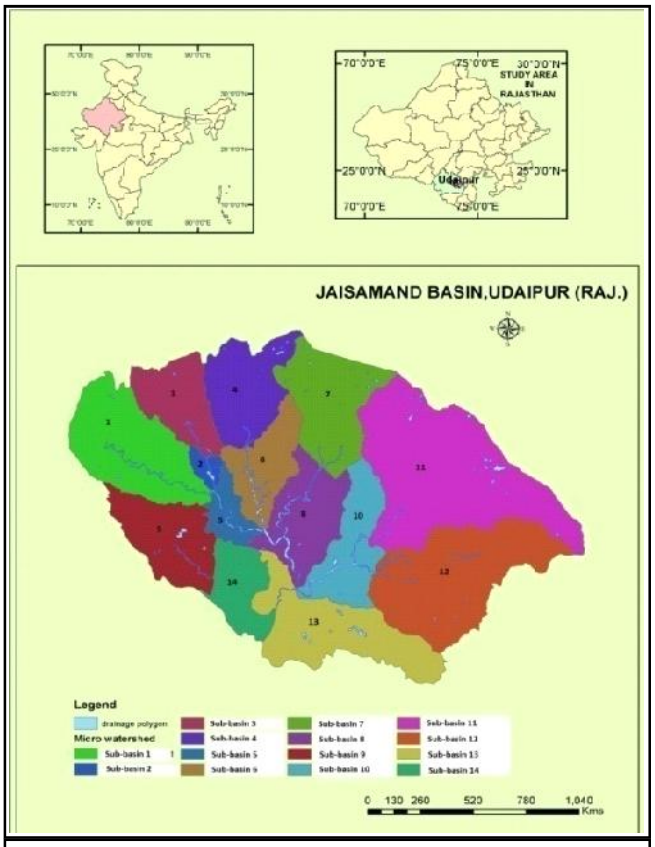

Fig. A : Location map of study area

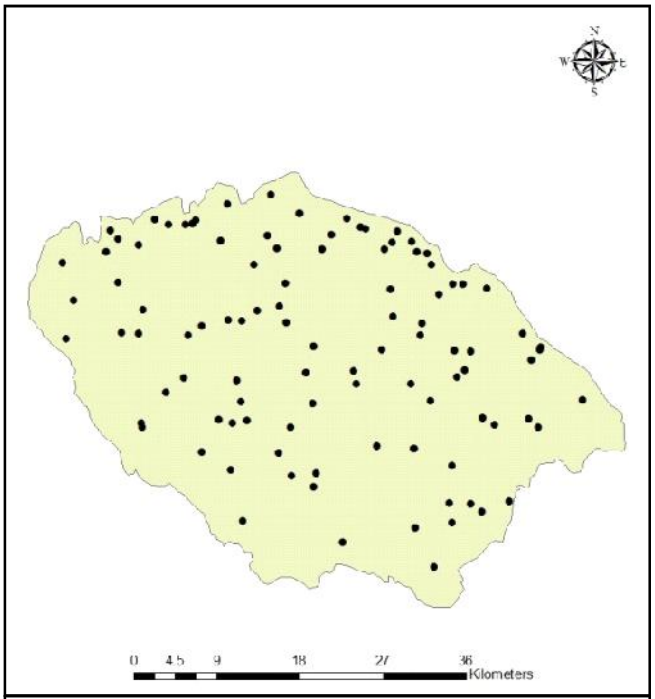

Fig. B : Location map of groundwater sample sites

Table A : Methods used for estimation of physio-chemical parameters

Sr. No.	Parameters	Methods	References
1.	pH	Using Glass Electrode pH meter	Jackson (1973)
2.	Electrical conductivity	Using EC meter	Wilcox (1950)
3.	Total dissolved solids	Using TDS meter	Singh and Kalra (1975)
4.	Calcium and magnesium	EDTA titration	Cheng and Bray (1951)and Diehl *et al.* (1950)
5.	Sodium	Flame Photometric method	Toth *et al.* (1948)
6.	Potassium	Flame Photometric method	Stanford and English (1949)
7.	CO_3 and HCO_3	Titration with standard H_2SO_4	A.O.A.C. (1950)
8.	Chloride	Silver Nitrate method	A.O.A.C. (1950)
9.	Sulphate	Titrimetric method	Munger *et al.* (1950)

different water quality parameter map of the Jaisamand catchment was prepared under GIS environment. Water samples for quality assessment were analysed for chemical constituents. Therefore, more attention was given to avoid the possibility of any external contamination.

Analysis of water samples :

The physico-chemical parameters such as pH, electrical conductivity (EC), total dissolved solids (TDS), calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), potassium (K^{+}), bicarbonate (HCO_3^{-}), carbonate (CO_3^{2-}), chloride (Cl^{-}) and sulphate (SO_4^{-}) were determined using standard methods. AR grade reagents were used for the analysis and double distilled water was used for preparation of solutions. Then water quality maps of Jaisamand catchment were prepared using GIS software. The methods used for estimation of various physico-chemical parameters are given in Table A.

■ RESULTS AND DISCUSSION

Eleven groundwater quality parameters, *viz*., pH, EC, TDS, Ca, Mg, Na, K, HCO_3, CO_3, Cl, and SO_4 were analysed for determining their spatial and temporal variations. Groundwater quality maps were prepared in GIS environment using IDWMA technique (Fig. 1 to 4) and various classes along with area contributed are given in Table 2 and 3 during pre monsoon and post monsoon period. The suitability of drinking quality was analysed using Indian standards for drinking purpose. The pH of groundwater varied from 6.80 to 7.90 with a mean of 7.35 in pre monsoon period and 7.20 to 8.50 with a mean of 7.77 in post monsoon period (Table 1). About 46.48 per cent area of Jaisamand catchment pH ranged between 7.10 to 7.35 pre monsoon period and 55.38 per cent area ranged between 7.70 to 7.85 during post monsoon period. The highest pH was observed in the Edana, Kheri, Ratanpura, Loda, Dedkiya, Sameta etc. villages during pre monsoon period and highest pH

Table 1 : Maximum and minimum value of water quality parameters in groundwater samples

Parameters	Pre-monsoon samples (meq/lit.)			Post-monsoon samples (meq/lit.)		
	Min.	Max.	Mean	Min.	Max.	Mean
pH	6.8	7.9	7.345	7.2	8.5	7.768
EC	0.62	6.7	1.596	0.25	5.83	1.139
TDS	390	4280	1018.709	157	3730	728.864
Ca	1.4	32.2	6.805	1	21.3	4.347
Mg	2.1	28.2	6.293	0.4	21.3	4.390
Na	1.2	7.8	3.559	0.7	13.5	2.745
K	0.0	0.5	0.022	0	0.6	0.026
HCO_3	1.8	7.2	4.194	0.4	28	4.658
CO_3	0.0	2.0	0.312	0	3.0	0.827
Cl	2.1	35.24	7.806	1.3	17	4.459
SO_4	1.1	25.21	4.664	0.3	5.3	1.812

observed in Songaron ka Khera, Naharpura, Adwas, Ajbara etc. villages in post monsoon period.

Concentration of TDS, a measure of quality, ranged from 390 to 4280 mg/lit. with a mean of 1018.709 mg/lit. during pre monsoon and 157 to 3730 mg/lit. with a mean of 728.86 mg/lit. in post monsoon period. Fig. 1 and 2 show that the 66.99 per cent area in pre monsoon and 83.17 per cent area in post monsoon showed concentration of total dissolved solids within its maximum permissible limit (<1500 mg/lit.).The western part of the study area, namely Kanpur, Umarda, Tank, Karget, Lakarwas etc. villages in pre monsoon period and Kanpur,

Table 2 : Pre monsoon water quality parameter classes and area

Parameters (Pre monsoon)	Classes		Area(km^2)	Per cent area
	From	To		
Ca	1.40	3.75	287.18	15.46
	3.75	10.00	1103.53	59.40
	10.00	32.20	467.15	25.14
Mg	2.10	2.50	12.09	0.65
	2.50	8.33	1141.12	61.42
	8.33	28.20	704.66	37.93
Cl	2.10	7.04	827.55	44.54
	7.04	28.16	1030.30	55.46
CO_3	0.00	0.10	488.95	26.32
	0.10	0.30	736.97	39.68
	0.30	0.72	481.28	25.91
	0.72	1.58	141.28	7.61
	1.58	2.00	9.02	0.49
EC	0.62	2.34	1246.03	67.07
	2.34	6.70	611.81	32.93
HCO_3	1.80	2.75	59.29	3.19
	2.75	3.45	303.96	16.36
	3.45	4.45	942.70	50.75
	4.45	5.60	473.05	25.47
	5.60	7.20	78.49	4.23
K	0.00	0.03	1583.09	85.23
	0.03	0.09	192.55	10.37
	0.09	0.17	56.30	3.03
	0.17	0.30	20.57	1.11
	0.30	0.50	4.99	0.27
Na	1.20	2.55	132.72	7.15
	2.55	3.10	461.29	24.83
	3.10	4.45	1028.34	55.36
	4.45	7.80	235.16	12.66
pH	6.80	7.10	104.71	5.64
	7.10	7.35	863.44	46.48
	7.35	7.59	806.65	43.43
	7.59	7.90	82.71	4.45
SO_4	1.10	4.17	772.32	41.57
	4.17	8.33	910.15	48.99
	8.33	25.21	175.41	9.44
TDS	390.00	1500	1244.55	66.99
	1500	4280	613.32	33.01

Lakarwas, Bhekra, Bhalon Ka Gurha, Hariya Khera, etc. villages in post monsoon shows that TDS was more than 1500 mg/lit.

The electrical conductivity (EC) varied from 0.62 to 6.70 dS/m with an average of 1.596 dS/m during pre monsoon and 0.25 to 5.83 dS/m with an average of 1.14 dS/m during post monsoon period. Table 2 and 3 revealed that about 67.07 per cent of the study area during pre monsoon and about 83.07 per cent area during post monsoon showed the EC less than 2.34 dS/m which is suitable for drinking purpose. The western part of the study area particularly Karget, Lakarwas, Tank, Mavali dangiyan etc. villages found more EC (>2.34dS/m) during pre monsoon period.

The mean concentration of major ion in groundwater was in the following order: cation:-calcium> magnesium> sodium>potassium during pre monsoon period and magnesium>calcium>sodium>potassium during post monsoon period and Anions:-chloride> sulphate> bicarbonate>carbonate during both pre and post monsoon period. Among the cations, the concentrations of Ca, Mg, Na, and K ions ranged from 1.40 to 32.20, 2.10 to 28.20,

Table 3 : Post monsoon water quality parameter classes and area

Parameters (Post monsoon)	Classes		Area(km^2)	Per cent area
	From	To		
Ca	1.00	3.75	710.33	38.23
	3.75	10.00	1053.91	56.73
	10.00	21.30	93.36	5.03
Cl	1.30	7.04	1253.24	67.45
	7.04	17.00	604.67	32.55
CO_3	0.00	1.00	1414.23	76.14
	1.00	2.00	440.80	23.73
	2.00	3.00	2.48	0.13
EC	0.25	2.34	1543.41	83.07
	2.34	5.83	314.53	16.93
HCO_3	0.40	1.73	19.31	1.04
	1.73	2.34	95.67	5.15
	2.34	2.62	200.49	10.79
	2.62	28.00	1542.03	83.02
K	0.00	0.05	1493.00	80.38
	0.05	0.19	329.00	17.71
	0.19	0.60	35.50	1.91
Mg	0.40	2.50	542.85	29.22
	2.50	8.33	1059.63	57.04
	8.33	21.30	255.37	13.75
Na	0.70	1.45	33.38	1.80
	1.45	4.11	1679.31	90.41
	4.11	13.50	144.82	7.80
pH	7.20	7.70	342.67	18.45
	7.70	7.85	1028.80	55.39
	7.85	7.99	396.35	21.34
	7.99	8.50	89.69	4.83
SO_4	0.30	1.27	180.69	9.73
	1.27	1.62	682.78	36.76
	1.62	2.59	854.74	46.02
	2.59	5.30	139.30	7.50
TDS	157	1500	1545.20	83.17
	1500	3730	312.66	16.83

1.20 to 7.80 and 0 to 0.50 meq/lit. with a mean of 6.81, 6.293, 3.56 and 0.022 meq/lit., respectively during pre monsoon period and 1 to 21.30, 0.40 to 21.30, 0.70 to 13.50 and 0 to 0.60 meq/lit. with a mean of 4.35, 4.40, 2.75 and 0.026 meq/lit., respectively during post monsoon period.

The major ion chemistry data revealed that Mg and Ca were the most predominant cationic constituents followed by Na during pre monsoon period as well as post monsoon period. The dissolved anions of HCO_3, CO_3, Cl and SO_4 ions ranged from 1.80 to 7.20, 0.0 to 2, 2.10 to 35.24 and 1.10 to 25.21 meq/lit. with a mean of

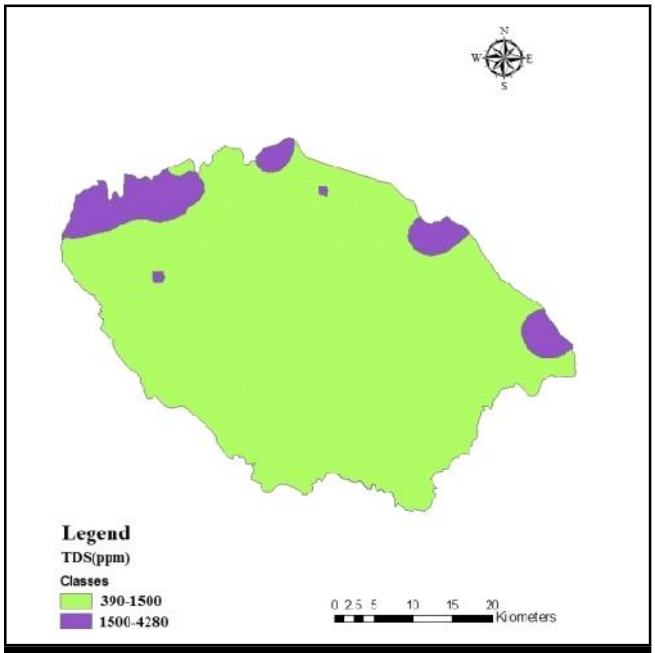

Fig. 1 : Variation of TDS during pre monsoon

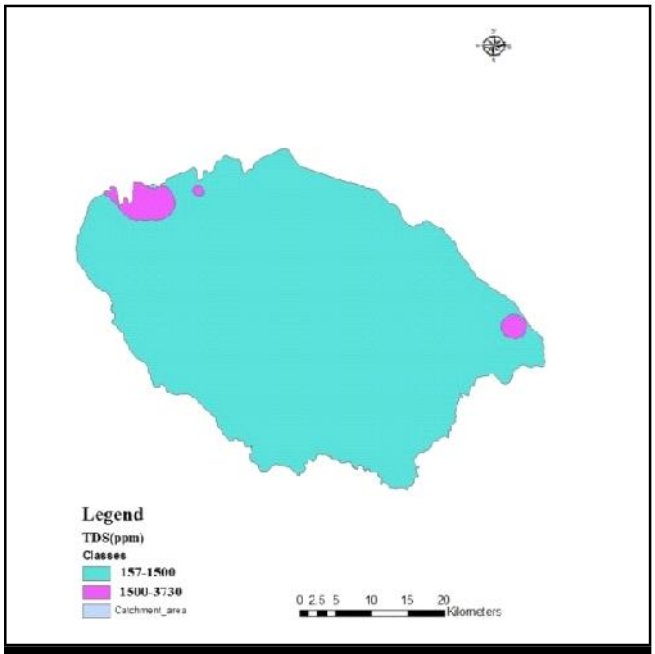

Fig. 2 : Variation of TDS during post monsoon

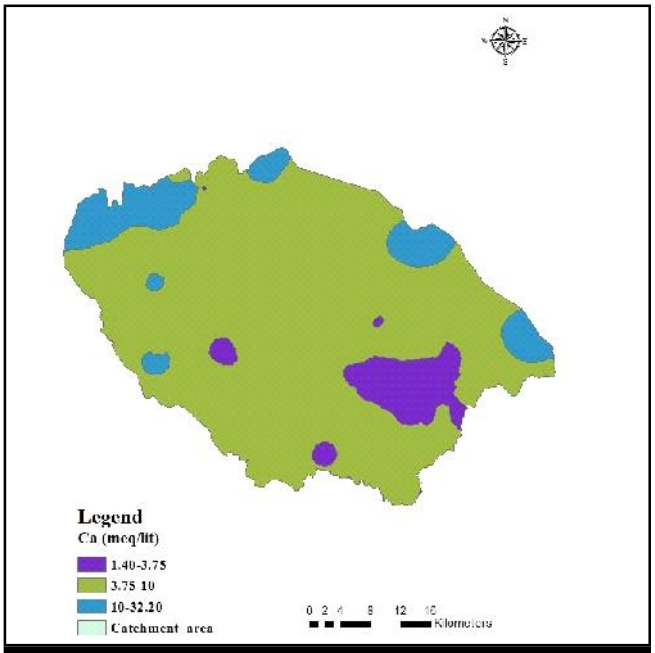

Fig. 3 : Ca variation in pre monsoon

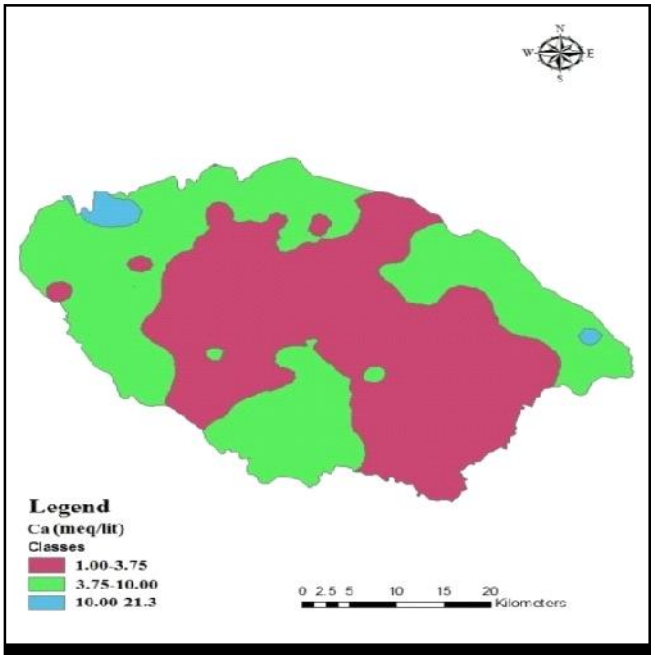

Fig. 4 : Ca variation in post monsoon

4.19, 0.31, 7.81 and 4.66 meq/l, respectively during pre monsoon period and 0.40 to 28, 0 to 3, 1.30 to 17 and 0.30 to 5.30 meq/l with a mean of 4.66, 0.83, 4.46 and 1.81 meq/l, respectively during post monsoon period. For the major anions (SO_4, Cl, HCO_3, and CO_3), the chloride and sulphate were found to be the most predominant anions followed by bicarbonate and carbonate during pre monsoon whereas chloride and bicarbonate were found to be most predominant anions followed by sulphate and carbonate during post monsoon period. Fig. 3 and 4 reveal that western part and some north east part of the study area had high calcium content during both pre and post monsoon period.

The maximum area showed the Ca content within the permissible limit (3.75-10 meq/lit.) during pre monsoon period for drinking purpose. The highest Ca were found in the Kanpur, Umarda, Gulabpura, Mahuri khera etc. villages during pre monsoon period and Bhekra, Lakrwas, Karget Bhalon ka Gurha etc. villages in post monsoon period. Figure also reveals that 25.14 per cent of the study area showed the calcium was greater than 10 meq/lit. in pre monsoon period and about 5.03 per cent study area showed calcium was greater than 10 meq/lit. during post monsoon period. The 61.42 per cent area in pre monsoon and 57.04 per cent area in post monsoon showed the Mg within the permissible limit (2.5-8.33 meq/lit). The 37.93 per cent area in pre monsoon and 13.75 per cent area in post monsoon exceeded Mg above permissible limit.

The highest Na was found in the Umarda, Kanpur, Bhekra, Gingala, Tinda, Jaithpura, Mavali Dangiyan etc. villages during pre monsoon period and Umarda, Dhamdhar, Karget, Rajpura, Mavali dangiyan etc. villages showed more Na during post monsoon period. Most part of the study area was found negligible K and CO_3 during both pre and post monsoon period. The highest HCO_3 was found in the Bortalai, Karget, Sathpur meenan, Umedpura etc. villages in pre monsoon period and about 83.01 per cent area showed the HCO_3 greater than 2.62 meq/lit. during post monsoon period.

In the South-West and North-East villages *viz.*, Gigla, Loda, Gamri, Oda, Nakoli, Basu, Umarda, Patiya etc. showed Cl within permissible limit during pre monsoon period and Kanpur, Lakarwas, Dedkiya, Bejarda, Bortalai etc. villages fell within permissible limit in post monsoon period. The 55.46 per cent area of Jaisamand catchment showed Cl within permissible limit (7.04-28.16 meq/lit) during pre monsoon period and 32.55 per cent area showed Cl within permissible limit during post monsoon (Table 2 and 3). The 48.99 per cent area showed SO_4 within permissible limit (4.17-8.33 meq/lit) in pre monsoon. The villages in East-West, some North side's portion and scatter patches in catchment showed the sulphate within the permissible limit.

Conclusion :

The present study was carried out in a Jaisamand catchment of Udaipur district in Rajasthan, Western India in order to evaluate and characterize suitability of groundwater quality for drinking purpose using pre monsoon and post-monsoon groundwater quality data of 109 sites. The results of analysis show that the maximum area had good groundwater quality for drinking purpose.

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REFERENCES

A.O.A.C. (1950).*Official and tentative methods of analysis.* The association of Official Agricultural Chemists, Washington. Ed. 7:910.

Bouwer, H. (2000). Integrated water management: Emerging issues and challenges. *Agric. Water Manage.,* **45** : 217-228.

Burrough, P.A. and McDonnell, R.A. (1998). *Principles of geographical information systems* (pp. 333). Oxford: Oxford University Press, NEW YORK, U.S.A.

CGWB (2006). *Dynamic groundwater resources of India (as on March, 2004).* Central Ground Water Board (CGWB), Ministry of water resources. New Delhi: Government of India 120 pp.

Cheng, K.L. and Bray, R.H. (1951). Determination of calcium and magnesium in soil and plant material. *Soil Sci.*, **72** : 449-458.

Diehl, H., Goetz, C.A. and Hauch, C.C. (1950). The versene titration for total hardness. *Amer. Water Works Assoc. J.* , **42**:40-48.

Evans, R.G. and Sadler, E.J. (2008). Methods and technologies to improve efficiency of water use. *Water Resour. Res.,* **44** :

W00E04. doi:10.1029/2007WR006200

Foster, S. (1998). Groundwater : Assessing vulnerability and promoting protection of a threatened resource. In *Proceedings of the 8th Stockholm water symposium* (pp. 79–90), 10–13 August, Sweden

Garg, N.K. and Hassan, Q. (2007). Alarming scarcity of water in India. *Curr. Sci.*, **93** : 932–941.

Goodchild, M.F., Parks, B.O. and Steyart, L.T. (1993). The state of GIS for environmental problem-solving. *Environmental modeling with GIS* (pp. 8–15). Oxford University Press, NEW YORK, U.S.A.

Gupta, S.A., Mahato, P., Roy, J.K. and Saha, R.N. (2008). Geochemistry of groundwater Burdwan District, West Bengal, India. *Env. Geol.*, **53**: 1271-1282.

Jackson, M.L. (1973). *Soil chemical analysis.* Prentice Hall of India Private Limited, NEW DELHI (INDIA). .

Lo, C.P. and Yeung, A.K.W. (2003). *Concepts and techniques of geographic information systems* (pp. 492). Prentice-Hall of India Pvt. Ltd., NEW DELHI (INDIA).

Munger, J.R., Nippier, R.W. and Ingold, R.S. (1950). Analytical chemistry of the sulphur acids. *Anal. Chem.*, **22** : 1455.

Rodell, M., Velicogna, I. and Famiglietti, J.S. (1991). Satellite-based estimates of groundwater depletion in India. *Nature*, **460** : 999–100213.

Saidi, S., Bouri, S., Dhia, H.B. and Anselme, B. (2009). A GIS-based susceptibility indexing method for irrigation and drinking water management planning: Application to Chebba-Mellouleche aquifer, Tunisia. *Agric. Water Mgmt.*, **96** : 1683–1690.

Shah, T., Molden, D., Sakthivadivel, R. and Seckler, D. (2000). *The global groundwater situation: Overview of opportunities and challenges*. Colombo: IWMI

Singh, T. and Kalra, Y.P. (1975). Specific conductance method for *in situ* estimation of total dissolved solids. *J. Am. Water Works Assoc.*, **67** (2) : 99.

Singh, V. and Chandel, C.P.S. (2006). Analysis of wastewater of Jaipur city for agricultural use. *Res. J. Chem. Env.*, **10**(1): 30-33.

Srinivasamoorthy, K., Chidambaram, S. and Vasanthavigar, M. (2008). Geochemistry of fluorides in groundwater: Salem District, Tamil Nadu. *India. J. Env. Hydrol.*, **1** : 16-25.

Standford, S. and English, L. (1949). Use of the flame photometer in rapid soil tests for K and Ca. *Agron. J.*, **4** : 446-447.

Stafford, D.B. (1991). *Civil engineering applications of remote sensing and geographic information systems*. New York: ASCE.

Toth, S.J., Prince, A.I., Wallace, A. and Mikkelsen, D.S. (1948). Rapid quantitative determination of eight mineral elements in plant tissue by a systematic procedure involving use of a flame photometer. *Soil Sci.*, **66** : 459-466.

Wilcox, L.V. (1950). Electrical conductivity. *Amer. Water Works Assoc. J.*, **42** : 775-776.

Zektser, I.S. (2000). *Groundwater and the environment: Applications for the global community* (175 pp.). BocaRaton: Lewis.