PREDICTION OF GROUNDWATER CHEMISTRY FOR IRRIGATION PURPOSES IN JHABUA DISTRICT MADHYA PRADESH

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Abstract

Ground water for irrigation in Jhabua district, Madhya Pradesh, India, is assessed for chemical purity. Twenty-five post-monsoon Meghnagar open-dug well water samples were analyzed for major cations and anions. Sodium Percent, Kelley's Ratio, Sodium Absorption Ratio, Residual Sodium Carbonate Ratio, and Magnesium risk describe irrigation ground water quality. pH (7.00-810), Electrical conductivity (305-910), and Total Dissolved Solids (250-460) ppm make water samples tasteless, odorless, and colorless. Chemical analysis analyzes Ca, Mg, K, Na, Cl, SO_4, HCO_3, NO_3, and F ions (0.20 – 1.05 ppm). The U.S. Salinity diagram and Wilcox diagram show ground water irrigation appropriateness based on chemical criteria including Sodium Percent, Kelley's Ratio, Sodium Adsorption Ratio, Residual Sodium Carbonate, and Magnesium-Hazard. Chemical characteristics determine groundwater irrigation. Jhabua's Meghnagar study region contains irrigation-quality groundwater.

Keywords: *Chemical Quality, Ground water, Irrigation, Jhabua*

Introduction

Most geological formations have holy groundwater. Groundwater is life-giving. Most irrigation uses groundwater. Agricultural, residential, and industrial pollutants degrade groundwater. Population growth and intensive agriculture have raised freshwater demand. Groundwater usage has grown due to complacency.

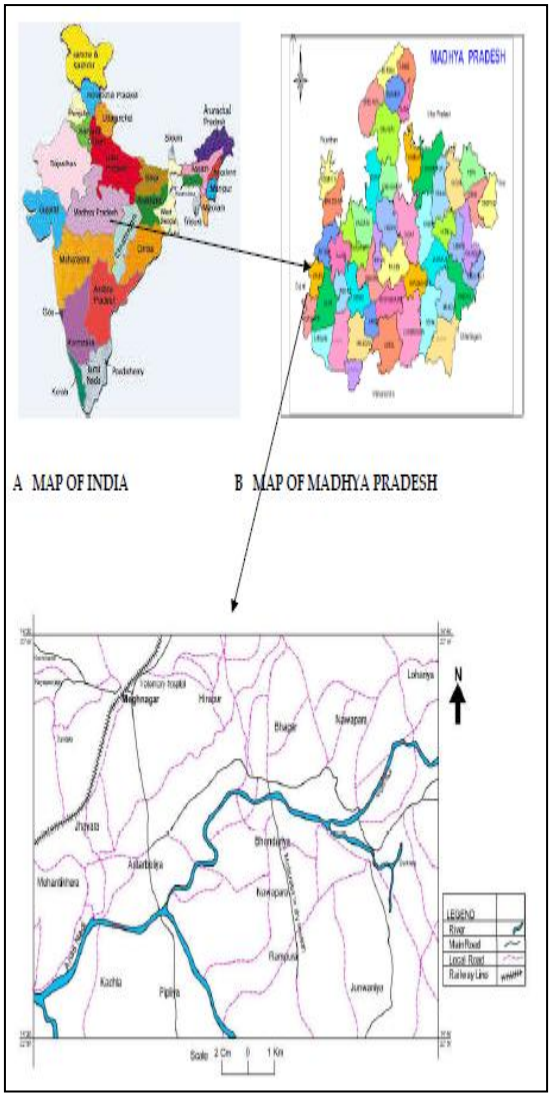
Groundwater quality is affected by soil or rock. Groundwater management programs value quality and quantity equally (Todd, 1980). Chemical analysis determines water total dissolved salts. Ions—cations (Calcium, Potassium) and anions (Calcium carbonate)—form from these water-dissolved salts (Johnsons,1983). An aquifer system's water's dissolved salts determine its suitability for agriculture, domestic water supply, and industry (Todd, 2001).

Soil and rock determine groundwater quality. Physical, chemical, biological, and radiological factors determine ground water quality. Groundwater's qualities determine its domestic, industrial, and agricultural uses. Groundwater quality data show rock geology, recharge, discharge, transport, and storage. Understanding water quality is essential for water and land resource management (Karanath, 1987 1994, 2003). To establish irrigation feasibility, this study examined Meghnagar ground water quality.

Study Area Characteristics

Study location is Meghnagar, 25 km from Jhabua, Madhya Pradesh. (Survey of India Toposheet No 46 J/9, Figure 1). Year-round rail and vehicle access. Natural and human processes coexist in the studied region. This tropical monsoon climate has three seasons: summer (March–June), rainy July–September, and winter (October–February) (October to February). Evenings are cool in simmer season. Rainy season cools. Clear, healthy winter. Rocks

form soil. The study site features black cotton soil. This particle-covered soil yields wheat, cotton, maize, and jawar. Quartzite and metamorphic rock weathering creates sand. This desert has extensive valleys for cultivation. Loamy southern granitic soil produces all crops. Few big trees grow. Scrubby jungle dominates the preserved woods. "Bhils and Pateliya" tribes dwell in the sparsely populated study area. They live in villages. They mostly consume arid ground crops.



C MAP OF STUDY AREA

Figure 1: Location map of the study area, Jhabua District, Madhya Pradesh

Collection of Ground Water Samples

Rainwater and Thatcher (1968), Walton (1970), Brown et al. (1970), I.C.M.R. (1975), A.P.H.A. (1998, 2005), Todd (2001), Karanth (2003), and others examined sample collection, preservation, analysis, and interpretation.

25 wells sampled study area groundwater. Locality, Sample number, and Collection Date were labeled on pre-clean sterilized 1-litre polyethylene bottles. Boxes held water samples. Labs examined samples. pH and EC meters tested groundwater samples. Laboratory methods assessed sodium, calcium, magnesium, potassium, carbonate, bicarbonate, chloride, and sulphate ionic concentrations.

Physico Chemical Analysis of Ground Water

Physical Analysis

Water irrigation factors include color, odor, taste, pH, EC, and TDS (TDS). Determine and show physical parameters (Table.1).

Table.1: Physical Parameters of dug well water samples of Meghnagar area, Jhabua, District, M. P.

Well No.	Location	Colour	Ordour	Taste	EC at 25°C	TDS ppm	pH

1.	Dhebar	CL	OL	TL	321	268	7.20
2.	Dhebar	CL	OL	TL	785	257	7.04
3.	Bhagaur	CL	OL	TL	515	325	7.95
4.	Balban	CL	OL	TL	310	395	8.00
5.	jhayara	CL	OL	TL	340	301	7.01
6.	Hirapur	CL	OL	TL	810	460	7.02
7.	Barkhera	CL	OL	TL	550	290	7.92
8.	Junwaniya	CL	OL	TL	320	355	7.00
9.	Junwaniya	CL	OL	TL	901	250	7.20
10.	Amlipathar	CL	OL	TL	360	332	7.80
11.	Dundaka	CL	OL	TL	490	295	7.07
12.	Negariya	CL	OL	TL	416	320	7.80
13.	Ishgarh	CL	OL	TL	365	345	7.95
14.	Kalyanpura	CL	OL	TL	910	403	7.30
15.	Kesariya	CL	OL	TL	305	372	7.45
16.	Amarpura	CL	OL	TL	385	395	8.10
17.	Antarbeliya	CL	OL	TL	745	289	7.33
18.	Meghnagar	CL	OL	TL	485	364	7.32
19.	Partapura	CL	OL	TL	355	358	7.71
20.	Rampura	CL	OL	TL	567	290	7.21
21.	Mauripara	CL	OL	TL	360	385	7.95
22.	Bhendarlya	CL	OL	TL	300	415	7.40
23.	Gundipara	CL	OL	TL	625	365	7.32
24.	Gopalpura	CL	OL	TL	430	310	7.20
25.	Nawapara	CL	OL	TL	625	422	7.09

Abbreviation: CL = Colourless, OL = Odourless, TL = Tasteless

Chemical Analysis

Tables 2 and 3 show the cation and anion concentrations of drilled well water samples.

Table 2: Determination of Ionic Concentration of Ground Water Samples Wells of Meghnagar study area, Jhabua, District M.P. (Values expressed in ppm)

S. No.	Location	Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	NO_3	F	TH
1.	Dhebar	82	90	60	1.20	-	85	130	150	30	0.65	172
2.	Dhebar	75	85	76	0.45	-	100	145	120	29	0.47	160
3.	Bhagaur	64	110	62	0.40	-	150	205	90	25	0.32	174
4.	Balban	12	95	55	0.75	-	135	201	110	21	0.30	21

		0										5
5.	jhayara	66	135	65	2.00	-	140	200	69	23	1.05	201
6.	Hirapur	110	108	64	1.75	-	185	140	100	35	0.40	218
7.	Barkhera	102	110	40	1.20	-	165	74	128	27	0.25	212
8.	Junwaniya	127	119	61	1.65	-	150	105	109	40	0.53	246
9.	Junwaniya	120	130	60	1.50	-	135	125	133	34	0.33	250
10.	Amlipathar	124	105	54	1.25	-	165	130	80	18	0.45	229
11.	Dundaka	165	45	67	1.40	-	140	150	115	30	0.54	210
12.	Negariya	154	61	58	1.60	-	205	110	90	37	0.40	215
13.	Ishgarh	205	110	50	1.25	-	150	205	125	45	0.35	315
14.	Kalyanpura	192	80	63	2.45	-	170	135	150	20	0.20	272
15.	Kesariya	134	103	48	1.40	-	225	160	80	12	0.65	327
16.	Amarpura	170	145	60	1.65	-	130	145	105	31	0.40	315
17.	Antarbeliya	135	82	55	1.25	-	180	125	75	35	0.25	217
18.	Meghnagar	131	102	70	1.50	-	250	85	155	40	0.60	233
19.	Partapura	107	145	59	2.05	-	135	78	95	29	0.45	252
20.	Rampura	119	105	61	1.75	-	120	110	130	20	1.00	224
21.	Mauripara	128	75	70	1.05	-	195	135	105	25	0.50	203
22.	Bhendarlya	110	95	71	2.60	-	260	90	60	15	0.25	205
23.	Gundipara	116	165	68	1.50	-	220	220	120	21	0.47	281
24.	Gopalpura	135	62	65	1.65	-	90	190	115	35	0.75	197
25.	Nawapara	92	130	67	2.25	-	135	140	100	29	0.60	222

Table 3: Determination of Chemical Parameters of Ground Water Sample of Dug Well of Meghnagar area, Jhabua, District M. P. (Values expressed in epm)

S.No.	Location	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	F
1.	Dhebar	1.09	7.40	2.61	0.03	-	1.39	3.66	3.12	0.48	0.03
2.	Dhebar	3.74	6.99	3.08	0.01	-	1.63	4.09	2.49	0.46	0.02
3.	Bhagaur	3.19	9.04	2.69	0.01	-	2.45	5.78	1.87	0.40	0.01
4.	Balban	5.98	7.81	2.39	0.01	-	2.21	5.67	2.29	0.33	0.01
5.	jhayara	3.29	11.10	2.82	0.05	-	2.29	5.64	1.43	0.37	0.06
6.	Hirapur	5.48	8.88	2.78	0.04	-	3.03	3.94	2.08	0.56	0.02
7.	Barkhera	5.08	9.04	1.74	0.03	-	2.70	1.97	2.66	0.43	0.01
8.	Junwaniya	6.33	9.78	2.65	0.04	-	2.45	2.96	2.26	0.64	0.03
9.	Junwaniya	5.98	10.69	2.61	0.03	-	2.21	3.52	2.76	0.54	0.01
10.	Amlipathar	6.18	8.63	2.34	0.03	-	2.70	3.66	1.66	0.29	0.02
11.	Dundaka	8.23	3.70	2.91	0.03	-	2.29	4.23	2.39	0.48	0.03
12.	Negariya	7.68	5.01	2.52	0.04	-	3.35	3.10	1.87	0.59	0.02
13.	Ishgarh	10.22	9.04	2.17	0.03	-	2.45	5.78	2.60	0.72	0.02
14.	Kalyanpura	9.58	6.58	2.74	0.06	-	2.78	3.80	3.12	0.32	0.01
15.	Kesariya	6.68	8.47	1.74	0.03	-	3.68	4.51	1.66	0.16	0.03
16.	Amarpura	8.48	11.92	2.61	0.04	-	2.13	4.09	2.18	0.50	0.02
17.	Antarbeliya	6.73	6.74	2.39	0.03	-	2.95	3.52	1.56	0.56	0.01
18.	Meghnagar	6.53	8.39	3.04	0.06	-	4.09	2.39	3.22	0.64	0.03
19.	Partapura	5.33	11.92	2.56	0.02	-	2.21	1.97	1.97	0.46	0.02

20.	Rampura	5.93	8.63	2.65	0.04	-	1.96	3.10	2.70	0.32	0.05
21.	Mauripara	6.38	6.16	3.04	0.02	-	3.19	3.80	2.18	0.40	0.02
22.	Bhendarlya	5.48	7.81	3.08	0.06	-	4.26	2.53	1.24	0.24	0.01
23.	Gundipara	5.78	13.57	2.95	0.03	-	3.60	6.20	2.49	0.33	0.02
24.	Gopalpura	6.73	5.10	2.82	0.04	-	1.47	5.35	2.39	0.56	0.04
25.	Nawapara	4.59	10.69	2.91	0.05	-	2.21	3.94	2.08	0.46	0.03

Table 4: Determination of percentage epm of Ground water samples of Meghnagar Area, Jhabua District, M.P.

S.N.	Location	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl	NO_3
1.	Dhebar	28.94	52.37	18.47	0.21	-	16.06	36.06	42.31	5.54
2.	Dhebar	27.06	50.57	22.28	0.07	-	18.80	28.71	47.17	5.30
3.	Bhagaur	21.36	60.54	18.01	0.06	-	23.33	17.80	55.04	3.80
4.	Balban	36.93	48.23	14.76	0.06	-	21.04	21.80	54.00	3.14
5.	hayara	19.06	64.31	16.33	0.28	-	23.53	14.69	57.96	3.80
6.	Hirapur	31.89	51.16	16.18	0.23	-	31.52	21.64	40.99	5.82
7.	Barkhera	31.96	56.89	10.95	0.18	-	34.79	34.27	25.38	5.54
8.	Junwaniya	33.67	52.02	14.09	0.21	-	29.48	27.19	35.61	7.70
9.	Junwaniya	30.96	55.35	13.51	0.15	-	24.47	30.56	38.98	5.98
10.	Amlipathar	35.97	50.23	13.62	0.17	-	32.49	19.97	44.04	3.48
11.	Dundaka	55.34	24.88	19.56	0.20	-	24.38	25.45	45.04	5.11
12.	Negariya	50.36	32.85	16.52	0.26	-	37.59	20.98	34.79	6.62
13.	Ishgarh	47.62	42.12	10.11	0.13	-	21.21	22.51	50.04	6.23

14.	Kalyanpura	50.52	34.70	14.45	0.31	-	27.74	31.13	37.92	3.19
15.	Kesariya	39.47	50.05	10.28	0.17	-	36.76	16.58	45.05	15.98
16.	Amarpura	36.78	51.71	11.32	0.17	-	23.93	24.49	45.95	5.6
17.	Antarbeliya	42.35	42.41	15.04	0.18	-	34.34	18.16	40.97	6.51
18.	Meghnagar	36.23	46.55	16.87	0.33	-	39.55	31.14	23.11	6.18
19.	Partapura	26.87	60.11	12.90	0.10	-	33.43	29.80	29.80	6.95
20.	Rampura	34.37	50.02	15.36	0.23	-	24.25	33.41	28.36	3.96
21.	Mauripara	40.89	39.48	19.48	0.12	-	33.33	22.77	39.70	4.17
22.	Bhendarlya	33.35	47.53	18.74	0.36	-	51.51	14.99	30.59	2.90
23.	Gundipara	25.88	60.77	13.21	0.13	-	28.52	19.73	49.12	2.61
24.	Gopalpura	45.81	34.71	19.19	0.27	-	15.04	24.46	54.75	5.73
25.	Nawapara	25.16	58.60	15.95	0.27	-	25.43	23.93	45.33	5.29

Chemical Quality of Ground Water

Determination of Chemical Parameters

According to the steps outlined above, the following variables are calculated to determine the quality of ground water utilized for irrigation:

Sodium Percent

The categorization system for irrigation water uses sodium percent (Na%). It is the quantity of sodium that is present in relation to the concentration of all cations. The following formula is used to determine the sodium percentage:

$$\text{Sodium Percent} = \frac{Na^{+} \times 100}{Na^{+} + Ca^{++} + Mg^{++} + K^{+}}$$

Equivalents per million are all ionic concentrations. Sodium percent usually reflects irrigation water quality. Base Exchange interactions with soil occur when irrigation water has high salt levels. Sodium replaces soil calcium and magnesium.

Residual Sodium Carbonate

Residual Sodium Carbonate (RSC) is computed by the use of following expression –

$$RSC = (CO3 + HCO3) - (Ca + Mg)$$

Sodium Absorption Ratio

Sodium adsorption ratio (SAR) determines water suitable for agriculture and irrigation. Solids in water determine it. Sodium content in ground water affects soil qualities, decreasing permeability (Kelley, 1951, Tijani, 1994). In C1 and C2 irrigation water classifications, clays swap

sodium for calcium and magnesium. Alkali soil has poor structure and limits aeration. Empirical parameter SAR quantifies this impact. Formula for sodium adsorption ratio:

$$SAR = \frac{Na}{\sqrt{(Ca+Mg)/2}}$$

$$SAR = [Na^+] / \{([Ca^{2+}] + [Mg^{2+}]) / 2\}^{1/2}$$

In milliequivalents per litre, sodium, calcium, and magnesium.

Higher salt adsorption ratios indicate less irrigation-suitable water. To minimize long-term soil damage, irrigation with high sodium adsorption ratio water may need soil additives.

Most soil includes calcium, magnesium, and minor amounts of sodium ions. Less than 5% of exchangeable cations are sodium ions. This percentage disrupts soil grain aggregation at 10% or above. If irrigation water with a high SAR is sprayed to soil for years, salt may displace calcium and magnesium, reducing soil's capacity to form stable aggregates and tilt. This reduces soil water penetration and permeability, affecting crop productivity. U.S. Salinity Laboratory (1954) proposed irrigation water quality categorization (Table 5).

Magnesium Hazards

Magnesium danger is the excess of magnesium over calcium and magnesium, which are generally in balance. Magnesium overdose degrades soil and stunts crop development. High-Mg water hinders plant development. Lime in irrigation water reduces Mg-hazard. Paliwal's method assessed irrigation water's magnesium threat (1972). Computation formula:

Mg Hazards = Mg x 100 / Ca + Mg

Magnesium weathers as insoluble silicates in igneous and metamorphic rocks. Weathering may increase ground water magnesium levels. The research area's Mg-Hazard levels are 31.01 to 73/91.

Table 5: Indices Derivative from the geochemical parameters of dug wells.

S.No.	Sodium Absorption Ratio	Residual Sodium Carbonate	Sodium Percent	Kelley's Ratio	Mg Hazards
1.	25.03	-10.1	83.89	0.227	64.40
2.	30.65	-9.1	86.86	0.287	65.14
3.	25.07	-9.78	83.51	0.219	73.91
4.	20.94	-11.58	79.94	0.173	56.63
5.	24.23	-21.1	81.82	0.195	77.13
6.	23.88	-11.33	81.63	0.193	61.83
7.	15.05	-11.42	73.86	0.123	64.02
8.	21.49	-13.66	79.06	0.164	60.70
9.	20.78	-14.46	78.22	0.156	64.12
10.	19.84	-12.11	78.44	0.158	58.27
11.	27.43	-9.64	84.85	0.243	31.01
12.	23.02	-9.34	70.73	0.198	39.47
13.	16.11	-16.81	72.16	0.112	46.93
14.	22.16	-13.38	79.52	0.169	40.71
15.	14.53	-11.47	72.49	0.114	55.90

18.	25.62	-10.83	82.37	0.203	56.23
16.	18.78	-18.27	74.58	0.127	58.43
17.	21.19	-10.52	80.29	0.177	50.03
19.	20.08	-15.04	77.35	0.148	69.10
20.	22.60	-12.6	80.68	0.182	59.27
21.	27.95	-9.35	84.78	0.242	49.12
22.	27.54	-9.03	84.17	0.231	58.76
23.	21.86	-15.75	77.82	0.152	70.12
24.	26.72	-10.36	84.55	0.238	43.11
25.	24.23	-13.09	81.37	0.190	69.96

Estimation of Irrigation Quality

Wilcox Diagram

This diagram is used to ascertain the classification of water for irrigation purposes. According to Wilcox (1955) the groundwater has been classified into five types such as: - (a) Excellent to good, (b) Good to permissible, (c) Permissible to doubtful, and
(d) Doubtful to unsuitable and (e) Unsuitable.

Conclusion

The article evaluated groundwater for irrigation quality estimates. Physicochemical examination of excavated well water samples. The plots of examined data on U.S. Salinity and Wilcox diagrams show that study region ground water is generally suitable for irrigation.

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