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Dynamic Modeling of Water Quality in Malpura Block District Tonk, Rajasthan, India

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Abstract

The present study consolidates the assessment of physico-chemical parameters of ground water samples of Malpura block in Tonk district, Rajasthan (India). Eighteen samples were collected from different sites of Malpura block (Tonk) from hand pumps and open wells. To study the physical parameters such as pH, EC, TDS and chemical parameters such as calcium, magnesium, sodium, potassium, carbonate, bicarbonate, sulfate, chloride, fluoride and nitrate during post-monsoon session (October 2008—January 2009). From the observation it may inferred that the concentration of hydrogen ion (pH), F^-, Cl^-, Mg^{2+}, EC and TDS exceeded permissible limits, but the value of Na^+, Ca^{2+}, NO_3^-, SO_4^{2-} and HCO_3^- were found to be within permissible limit as prescribed by WHO. From the Hill-Piper trilinear diagram it is observed that the majority of ground water is calcium-magnesium-chloride-sulfate type water.

Key words : Malpura block, Physico-chemical parameters, Hill-Piper trilinear diagram.

Water is the most vital resource for all kind of life on this planet, is being adversely affected both quantitatively and qualitatively by all kinds of human activities on land, in air and in water. Ground water is used as a major source for drinking purposes, so the quality of ground water is equally important to its quantity owing to suitability of water for various purposes. The chemical, physical and bacterial characteristic of ground water determine its usefulness for municipal, commercial, industrial, agricultural and domestic water supplies. Various workers in our country have carried out extensive studies on water quality. Abbasi et al. (1) studied water quality of Buckingham canal. Raju (2) studied hydro-geochemical parameters for assessment of ground water quality in upper Gunjanaeru river basin, Cuddaph district, Andhra Pradesh, South India. Laluraj et al. (3) studied ground water chemistry of shallow aquifers in the coastel zones of Coachin. Jha and Verma (4) have reported the physico-chemical property of drinking water in town area of Godda district under Santal Pargana, Bihar. Studies of industrial waste water and ground water have also been studied in our laboratory (5—7). The objectives of the scientific investigations is to determine the hydrochemistry of the ground water and to classify the water in order to evaluate the water suitability for drinking, domestic and irrigation uses and its suitability for municipal, agricultural and industrial use.

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Methods

Malpura block (longitude : 75°38′ E; latitude : 26°28′ N) is located at the north eastern part of Tonk district in Rajasthan. Ground water samples from different hand pumps, open wells and tube wells of eighteen sampling point were analyzed during post-monsoon session. Ground water samples were collected in sterilized screw-capped polythene bottle of one liter capacity, labeled properly. The instruments were used in the limit of precise accuracy, chemical were used of analytical grade, double distilled water used for preparing solution for analysis.

Various physical parameters like pH, EC and TDS were determined at the site with help of digital por-

Table 1. Estimation of various physico-chemical parameters by different methods.

Parameters	Method used
1. Chloride (as Cl^- in mg/l)	Argentometric titration
2. Carbonate (as CO_3^{2-} in mg/l)	Titrimetry
3. Bicarbonate (as HCO_3^- in mg/l)	,,
4. Magnesium (as Mg^{2+} in mg/l)	EDTA titration
5. Calcium (as Ca^{2+} in mg/l)	,,
6. Sodium (as Na^+ in mg/l)	Flame photometric method
7. Potassium (as K^+ in mg/l)	,,
8. Sulfate (as SO_4^{2-} in mg/l)	,,
9. Nitrate (as NO_3^- in mg/l)	,,
10. Fluoride (as F^- in mg/l)	,,

table water analyzer kit (CENTURY-CK-710). The samples collected were analyzed as per standard procedure of APHA (8). Determination of major cations and anions were made in the laboratory using various analytical methods shown in Table 1).

Results and Discussion

The observed value of physico-chemical parameters of ground water samples of Malpura block are illustrated in Table 2. All the observed value is compared with standard values as recommended by world health organization (9).

Ground Water Quality

The pH. The observed pH value of ground water samples varied 9.5 to 11.1, which shows that ground water samples were alkaline in nature. All samples exceed the maximum permissible limit (9.5) of pH except A2, AB and AF.

EC. Electrical conductivity of the ground water samples varied from 252 µs/cm to 6720 µs/cm at 25 C. The maximum limit of EC in drinking water is 1500 µs/cm as prescribed by WHO (9). The ground water samples (A_1, A_6, A_7, A_8, AA, AB, and AI) exceed the permissible limit.

TDS. The total dissolved solid in water are represented by the weight residue left when water samples has been evaporated to dryness. The TDS value of ground water samples varied from 128.0 to 3430.0 mg/liter. The permissible value of TDS in drinking water is 1000 mg/liter. Ground water samples (A_1, A_6, A_7, AA, AB, AC and AI) exceed the permissible limit as prescribed by WHO (9).

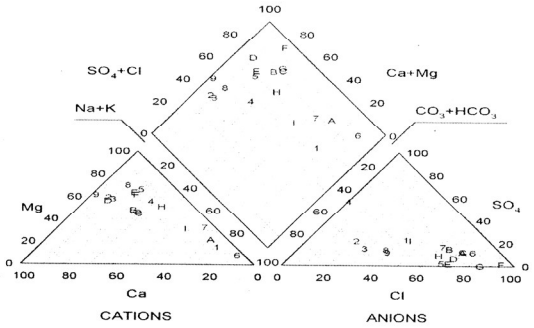

Figure 1. Piper diagram showing ground water quality of sampling sites of Malpura block.

Calcium (Ca^{2+}). The calcium concentrations are varied from 30.06 to 250.5 mg/liter and except AB all samples are with in permissible limit as prescribed by WHO (9).

Magnessium (Mg^{2+}). The magnesium concentration are varied from 60.10 to 276.3 mg/liter and these value are within the permissible limit prescribed by WHO (9) except AB, AC, AE and AF.

Sodium (Na^+) and Potassium (K^+). The sodium and potassium concentration are varied from 8.1 to 1363.3 mg/liter and 0.8 to 136.0 mg/liter respectively.

Sodium Percentage (Na %). The sodium percentage was calculated by Todd's (10) method :-

$$Na\ \% = \frac{(Na^+ + K^+)}{Ca^{2+} + Mg^{2+} + Na^+ + K^+} \times 100$$

Here all concentration is expressed in meq/liter. The value of Na % is varied from 1.86 to 88.82 (Table 3).

Sodium Adsorption Ratio (SAR). The sodium hazards expressed as the sodium adsorption ratio (SAR). This index quantifies the proportion of sodium (Na^+) to calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions in a sample. SAR is important parameter for determination of suitability of irrigation water. The sodium adsorption ratio for ground water samples were calculated by using Richard (11) equation :

$$SAR = (Na^+ \text{ meq/l}) / \sqrt{[(Ca^{2+} \text{ meq/l}) + (Mg^{2+} \text{ meq/l}) / 2}$$

Table 2. Ionic variation of ground water in Malpura block (Tonk district), Rajasthan. All values are in mg/liter except pH, EC and TDS.

Code	pH	EC	TDS	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	SO_4^{2-}	Cl^{-}	NO_3^{-}	F^{-}
A_1	10.3	3070	1518	50.1	60.1	534.6	53.2	0.0	579.5	299	408.2	5.29	3.6
A_2	9.50	1302	656	84.1	94.8	23.5	2.23	0.0	366.0	111	79.8	14.5	1.1
A_3	9.90	1116	557	70.1	79.0	26.7	2.56	0.0	347.7	74.	99.7	12.9	0.4
A_4	10.3	916	457	30.0	63.2	56.6	5.24	18.0	305.0	325	62.4	13.1	7.0
A_5	9.80	504	251	48.0	128	63.3	6.3	12.0	244.0	13	319.5	10.2	0.14
A_6	9.60	6720	3430	40.0	71.7	1363	136	0.0	427.0	335	1579	0.0	1.61
A_7	11.1	4440	2220	40.0	182	629.9	61.2	36.0	536.8	321	871.8	14.9	8.12
A_8	9.67	1845	916	70.0	158	44.9	4.35	0.0	457.5	107	210.1	13.8	0.83
A_9	9.70	1294	643	144	149	8.1	0.8	0.0	488.0	95	230.7	4.57	3.18
AA	9.80	6420	3250	96.1	178	1027	101	0.0	549.0	318	1405	15.5	1.00
AB	9.51	3010	1466	250	267	241.4	23.4	0.0	469.7	273	869.7	15.3	0.59
AC	9.73	2760	1360	210	212	241.4	21.0	0.0	317.2	194	834.2	14.5	0.15
AD	10.9	1257	627	180	182	38.4	3.4	30.0	305.0	69	550.2	0.0	3.35
AE	10.5	1250	640	128	252	121.9	11.2	30.0	457.5	25	692.2	6.4	1.3
AF	9.52	252	128	144	276	151.6	14.5	0.0	91.5	23	1011	0.0	0.16
AG	10.6	312	152	140	145	153.6	14.5	0.0	195.2	0.0	656.7	0.0	0.26
AH	10.1	1480	743	70.0	158	190.9	18.5	0.0	353.8	92	468.6	10.20	1.54
AI	10.3	3250	1586	90.1	127	402.3	39.5	12.0	573.6	303	303.0	13.82	11.3

Here all concentration is expressed in meq/liter. Sodium adsorption ratio varied from 0.1121 to 29.83 meq/liter (Table 3).

Residual Sodium Carbonate (RSC). In water having high concentration of bicarbonate there is tendency for calcium and magnesium to precipitate as carbonates. To explain this effect an experimental parameter termed as residual sodium carbonate was used. RSC is calculated as follows :

$$RSC = (CO_3^{2-} + HCO_3^{-}) - (Ca^{2+} + Mg^{2+})$$

Where the concentration are reported in meq/liter. Where all the samples fall in good category except sample A_1, which falls doubtful category (Table 3).

Carbonate (CO_3^{2-}) and Bicarbonate (HCO_3^{-}). Carbonate and bicarbonate concentration varied from 0.0 to 36.0 mg/liter and 91.52 to 579.5 mg/liter respectively.

Chloride (Cl^{-}). The chloride concentration varied from 0.71 to 1579.7 mg/liter. The maximum permissible limit of chloride for drinking water is specified as 400 mg/liter. About 65% of ground water samples exceed the maximum permissible limit as per WHO (9) standard.

Sulfate (SO_4^{2-}). The sulfate concentration varied from 0.0 to 335.0 mg/liter and these values are with in permissible limit as prescribed by WHO (9) standard.

Fluoride (F^{-}). The fluoride concentration varied from 0.07 to 113.0 mg/liter. Out of eighteen samples, six samples (A_1, A_6, A_7, A_9, AD and AI) exceed maximum permissible limit of fluoride in drinking water prescribed as WHO (9). These ground water samples are very hazardous for human consumption. Approximately 1.0 mg/liter of fluoride concentration are desirable in public water for optimal dental health. When the fluoride concentration increases more than 1.5 mg/liter, it reduced a development disease of teeth in the calcification stage of children.

Nitrate (NO_3^{-}). The nitrate concentration varied from 0.0 to 15.57 mg/liter and these values are with in permissible limit as prescribed by WHO (9) standard. Nitrates are dangerous for human health especially in infants below six month of age. Excessive concentration of nitrate in portable water in considered hazardous for infants because in their intestinal track is reduced to nitrate which may cause Methaemogloinaemia also called "blue baby syndrome". Nitrate concentration is excess in drinking water also creates several problem like cyanosis tumors, oral cancer of colon, rectum or other gastrointestinal cancers lymphomodispsmia.

Chemical Classification of Ground Water (Piper Trilinear Diagram)

The Piper (12) trilinear diagram (Fig. 1) consid-

Table 3. Irrigation quality characteristics of ground water on the basis of various parameters.

	Parameters	Range	Water class	Samples
1.	% Na	0—20	Excellent	A_2, A_3, A_5, A_8, A_9, AD, AE and AF
		20—40	Good	A_4, AB, AC, AG and AH
		40—60	Permissible	AI
		60—80	Doubtful	A_1, AA
		>80	Unsuitable	A_6
2.	SAR	0—10	Low	A_2, A_3, A_4, A_7, A_8, A_9, AB, AC, AD, AE, AF, AG, AH and AI
		10—18	Medium	A_1, AA
		18—26	High	Nil
		>26	Very High	A_6
3.	RSC	<1.25	Good	All samples except AI
		1.25–2.5	Doubtful	AI
		>2.5	Unsuitable	Nil
4.	EC	0—250	Good	Nil
		251—750	Permissible	A_5, AF, AG
		751—2250	Doubtful	A_2, A_3, A_4, A_8, A_9, AD, AE and AH
		>2250	Unsuitable	A_1, A_6, A_7, AA, AB, AC and AI

ered as the first step in chemical classification of water facies for the purpose of studying the evaluations of ground water. Major cations and anions such as Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, HCO_3^{-}, SO_4^{2-}, Cl^{-}, SO_4^{2-} and CO_3^{2-} in meq/liter were plotted in Piper trilinear diagram (Fig. 1) to evaluate the hydrochemistry of ground water of Malpura Block with the help of GWW software. This figure shows that most of ground water samples fall in field of $Ca^{2+} - Mg^{2+} - Cl^{-} - SO_4^{2-}$ type water. On the basis of Walton (13) classification nearly 72.2% samples showed an excess of alkaline earth over alkaline and nearly 88.8% of the ground water samples showed an excess of strong acid over weak acid.

Conclusion

The quality of almost all ground water samples collected from the study area indicated that the values of Na^{+}, K^{+}, Ca^{2+}, NO_3^{-}, SO_4^{2-} and HCO_3^{-} are with in permissible limits of WHO but more than 50% of ground water samples were high in pH, EC, TDS, F^{-}, Cl^{-} and Mg^{2+} which suggest that these sample have water quality on critical limit. It may concluded that the general characteristic of ground water samples from the study area classify the water under moderate category and are not best for household and irrigation.

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