



A statistical approach to study groundwater quality of Pardi Taluka, Valsad District, Gujarat, India

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Abstract

In present investigation, 72 groundwater samples collected from three stations of Pardi taluka of Valsad district, South Gujarat for a period of two years and were analyzed by standard methods. For this study, physico-chemical parameters such as pH, Colour, Electrical Conductance (EC), Total Alkalinity (TA), Total Hardness (TH), Calcium, Magnesium, Sodium, Copper, Lead, Manganese, Fluoride (F⁻), Chloride (Cl⁻), Silica, Sulphate (SO₄⁻²), Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS) and Sodium Adsorption Ratio (SAR) were determined. The results were compared with the Indian standard. Correlation coefficient 'r', Regression analysis and Water Quality Index (WQI) were determined for monitoring water quality.

Keywords: Groundwater, Pardi Taluka, Correlation coefficient, Regression equation, WQI.

Introduction

Ground water is a crucial problem in environmental engineering and water supply systems, thus protection and purification of ground water have a crucial capacity in any community. India is a predominantly agricultural country. The sources of water irrigation to agricultural land for irrigating are rainwater, surface and groundwater. The ground water quality is depended upon the hydro geochemical composition, which are basic reason in variation of water qualities of groundwater sources. Various classifications based on Electrical conductivity (EC), Sodium absorption ratio (SAR) etc. have been proposed to classify water for irrigation purpose. WQI is one of the most effective tools¹⁻⁴ to communicate information on the quality of water to the concerned citizens and policy makers. The WQI suggestion is based on comparison of water quality parameter with respective to regulatory standards⁵. Horton⁶ gives the idea of WQI. Regression analysis helps in estimating or predicting the unknown value of one variable from known values of another variables⁷⁻⁹. The present investigation carried out for statistical analysis of ground water from Pardi Taluka, Valsad district (South Gujarat), India.

Materials and methods

Study area: For present study, Pardi Taluka of Valsad district was selected. Valsad district has total geographical area of 3055 sq km, extended by the North latitude of 20°07' to 20°45' and East longitude of 72°43' to 73°29'. Valsad district is one of the important tribal districts of Gujarat State. The district has varied agriculture crops, both food crops, horticulture and nonfood crops. Main food crops consist of food grains such as paddy, wheat, jowar, bajra, maize etc., and pulses.

Climate: There are three seasons (a) Monsoon (b) Winter and (c) Summer.

Rainfall: In Pardi taluka, value of annual rainfall was 2216mm in 2007, 2192mm in 2008 and 1742mm in 2009.

Sampling and method of analysis: Before collection of water sample, polythene bottles were cleaned with water samples to be analyzed. 72 water samples were collected from privately owned manually operated Hand pumps (from 50 Ft. depth) and Bore well (from 100 Ft. depth) from three sampling stations such as Pardi, Khadki and Vapi from August-2007 to July-2009. pH measured on the sites during sampling. Physico-chemical parameters like pH, Colour, EC, TA, TDS, Total Hardness (TH), Calcium, Magnesium, Sodium, Cu⁺², Pb, Mn⁺², Fluoride (F⁻), Chloride (Cl⁻), Silica, SO₄⁻², COD were taken for study and measured by using standard techniques^{10,11}.

Results and discussion

Physico-Chemical Parameters of groundwater of Pardi Taluka were presented and compared with IS Standards¹² for drinking water were shown in Table-1.

Fluoride acts like double edge sword. Lower value of fluoride than permissible limit causes dental caries in children while higher concentration is associated with dental fluorosis like chalky white teeth, pitting and mottling of teeth.

Correlation coefficient¹³⁻¹⁷: The correlation between the various parameters is studied using Pearson's Correlation coefficient Matrix¹⁸. When value of 'r' is in the range of ± 0.8 to ± 1.0 the correlation between the parameters is characterized as

strong, moderate when 'r' is in the range of ± 0.5 to ± 0.8 and consider as weak when value of 'r' in the range of ± 0.0 to ± 0.5¹⁹.

$$r = \frac{\sum [(x-\bar{x})(y-\bar{y})]}{\sqrt{\sum (x-\bar{x})^2 \sum (y-\bar{y})^2}} \quad (1)$$

Where $x = x - \bar{x}$, (2)

According to Karl Pearson, coefficient of correlation 'r' between two parameters x and y was calculated as shown below;

$$y = y - \bar{y} \quad (3)$$

Table-2 shows the correlation coefficients between the major ions at three stations.

Table-1: Values of physico-chemical parameters of groundwater in Pardi taluka. (Data were expressed in mg/l except SAR and pH)

Parameters	Values of water parameters (in mg/l)			I.S. limit for drinking Water IS-105000-(1991)	
	Min.	Max.	Mean± S.D.	Desirable	Permissible
pH	6.9	8.0	7.4± 0.23	6.5-8.5	No relaxation
Colour (Hz)	-	20	4.0 ± 4.04	5	25
EC (mmho/cm)	0.6	1.28	0.844 ± 0.09	-	-
Total Hardness	290	705	394 ± 50.91	300	600
Calcium	56.11	126.25	92 ± 12.04	75	200
Magnesium	19.44	110.57	40 ± 10.62	30	90
Total Alkalinity	200	485	369 ± 40.09	200	600
TDS	536	1155	760 ± 77.67	500	2000
Silica	10	35	23 ± 4.88	-	-
Chloride	46.85	266.96	103 ± 31.83	250	1000
Sulphate	4.9	88.2	29.6 ± 14.88	200	400
Fluoride	0.33	0.48	0.34 ± 0.27	1.0	1.5
COD	Not Detected	24.24	4.3 ± 5.57	-	-
Copper	-	0.02	0.002 ± 0.00	0.05	0.15
Lead	-	-	-	0.05	No relaxation
Manganese	-	0.06	0.002 ± 0.01	0.1	0.3
Sodium	49.0	240	101 ± 32.93	-	-
SAR	1.21	5.07	2.21 ± 0.45	-	-

Table-2: Correlation coefficient ‘r’ for various parameters of groundwater of Pardi taluka.

	pH	EC	TH	Ca ⁺²	Mg ⁺²	TA	TDS	Silica	Cl ⁻	SO ₄ ⁻²	COD	Cu ⁺²	Mn ⁺²	SAR	F ⁻	Na ⁺
pH	1.00															
EC	0.57	1.00														
TH	0.48	0.99	1.00													
Ca ⁺²	-0.72	0.16	0.26	1.00												
Mg ⁺²	0.99	0.52	0.44	-0.75	1.00											
TA	-0.34	0.59	0.66	0.89	-0.38	1.00										
TDS	0.55	0.99	0.99	0.19	0.50	0.61	1.00									
Silica	0.57	-0.35	-0.44	-0.97	0.62	-0.96	-0.37	1.00								
Cl ⁻	0.82	0.94	0.90	-0.19	0.78	0.27	0.93	-0.01	1.00							
SO ₄ ⁻²	0.36	-0.57	-0.64	-0.90	0.41	-0.99	-0.59	0.97	-0.25	1.00						
COD	0.87	0.90	0.86	-0.28	0.84	0.18	0.89	0.08	0.99	-0.16	1.00					
Cu ⁺²	-0.40	-0.98	-0.99	-0.35	0.07	-0.73	-0.99	0.53	-0.36	0.72	-0.80	1.00				
Mn ⁺²	-0.86	-0.07	0.03	0.97	0.07	0.77	-0.05	-0.90	0.41	-0.78	-0.49	-0.12	1.00			
SAR	0.74	0.98	0.95	-0.06	0.70	0.39	0.97	-0.14	0.99	-0.37	0.98	-0.91	-0.29	1.00		
F ⁻	0.40	0.98	0.99	0.34	0.34	0.73	0.98	-0.53	0.85	-0.72	0.80	-0.99	0.12	0.91	1.00	
Na ⁺	0.73	0.98	0.95	-0.05	0.69	0.40	0.97	-0.14	0.99	-0.38	0.97	-0.99	-0.23	0.99	0.91	1.00

Table-2 shows a strong positive correlation between pH with Mg⁺², Cl⁻, COD and Mn⁺²; EC with TH, TDS, Cl⁻, COD, SAR, F⁻ and Na⁺; TH with TDS, Cl⁻, COD, SAR, F⁻ and Na⁺; Ca⁺² with TA and Mn⁺², Mg with COD; TDS with Cl⁻, COD, SAR, F⁻ and Na⁺; Silica with SO₄⁻²; Cl⁻ with COD, SAR, F⁻ and Na⁺; COD with SAR, F⁻ and Na⁺; SAR with F⁻ and Na⁺; F⁻ with Na⁺.

Regression equation: Regression is some sort of functional relationship between two or more related variables. The regression equation is presented as y=ax+b, where x is independent variable and y is dependent variables²⁰. Correlation coefficient ‘r’ values and regression equations values for various physico-parameters was shown in Table-3.

Water Quality Index (WQI): WQI is defined as a rating reflecting the composite influence of different water quality parameters. Here WQI created by CCME (Canadian Council of

Ministers of the Environment) and was used and referred as CWQI²¹:

$$WQI = 100 - \{[F_1^2 + F_2^2 + F_3^2]^{1/2} / 1.732\} \quad \text{---(4)}$$

Where; F₁ is no. of variables not correlate with water quality objectives, F₂ is the number of times the objectives that are not correlate and F₃ is the extent to which objectives exceeds. CWQI between 95 to 100 consider as Excellent, between 80 to 94 consider as good, between 65 to 79 consider as fair, between 45 to 64 considered as marginal and between 0 to 44 considered as poor. WQI of Pardi taluka for the study period was 80 for August 2007 to July 2008, 86 for August 2008 to July 2009 and 80 (composite of two year) which is in good category according to CCME (WQI). Cation anion ratio of parameters was shown in Table-4.

Table-3: Values Correlation coefficient ‘r’ and regression equations for groundwater parameters.

Pardi						
No.	Correlation between		'r' value	Equation		
1	pH	x	Mg	0.996	Y= 6.6747 + 0.0181	Mg
2		x	Chloride	0.815	Y= 7.1632 + 0.0019	Chloride
3		x	COD	0.866	Y= 6.6333 + 0.1667	COD
4		x	Mn	-0.861	Y= 7.4513 + (-0.7936)	Mn
5	EC	x	TH	0.995	Y= -3.0752 + 0.0100	TH
6		x	TDS	0.999	Y= -0.0280 + 0.0012	TDS
7		x	Chloride	0.940	Y= 0.4599 + 0.0032	Chloride
8		x	COD	0.903	Y= -0.3058 + 0.2528	COD
9		x	Cu	-0.981	Y= 0.9931 + (-113.4211)	Cu
10		x	SAR	0.975	Y= 0.4150 + 0.1782	SAR
11		x	Fluoride	0.978	Y= -0.3056 + 2.8355	Fluoride
12		x	Na	0.977	Y= 0.4379 + 0.0037	Na
13	TH	x	TDS	0.997	Y= 305.9819 + 0.1146	TDS
14		x	Chloride	0.900	Y= 356.0386 + 0.3086	Chloride
15		x	COD	0.856	Y= 284.1111 + 23.8889	COD
16		x	Cu	-0.994	Y= 407.7684 + (-11473.6842)	Cu
17		x	SAR	0.948	Y= 351.1359 + 17.2839	SAR
18		x	Fluoride	0.990	Y= 276.3947 + 286.8421	Fluoride
19	TDS	x	Na	0.950	Y= 353.3309 + 0.3567	Na
20		x	Chloride	0.931	Y= 426.7248 + 2.7746	Chloride
21		x	COD	0.892	Y= -228.666 + 216.6667	COD
22		x	Cu	-0.985	Y= 886.6105 + (-98842.105)	Cu
23	x	SAR	0.970	Y= 386.7827 + 153.7167	SAR	
24	Mg	x	COD	0.836	Y= -0.8889 + 8.8889	COD
25	TA	x	Silica	-0.959	Y= 661.1081 + (-13.1351)	Silica
26		x	Sulphate	-0.998	Y= 457.8560 + (-4.4935)	Sulphate

Table-4: Cation–Anion ratio of parameters.

Stations	Ratio	Aug 2007- July 2009 (2 yr.)		
Pardi	$\text{Na}^+/\text{Ca}^{++} + \text{Mg}^{++}$	0.42	0.69	0.56
	Na^+/Cl^-	1.18	1.78	1.51
	$\text{Ca}^{++} + \text{Mg}^{++}/\text{Cl}^-$	2.28	3.38	2.74
	Cl^-/F^-	100.89	158.71	130.77
Khadki	$\text{Na}^+/\text{Ca}^{++} + \text{Mg}^{++}$	0.34	0.69	0.48
	Na^+/Cl^-	1.15	1.64	1.38
	$\text{Ca}^{++} + \text{Mg}^{++}/\text{Cl}^-$	2.04	4.69	2.99
	Cl^-/F^-	69.76	232.67	142.68
Vapi	$\text{Na}^+/\text{Ca}^{++} + \text{Mg}^{++}$	0.64	1.24	0.84
	Na^+/Cl^-	1.29	1.59	1.41
	$\text{Ca}^{++} + \text{Mg}^{++}/\text{Cl}^-$	1.13	2.22	1.75
	Cl^-/F^-	126.57	340.67	201.62

Conclusion

In general, groundwater quality for Pardi taluka is found satisfactory for drinking purpose. Values of SO_4^{2-} , Ca^{+2} , TA, TDS, Cl^- , F^- and Na^+ of water samples are found within permissible limits. A positive (strong) correlation found between pH with Magnesium, Chloride, COD and Mn^{+2} , EC with TH, TDS, Cl^- , COD, SAR, F^- and Na^+ . The WQI of the study area was between 80 to 86 which was considered as good category according to CCME.

In addition to water quality, other factors such as type of soil, type of crop and rainfall and climate etc., were play vital role in determining the suitability of water.

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