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GROUNDWATER QUALITY SURVEILLANCE OF AJMER-PUSHKAR RAILWAY LINE REGION IN PRE- AND POST-MONSOON SEASONS-A CASE STUDY

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ABSTRACT

In the present work, an attempt is made to address the groundwater quality issue of Ajmer-Pushkar railway line region in pre- and post-monsoon seasons. Physico-chemical characterization of groundwater in the study area has been carried out as per various national and international standards. The study revealed significant rise in groundwater contamination from pre- to post-monsoon season. Some samples were found to have higher contents of Ca, TDS, Na and F than the limits prescribed by BIS, WHO and ICMR. The high percentage rise was observed in nitrate content from pre- to post-monsoon season.

INTRODUCTION

Groundwater is fresh and clean in nature. But human activities are constantly adding industrial, domestic and agricultural wastes to groundwater reservoirs at an alarming rate. In comparison with rivers or streams, groundwater tends to move slowly and with very little turbulence. Once contaminants reach groundwater, little dilution or dispersion normally occurs. Groundwater quality may also vary temporarily in pre- and post-monsoon seasons. The pollutants present on surface get dissolved in rainwater and percolate through ground to reach the groundwater table. However, the dissolution and percolation of pollutants depend on many parameters such as solubility and chemical nature of the pollutants, the soil type, i.e., soil texture and its quality as well as the ground cover. The present work investigates seasonal changes in groundwater quality of Ajmer-Pushkar railway line region, which is a part of EIA studies being carried out for the project. It becomes necessary to evaluate the present quality of groundwater because it is a main source of drinking water in the study area and directly affects human health. Present study of groundwater monitoring in pre- and post-monsoon seasons is useful in understanding the nature of pollution and seasonal fluctuations in groundwaterquality.

STUDY AREA

The study area of Ajmer-Pushkar region mainly has two cities Ajmer and Pushkar, both of which are of historic, tourist and religious importance. Ajmer is a big and rapidly growing city. Pushkar is a small town situated 12 km northwest of Ajmer. State Highway no. SH-18 connects Pushkar to Ajmer. The area covered by Ajmer city is 241.50 sq. km. It lies between 26^0 20' N to 26^0 33' N Latitude and $74^0$35' E to $74^0$43' E Longitude at an elevation of about 486.0 m above mean sea level (MSL). Pushkar is located at 26^0 27' N Latitude and 74^0 37' E Longitude, at an elevation of 530 m MSL. Pushkar lies on eastern fringe of the 'Thar Desert'. Location map showing the sampling sites is represented in figure 1.

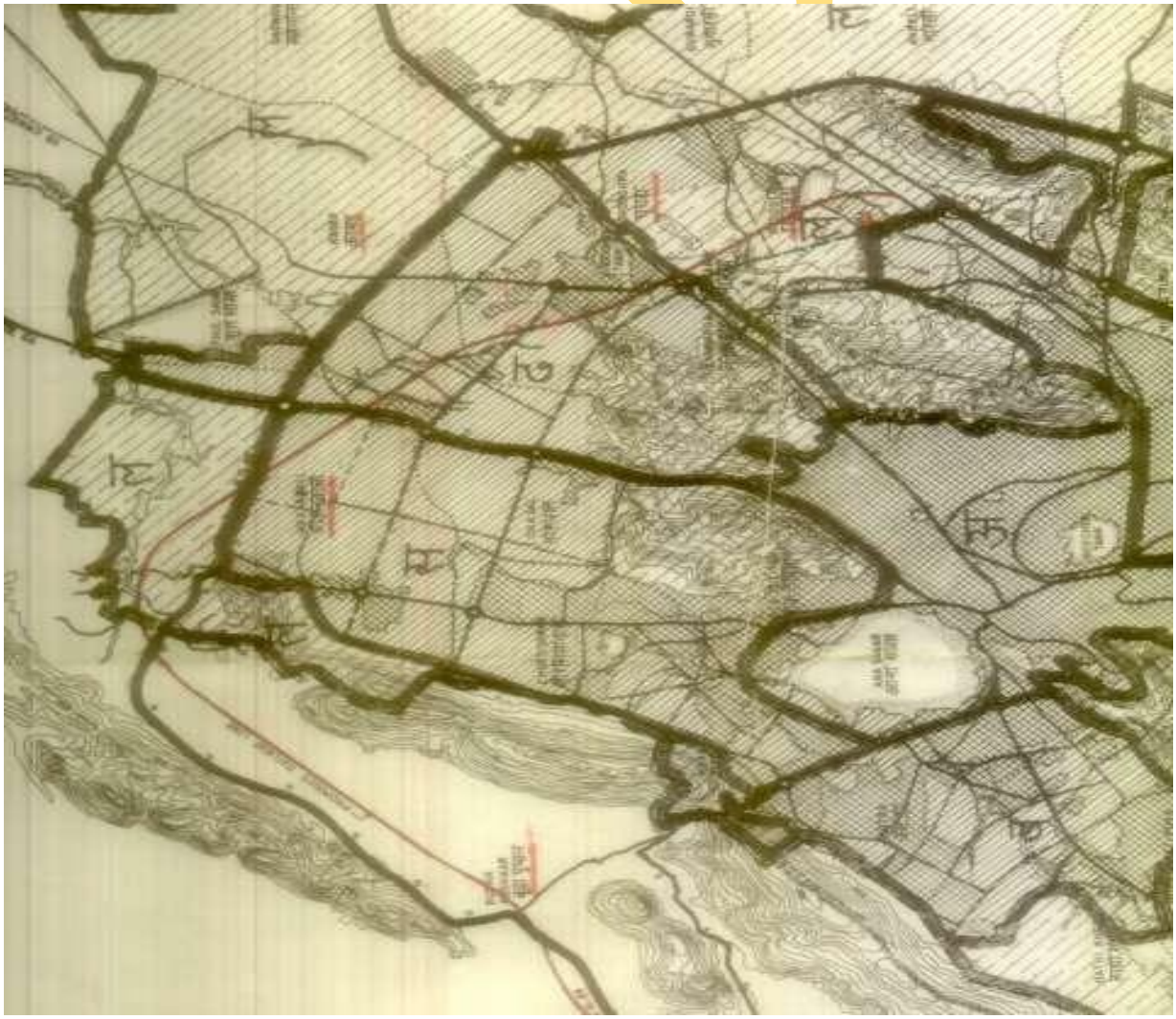

Figure 1: Location map of sampling sites

Ajmer-Pushkar region and its surrounding areas are hilly and mountainous with strong to steep slopes, and dissected narrow valleys; slightly narrow to moderately sloping hilltops are also observed. Nagpahar, situated at a distance of 10 km northwest of Ajmer is a prominent mountain of Pushkar watershed. The hilly slopes are moderate towards Ajmer but steep towards Pushkar facing Leele Sewari sandy area. In southwest, Gori River arises from the slopes and feeds the Pushkar Lake. The southwest monsoon (June-September) accounts for 90% of the total annual precipitation. Annual rainfall in the area is about 470 mm while the average annual temperature is 330C.

MATERIAL AND METHOD

Sources of groundwater samples were tube wells in most of the cases, many of them being public tube wells. Some of them were located in residential areas and others in agricultural fields and nurseries. Random sampling method was adopted for the collection of samples from 14 sites, which are directly affected by Ajmer-Pushkar railway line project. Sampling was done in pre-monsoon (May 2010) and post-monsoon (Dec 2010) seasons. Physico-chemical analysis of water was carried out referring the 'Standard Methods (APHA 1989)'. Various methods used are listed in table-1.

Table-1.Physico-chemical analysis by different methods

Parameters	Method/Equipment used
pH	Digital pH meter
Electrical Conductivity	Digital conductivity meter
Alkalinity, Cl, Ca & Mg	Titrimetry
Na & K	Flame Photometry
F, NO_3, PO_4,& SO_4	UV-Vis spectro-photometry

Sets of three samples were collected from each sampling site in pre- and post- monsoon seasons. Analytical (A.R.) Grade reagents were used for the preparation of various standard stock solutions and other analyticalreagents.

RESULT AND DISCUSSION

Based on the laboratory studies carried out, the physico-chemical characteristics of groundwater of Ajmer-Pushkar railway line region are represented in tables 2 and 3 for pre- and post-monsoon seasons respectively. The results reported are the average values of three samples taken from each sampling site. All the results are reproducible within ±2%accuracy.

As evident from above results, pH values in the study area varied from 7.10-8.20 in pre- monsoon and 7.48-8.66 in post-monsoon seasons, which indicated the alkaline nature of groundwater. The pH values of all the samples in both seasons are well within the limits of 6.5-9.20 as prescribed by BIS 1993, WHO 1971 and ICMR 1975. Electrical conductivity (EC) varied from 0.12-1.54 mmho/cm in pre- and 0.30-3.50 mmho/cm in post-monsoon seasons. The increase in EC values indicate the increase of total dissolved solids (TDS) content in post-monsoon season, which is in agreement with the experimentalobservations.

Total hardness (TH) varied from 28-343 mg/l during pre- and 40-440 mg/l during post-monsoon seasons. Except samples S-2 and S-3 in pre-monsoon season and S-1, S-2 and S-3 in post-monsoon season, all the samples in both seasons lie within the specified limit of 300 mg/l. Calcium (Ca) and magnesium (Mg) along with their carbonates, sulphates and chlorides make the water hard, both temporary and permanent. Ca content varied from 17-147 mg/l in pre- and 22-190 mg/l in post-monsoon season. It was found to be higher than the prescribed limit (75 mg/l) in eight out of fourteen (pre- monsoon season) and eleven out of fourteen (post-monsoon season) samples. Higher values of Ca in most of the samples suggest the excess of calcium minerals in study area. This observation is also supported by sharp rise of 30-35% in Ca content from pre- to post-monsoon season. Ajmer-Pushkar and its nearby areas have natural abundance of Ca minerals and the marble mines, hence higher Ca content is found in groundwater. It is less than maximum allowed limit of 200 mg/l in all the samples in present case. Mg content varied from 4.13-47.63 mg/l in pre-monsoon and 4.37-62.21 mg/l in post-monsoon seasons. The percentage rise in Mg concentration was of the order of 25-30%. All the samples except S-2 and S-3 in both seasons fall within the specified limit of 30 mg/l making it suitable for domestic uses. Mg content is significantly lower than Ca content even though both contribute to total hardness. Generally in groundwater, Ca content exceeds Mg content in accordance with their relative abundance in rocks. Despite the higher solubility of $MgSO_4$ and $MgCl_2$, Mg usually occurs in lesser quantities because the dissolution of Mg rich minerals is a slow process and also that Ca is more abundant in earth's rocks. Total alkalinity (TA) varied from 35-135 mg/l in pre-monsoon and 50-180 mg/l in post-monsoon seasons. Presence of hydroxides, carbonates and bicarbonates are main causes of alkalinity in natural waters. In present study, carbonates were below detection limits. Bicarbonates represent the major form since they are formed in considerable amounts from the action of carbonates upon basic minerals in soil. All the samples in both seasons fall within the prescribed limit of 200 mg/l for drinking water uses. Comparatively higher values were observed in post-monsoon season indicating the dissolution of bicarbonates in rainwater. Samples S-1, S-2 and S-3 were having higher values of TA than rest of thesamples.

Total solids (TS) refer to matter, suspended or dissolved in water. Mathematically it is the sum of total dissolved solids (TDS) and total suspended solids (TSS). In present study, TS was observed to vary from 103-1370 mg/l in pre-monsoon and 140-1740 mg/l in post-monsoon seasons. TDS values varied from 72-1310 mg/l in pre-monsoon and 100-1600 mg/l in post-monsoon seasons. TSS values varied from 30-151 mg/l in pre-monsoon and 40-180 mg/l in post-monsoon seasons. All values of TS and TDS were remarkably higher in samples S-1 to S-7 collected from Ajmer city and nearby areas as compared to sample S-8 to S-14 collected from Pushkar and nearby villages. TDS values were found to be substantially high than specified limit (500mg/l) indicating the saline nature of groundwater

Chloride content in water samples varied from 26.0-122.0 mg/l in pre-monsoon and 35.5-170.4 mg/l in post-monsoon seasons, which was within the prescribed limit of 250 mg/l. However, adverse health effects on humans have been reported from intake of waters containing even higher content of chloride. Sodium (Na) content in the basin varied from 11-52 mg/l in pre-monsoon and 14-65 mg/l in post-monsoon seasons. Na content more than 50 mg/l makes the water unfit for domestic use. All the samples (pre-monsoon season) fall within the limit of 50 mg/l except samples S-2 (51 mg/l) and S-3 (52 mg/l), which are marginally higher. In post-monsoon season, all samples except S-1 (51 mg/l), S-2 (62 mg/l), S-3 (65 mg/l), S-6 (54 mg/l) and S-7 (59 mg/l) lie within the prescribed limit. The rise from desired limit is only marginal making the water suitable for domestic use. But on the same time, even small rise in Na concentration may result in alarming situation. The difference between pre- and post-monsoon valueswasonlymarginalindicatinglessereffectofNaionsdissolutioninrainwater.Potassium
(K) content varied from 18-38 mg/l in pre-monsoon and 21-41 mg/l in post-monsoon seasons. It did not vary significantly from pre- to post-monsoon seasons. Its common sources in groundwater are feldspar and micas of igneous and metamorphic rocks. Generally high K content can be attributed to the application of fertilizers and their subsequent leaching during rainy season. Since the study area is primarily a residential area with less agricultural activities, K contents in both seasons are not high. Sulphate content in the area varied from 13-54 mg/l in pre-monsoon and 15-60 mg/l in post-monsoon seasons, which was well within the prescribed limit of 200 mg/l. Generally arid to semi-arid regions show high sulphate content due to the accumulation of soluble salts in soil. Since the study area doesn't have big and high polluting industries, the possibility for higher sulphate contents is less. Nitrate content varied from 3-9 mg/l in pre-monsoon and 10-15 mg/l in post-monsoon seasons. The values are within the prescribed limit of 45 mg/l. Variations from pre to post-monsoon values were significantly higher (1.5-2.0 times). This indicates the alarming rate at which groundwater is receiving nitrates.

A specific water quality problem in hard-rock areas is due to high fluoride concentrations. Fluoride is mainly found in dark preliminary minerals such as in biotite gneiss. However, if anorthite is also present, calcium will be released to check the fluoride concentration in the water. Since Ajmer-Pushkar region is rich in Ca minerals, it helps to check fluoride ion content in groundwater to an extent. Fluoride can enter in groundwater through the exchange of basalt. The most important minerals containing fluorides are fluorspar (CaF_2) and cryolite ($NaF.AlF_3$). Fluoride content in the study area varied from 0.05-2.44 mg/l in pre-monsoon and 0.11-5.36 mg/l in post-monsoon seasons. In pre-monsoon season, all the samples except S-7 (2.44 mg/l) fall within the specified limit of 1.0 mg/l. Same sample showed exceptionally high value of 5.36 mg/l in post-monsoon season also. This may be attributed to the localized effects. In post-monsoon season, the samples S-1 to S-7 except S-5 (0.819 mg/l) collected from Ajmer city were reported to have higher values of fluoride content. Phosphate content varied from 0.02-0.25 mg/l in pre-monsoon and 0.02-0.30 mg/l in post-monsoon seasons. All the values for both seasons are well below the prescribed limit of 1.0 mg/l. Hence there are no adverse health effects from phosphate content in presentcase.

CONCLUSION

Physico-chemical characterization of groundwater in Ajmer-Pushkar railway line region was carried out in pre- and post-monsoon seasons. It showed significantly high variations from pre- to post-monsoon seasons. About 57% and 78% samples in pre- and post-monsoon seasons respectively showed Ca content beyond specified limit of 75 mg/l. All the samples collected from Ajmer city and nearby areas showed higher values of TDS than the prescribed limit of 500 mg/l in both seasons, two of which crossed even the maximum allowed limit of 1500 mg/l in post-monsoon season. Few samples showed marginally higher values of Na content than recommended value of 50 mg/l. Nitrate contents were within the limits of 45 mg/l, but the high percentage change was observed from pre- to post-monsoon season. About 43% samples contained fluoride beyond specified limit of 1.0mg/l.

All the samples collected from Ajmer and nearby areas had higher levels of contaminations as compared to the samples collected from Pushkar and nearby villages. This can be attributed to the rapid growth of Ajmer city, which has impact on overall environmental quality including groundwater. Since Pushkar is a small town having total population of 14,789 (Census 2001) with low to average growth rate, the groundwater pollution is found to be less in nearby area.

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S. No	Chemical Constituents	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14
1.	pH	7.18	7.14	7.10	7.32	7.23	7.52	7.91	7.89	8.12	8.08	8.20	8.13	8.18	8.20
2.	EC at 25ºC (µ mho/cm)	0.88	1.54	1.32	0.88	0.93	0.89	0.84	0.38	0.12	0.15	0.20	0.23	0.22	0.26
3.	Total Hardness (as $CaCO_3$)	232	343	310	93	102	88	28	166	97	107	114	116	107	135
4.	Ca Hardness (as $CaCO_3$)	114	147	131	76	73	53	17	135	75	69	82	76	49	116
5.	Mg Hardness (as $CaCO_3$)	28.67	47.63	43.50	4.13	7.05	8.50	2.67	7.53	10.69	9.23	7.78	9.72	14.09	4.62
6.	Carbonate Alkalinity	bdl*	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
7.	Total Alkalinity (= HCO_3^-)	110	135	82	38	49.0	87	95	143	39.0	43	33	46	42	45
8.	Total Solids	1005	1370	1300	1070	1030	889	982	429	218	103	339	500	275	435
9.	Total Dissolved Solids (TDS)	971	1310	1270	1024	974	841	831	357	143	72	221	413	220	390
10.	Total Suspended Solids	34	60	30	46	56	48	151	72	75	31	118	87	55	45
11.	Chloride	81	112	90	134	88	82	41	30	26	30	31	29	32	48
12.	Sodium	43	51	52	30	30	43	50	20	11	29	17	15	29	27
13.	Potassium	25	30	31	32	38	18	25	18	19	20	19	20	21	21
14.	Sulphate	52	54	50	42	55	57	58	15	22	13	17	23	20	24.2
15.	Nitrate	4	7	8	6	5	6	6	3	5	9	2	3	4	5
16.	Fluoride	0.85	0.9	0.83	0.83	0.41	0.69	2.44	0.17	0.05	0.08	0.19	0.09	0.05	0.08
17.	Phosphate	0.17	0.17	0.25	0.09	0.12	0.1	0.18	0.12	0.07	0.04	0.03	0.02	0.02	0.03

* bdl: below detection limit

Note: All values except pH, Electrical Conductivity, and Temperature are in mg/l (ppm).

Table 3. Physico-Chemical Analysis of Groundwater at Ajmer-Pushkar Railway Line Region (Post-Monsoon data)

S No	Chemical Constituents	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14
1.	pH	7.67	7.60	7.48	7.58	7.65	7.93	8.20	8.11	8.66	8.53	8.64	8.58	8.58	8.54
2.	EC at 25ºC (μ mho/cm)	2.00	3.50	3.00	2.00	2.10	1.90	1.90	0.85	0.30	0.30	0.40	0.40	0.40	0.60
3.	Total Hardness (as $CaCO_3$)	310	440	430	132	140	124	40	224	140	146	150	154	110	204
4.	Ca Hardness (as $CaCO_3$)	150	190	174	98	106	70	22	179	110	98	116	110	70	158
5.	Mg Hardness (as $CaCO_3$)	38.88	60.7	62.21	8.26	8.26	13.12	4.37	10.93	7.29	11.66	8.26	10.69	9.72	11.12
6.	Carbonate Alkalinity	bdl*	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
7.	Total Alkalinity (= HCO_3^-)	138	180	120	59	65	110	105	175	59	50	65	60	50	60
8.	Total Solids	1240	1740	1700	1480	1460	1140	1260	580	300	140	440	620	340	580
9.	Total Dissolved Solids	1170	1600	1540	1435	1400	1100	1080	470	180	100	320	540	280	520
10.	Total Suspended Solids	70	140	160	45	60	40	180	110	120	40	120	80	60	60
11.	Chloride	98.4	142.1	170.4	110	107.9	99.4	51.1	42.6	35.5	35.5	38.9	38.3	41.2	59.6
12.	Sodium	51	62	65	38	40	54	59	25	18	14	21	21	38	38
13.	Potassium	29	35	36	39	41	25	32	21	24	25	24	23	25	24
14.	Sulphate	57.5	60.5	58.9	49.2	62.4	62.5	50	17.5	26.8	15	22.5	27.5	26.5	23.3
15.	Nitrate	10	14	15	10	10	15	15	5.0	10	15	5	10	10	8
16.	Fluoride	2.02	2.00	1.93	1.72	0.81	1.60	5.36	0.42	0.11	0.17	0.44	0.18	0.12	0.17
17.	Phosphate	0.20	0.23	0.25	0.13	0.13	0.12	0.28	0.15	0.09	0.05	0.03	0.03	0.02	0.04

* bdl: below detection limit

Note: All values except pH, Electrical Conductivity, and Temperature are in mg/l (ppm).