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Assesment of Shallow Groundwater Quality for Irrigational Use in and around Berasia, M. P., India

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ABSTRACT
Water is very important for irrigation. Farmers of the study area mostly used dug well waters for irrigational purposes. The present study mainly concerns the irrigational utility of shallow groundwater in and around Berasia area, District Bhopal, Madhya Pradesh. In order to assess the shallow groundwater quality for irrigational use, 15 shallow groundwater samples have been collected during pre monsoon and post monsoon period and analysed by using the standard procedures as suggested by APHA (1995). The analytical results were used to determine the various irrigational specifications like Sodium Adsorption ratio, Kellys ratio, Residual sodium Carbonate, Salt Index, Magnesium Hazards Adj.SAR. On the basis of various irrigational specifications, it is suggested that the majority of shallow groundwater of the study area is quite suitable for irrigational purposes.

INTRODUCTION

Water is played most significant role in shaping the land and regulating the climate. Water is one of the main compounds that extremely influence the life. The shallow ground water is used for irrigational purposes in all around the globe. In the last few years, there has been a remarkable raise in the demand for water due to unplanned urbanization and industrialization for the past few decades in few parts of the country. The farmers of the study area are mostly using the shallow groundwater for agricultural purposes. Thus the hydro-geochemistry study is very important to keep pace with agricultural development in rural areas.

The area of present investigation falls on Survey of India Toposheet Nos. 55E/11, 55E/10, 55E/7, 55E/6, 55E/5, and is bounded between latitude $23^0$10' to $23^0$50' N and longitude $77^0$42' to 77^0 E. The important fringing rocks are the deccan traps lava flows of basaltic composition and traversed by a succession of sandstone hill of vindhyan range. The climate of the Study area has a humid subtropical climate, with cool, dry winters, a hot summer and a humid monsoon season. The soils of the study area are moderately fine textured and are clay to clay loam.

In the study area the alluvial is a rich source for groundwater occurrences. The groundwater occurs both under water table and confined condition. The alluvial aquifer system is the most extensive. The top aquifer ranges in thickness from 2 to 3 meter and comprises of fine medium grained sand with intercalations of clay and silt and at place also of-coarse sand or gravel. Confined condition has resulted in places where the granular zone occurs in between clay horizons. All the aquifers are principally recharged by a lateral flow from the south and also by direct vertical percolation of rain, Irrigation water, seepage from tanks and canals.

Material and Methods

In order to know the spatial and temporal variation in shallow groundwater quality, about 15 shallow ground water samples were collected from dug wells during Pre Monsoon and Post Monsoon period. In order to assess the potability of shallow ground waters of the study area the physical characters of the

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water samples were studied at the sampling point in the field, and the chemical characters have been determined in the laboratory by using the standard procedures as suggested by APHA (1995). The chemical analysis of water samples provide important information about the environment to which natural water is exposed in the hydrologic cycle. The concentration of major cations and anions are presented in Table-1 and 2. The chemical constituents have been converted to me/l and irrigational specifications like Salt Index, Kellys Ratio (KR), Sodium Adsorption Ratio (SAR), Soluble Sodium Percentage (SSP), Residual Sodium Carbonate (RSC) have been computed and presented in Table-3 and 4.

Table No. 1: Hydrochemistry of the study area (Premonsoon)

Well No.	Name Of the Village	pH	ECX10^6 at 25^0 C	TDS	CONCENTRATIONS IN MILIGRAM PER LITRE										
					CATIONS				T.H. as $CaCO_3$	ANIONS					
					Na^+	K^+	Ca^{++}	Mg^{++}		HCO_3	Co_3--	Cl^-	NO_3	SO_4	PO_4
2	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Khijradev	7.60	1400	896	36	7.6	42	12	152	150	Ab	23	75	46	0.24
2	Golkhari	7.50	820	525	36	1.6	45	20	225	180	Ab	34	80	35	0.12
3	sukha nipaniya	7.10	660	422	40	14.1	65	32	208	240	Ab	32	40	35	0.25
4	Bagonia	7.40	780	499	60	6.2	69	26	229	195	Ab	40	45	48	0.21
5	semerhari	7.20	810	518	25	3.1	58	36	306	220	Ab	45	60	46	0.18
6	Chandu khri	7.70	700	448	70	2.0	76	14	311	160	Ab	50	65	42	0.12
7	Intkeri	7.30	840	538	20	4.0	63	15	183	184	Ab	38	65	28	0.16
8	Taradi kalan	7.80	810	518	46	6.0	63	10	190	260	Ab	53	38	39	0.67
9	Habibganj	7.10	900	576	24	4.9	60	22	324	200	Ab	20	65	27	0.20
10	Kutkipura	7.40	870	557	30	3.6	42	28	193	195	Ab	34	75	36	0.35
11	Bhojapura	7.20	490	314	32	1.2	41	26	262	255	Ab	38	38	27	0.10
12	Semera	7.40	800	512	61	3.2	69	32	294	72	Ab	37	40	43	0.63
13	Bhamora	7.20	500	320	27	9.7	65	24	215	90	Ab	44	45	20	0.07
14	Imlipura	7.70	860	550	32	2.4	57	15	196	300	Ab	64	85	39	0.46
15	Pursora	7.60	440	218	30	3.6	65	18	210	190	Ab	40	76	27	0.10

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Table No. 2: Hydrochemistry of the study area (Post monsoon)

Well No.	Name Of the Village	pH	ECX10^6 at 25^0 C	TDS	CONCENTRATIONS IN MILIGRAM PER LITRE										
					CATIONS				T.H. as $CaCO_3$	ANIONS					
					Na^+	K^+	Ca^{++}	Mg^{++}		HCO_3	Co_3--	Cl^-	NO_3	SO_4	PO_4
2	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Khijradev	7.50	1350	890	32	7.50	41	11	150	145	Ab	21	72	42	0.22
2	Golkhari	7.30	810	500	32	1.40	42	18	200	175	Ab	32	78	32	0.12
3	sukha nipaniya	7.00	650	412	38	12.10	60	30	200	210	Ab	30	38	30	0.25
4	Bagonia	7.20	770	432	58	4.20	67	25	220	180	Ab	32	42	44	0.19
5	semerhari	7.00	800	500	22	2.10	55	28	300	198	Ab	40	58	42	0.10
6	Chandu khri	7.70	680	422	65	1.70	72	32	310	140	Ab	45	60	40	0.10
7	Intkeri	7.20	810	502	20	2.00	60	9	170	170	Ab	34	60	24	2.00
8	Taradi kalan	7.60	790	498	42	4.00	60	10	180	230	Ab	50	34	13	0.10
9	Habibganj	7.10	880	525	22	4.00	58	20	320	180	Ab	18	60	25	0.32
10	Kutkipura	7.20	850	550	28	2.90	40	25	194	185	Ab	32	65	34	0.30
11	Bhojapura	7.10	470	300	30	1.00	38	23	260	240	Ab	34	38	25	0.60
12	Semera	7.20	780	448	48	3.00	65	30	280	250	Ab	35	38	32	0.63
13	Bhamora	7.00	450	300	25	8.70	60	20	225	85	Ab	23	45	18	0.07
14	Imlipura	7.50	830	525	30	2.00	52	13	180	265	Ab	42	82	35	0.36
15	Pursora	7.30	530	335	19	3.10	29	11	198	240	Ab	32	34	28	0.12

Results and Discussion:

Hydrochemistry of the study area:

The hydrochemistry of collected groundwater samples during the pre- monsoon and post-monsoon period are presented in Table -1 and Table-2 respectively. The pH value of groundwater of the study area varies from 7.10 to 7.80 in pre-monsoon and 7.00 to 7.70 in post-monsoon period which suggests that the water is mildly alkaline in nature. The Electrical conductivity (EC) values in groundwater varies from 440 µmohs/cm to 1400 µmohs/cm and 450 µmohs/cm to 1350 µmohs/cm in pre-monsoon post-monsoon period respectively indicating that the shallow ground water has medium to high salt concentration.

Calcium content in groundwater varies from 41 mg/l to 76 mg/l in pre-monsoon and 29 mg/l to 72 mg/l in post-monsoon periods. The Magnesium concentration in groundwater varies from 10 mg/l to 36 mg/l in pre-monsoon and 09 mg/l to 32 mg/l in post-monsoon period. The sodium content in groundwater varies from 20 mg/l to 70 mg/l in pre-monsoon and 19 mg/l to 65 mg/l in post-monsoon period. The Potassium content in groundwater is varies from 1.2 mg/l to 14.1 mg/l in pre-monsoon and 1.00 mg/l to 12.10 mg/l in post-monsoon period. The total hardness in terms of CaCO3 ranges from 152 mg/l to 324 mg/l in pre-monsoon and 150 mg/l to 320 mg/l in post-monsoon period.

The chloride concentration in groundwater varies from 20 mg/l to 64 mg/l in pre-monsoon and 18 mg/l to 50 mg/l in post-monsoon period. The Sulphate concentration in the groundwater of the study area varies from 20 mg/l to 48 mg/l in pre-monsoon and 13 mg/l to 44 mg/l in post-monsoon period. In the present investigation, the Nitrate content in the groundwater varies from 38 mg/l to 85 mg/l in pre-monsoon and 34 mg/l to 82 mg/l in post-monsoon period. The Phosphate concentration in groundwater of the

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study area varies from 0.10mg/l to 0.67 mg/l in pre-monsoon and 0.07 mg/l to 2.00 mg/l in post-monsoon period. The carbonate content is found to be absent in all the samples of groundwater, collected during the pre-monsoon and post-monsoon periods. Bicarbonate is the predominant anion in the groundwater of the study area. Bicarbonate concentration in the groundwater varies from 72 mg/l to 300 mg/l in pre-monsoon and 85 mg/l to 265 mg/l in post-monsoon period.

Table No. 3 : Tabulated computed data of various Irrigational specifications of shallow groundwater in pre monsson

Well No.	Name of Village	Agricultural Utility					
		R.S.C.	K.R.	Mg%	Salt Index	Na %	SAR
1	2	3	4	5	6	7	11
1	Khijradev	-0.71	0.9	35.4	-11	33.04	1.2
2	Golkhari	-0.94	0.67	25.4	-7.2	28.3	1.2
3	sukha nipaniya	-0.62	1.12	37.5	-9	27.75	1.1
4	Bagonia	-1.73	0.56	44.3	-5.2	35.9	1.7
5	semerhari	-2.29	0.67	35.8	-2.5	14.49	1.3
6	Chandu khri	-1.33	1.62	40.7	-7.2	37.68	0.5
7	Intkeri	0.25	0.2	45.4	-2	16.24	2
8	Taradi kalan	-1.6	1.11	42.7	-9.2	33.55	0.5
9	Habibganj	-1.34	0.98	33.9	-4	17.18	1.5
10	Kutkipura	0.01	0.32	38.5	-6.4	22.87	0.6
11	Bhojapura	-1.62	0.66	47	-12.3	25.55	0.9
12	Semera	-2.28	0.48	39.6	-6.9	21.85	0.9
13	Bhamora	0.85	1.08	41.7	-13.5	35.44	0.8
14	Imlipura	-1.58	1.05	44.6	-8.3	18.99	1.6
15	Pursora	1.67	0.54	35	-10	12.52	0.9

Table No. 4: Tabulated computed data of various Irrigational specifications of shallow Groundwater in post monsoon

Well No.	Name of Village	Agricultural Utility					
		R.S.C.	K.R.	Mg%	Salt Index	Na %	SAR
1	2	3	4	5	6	7	11
1	Khijradev	0.05	0.8	33.45	-8	31.45	1.64
2	Golkhari	0.82	0.8	23.4	-4.5	32.43	1.23
3	sukha nipaniya	-2.13	1.16	39.5	-3.8	22.26	0.66
4	Bagonia	-2.43	0.58	47.4	-11.6	25.41	1
5	semerhari	-1.6	0.77	37.7	-12.5	18.11	0.85
6	Chandu khri	-4.02	0.48	42.4	-1.7	15.48	1.63
7	Intkeri	-0.17	0.89	49.2	-2.5	32.14	0.5
8	Taradi kalan	-1.19	0.64	43.31	-12.19	16.81	1.5
9	Habibganj	-0.87	0.23	35.01	-13.8	23.22	0.56
10	Kutkipura	-1.64	0.4	40.03	-8.4	26.94	1.5
11	Bhojapura	-0.3	0.56	45.7	-7.4	30.54	1.46
12	Semera	-1.7	0.67	37.5	-4.47	26.87	1.28
13	Bhamora	-0.39	0.84	39.1	-6.8	199.63	0.85
14	Imlipura	-0.42	0.78	43.7	-7.8	21.49	1.07
15	Pursora	-0.95	0.67	38.12	-9.3	15.66	1.44

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Irrigation Water Quality

In the present study, the specifications as proposed by Asgar et al. (1936); Kelley et al. (1940); Eaton, (1950); US Soil Salinity Laboratory Staff (1954); Wilcox (1955) and Paliwal (1972) have been used in terms of Salt Index, Kellys Ratio, Residual Sodium Carbonate (RSC), Soluble Sodium Percentage (SSP) and Sodium Adsorption Ratio (SAR), and Magnesium hazard respectively to assess the suitability of shallow groundwater for agricultural purposes. On the basis of irrigational specifications presented in Table -3 and 4, the irrigational suitability of shallow ground water have been evaluated and classified into various categories. The recommended classification of irrigation water quality with respect to EC, SAR, Kelly's Ratio, Mg. Ratio, RSC and Na% are presented in Table -5**.**

Asgar et al. (1936) suggested that salt index parameter evaluates the agricultural water quality. If salt index is negative, the water belongs to good category and if the salt index is positive then the water is unsuitable for irrigational purposes. In the present study, the values of all the shallow ground water samples are negative which indicates that the water is suitable for irrigation purposes.

On the basis of Kellys Ratio, the sodium problem in water can be evaluated. As per Kellys et al. (1940), if the Kelly ratio is less than one then the water is suitable, if it is between one and two then the water is marginally suitable and if it is beyond two then the water is unsuitable for irrigational purposes. In the present study, Table 3 and 4 reveals that the values of shallow ground water samples during pre and post monsoon period varies from 0.20 to 1.62 in pre monsoon and 0.23 to 1.16 in post monsoon period. Further, Table-5 indicates that the majority of shallow groundwater samples; 67% in pre monsoon period and 93% in post monsoon period, belongs to suitable category.

Eaton (1950) recommended that indirect effect of carbonate and bicarbonate on water quality is expressed in terms of Residual Sodium Carbonate (RSC). As per U.S. Soil Salinity Staff (1956), water with less than 1.25 me/l of RSC are safe, between 1.25 and 2.5 me/l of RSC are marginal in nature and beyond 2.5 of RSC are unsuitable for irrigational purposes. Table 3 and 4 reveals that all the shallow groundwater samples of the study area have RSC values less than 1.25 which clearly indicates that these waters are quite safe and suitable for irrigational purposes.

Wilcox (1955) proposed a classification based on the values of Electrical conductivity, Boron and Soluble sodium Percentage (SSP) for assessing irrigation water. When the values of EC and SSP concentration of shallow groundwater compared with this classification, the shallow groundwater are classified as Excellent to good and good to permissible class with respect to Na% and EC values respectively.

Paliwal (1972) has utilized the term magnesium percentage ratio as an index of magnesium hazards of irrigation water. When the Mg/Ca ratio in irrigation water increases the degree of hazardous effect also increases. As per Paliwal (1972), when this ratio exceeds 50% then the magnesium hazard is likely to be developed. In the present study the magnesium % varies from 33.5 to 68.2 in pre monsoon period and 12.54 and 57.23 in post monsoon period. Table-5 reveals that majority of shallow groundwater does not have magnesium hazards .However, few of the samples have more than 50% of magnesium which have quite restriction for sensitive crops.

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Table 5: Tabular classification of Groundwater of the study area

Irrigational Specifications	Range	Class	Type of Water			
			Pre Monsoon		Post Monsoon	
			No. of Samples	%	No. of Samples	%
EC	<250	Low	0	Nil	0	Nil
	250-750	Medium	5	33%	6	40%
	750-2250	High	10	67%	9	60%
	>2250	Very High	0	Nil	0	Nil
	Total		**15**	**100%**	**15**	**100%**
SAR	<10	Low	15	100%	15	100%
	10-18	Medium	0	Nil	0	Nil
	18-26	High	0	Nil	0	Nil
	>26	Very High	0	Nil	0	Nil
	Total		**15**	**100%**	**15**	**100%**
Kelly's Ratio	< 1	Suitable	10	67%	14	93%
	1-2	Marginal	5	33%	1	7%
	> 2	Unsuitable	Nil	Nil	Nil	Nil
	Total		**15**	**100%**	**15**	**100%**
Magnesium Ratio	< 50	suitable	15	100%	15	100%
	>50	Unsuitable	Nil	Nil	Nil	Nil
	Total		**15**	**100%**	**15**	**100%**
Residual Sodium Carbonate (RSC)	<1.25	Safe	15	100%	15	100%
	1.25-2.50	Marginal	Nil	Nil	Nil	Nil
	>2.50	Unsuitable	Nil	Nil	Nil	Nil
	Total		**15**	**100%**	**15**	**100%**
Salt Index	-Ve(Negative)	Suitable	15	100%	15	100%
	+Ve(Positive)	Un Suitable	0	Nil	0	Nil
	Total		**15**	**100%**	**15**	**100%**

Conclusions :

On the basis of the hydrochemistry, interpretations and discussions with respect to irrigational specifications, it is concluded that the majority of shallow groundwater samples of the study area quite suitable for irrigational purpose. However few of the water sample have magnesium hazard and such water should be restricted for irrigational use.

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