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Physico-Chemical Contamination of Groundwater in and Around Industrial Areas of District Alwar, Rajasthan

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ABSTRACT

Chemical behaviors of groundwater in various locations are one of the most dynamic fields of research in the present world. In the present study, groundwater sampling from four industrial areas viz. Matsya Nagar, Bhiwadi, Neemrana and Behror was conducted with an aim to assess the groundwater chemistry and the interpretation of the 'water type' was made using Hill-Piper and Wilcox diagrams. The chemical quality was assessed by examining the major cations, anions and other parameters like sodium adsorption ratio, residual sodium carbonate and sodium percent. The groundwater chemistry was then assessed and factors affecting the area were identified. It was resulted that the groundwater quality of the area was influenced by industrial and human activities which cause pollution in the aquifer system and the data supported the pollution level in the area. Majority of the samples were behaved in more or less same way. The TDS were found in average range of 1000 mg/l, while total hardness ranged the average value of 400 mg/l. Carbonate alkalinity was found in all the water samples and the average pH value were observed 8.60. In some locations, up to 337 mg/l nitrate indicates the nitrogenous contamination in the area. Fluoride was found within the prescribed limits as per BIS (Indian Drinking Water Standard, IS: 10500, 1991) norms, except one significant location at Majri Kalan in Neemrana industrial area has high fluoride as 13.0 mg/l. The interpretation of the 'water type' was made using Hill-Piper and Wilcox diagrams. The prominent type was Na/Mg-HCO_3 and Na/Mg-Cl type of water. However, a slight variation was observed in the Na-HCO_3 type of water. Sodium (alkali) hazard were observed from low (S1) to high (S3) and salinity hazard is high (C3) to very high (C4).

Key words: Groundwater quality, Physico-chemical contamination, Piper diagram, water type.

INTRODUCTION

Water is one of the abundantly available substance in the nature next to air. Water is considered as a very dilute solution of number of chemicals essential for maintaining equilibrium in biochemical reactions taking place in all living organisms in order to maintain the physiology. Water quality as well as quantity crisis is the burning issue all around the world and raise a big challenge as the groundwater as use as drinking purposes become very scare in the world. Water scarcity and poor quality water is not only harmful to human life but also affects the fertility of soil and therefore diminishes the growth of plants and crops.

Development never means on the cost of nature, but the global modernization procedures puts stress on groundwater as well as surface water resources all around the world. Industrial development is the main source of water pollution as it gives out harmful chemicals and micro organisms.

Hard water mostly contains dissolved salts of calcium and magnesium as bicarbonates, sulphates and chlorides. Major cations, anions, conductivity, dissolved solids, pH, SAR, RSC and %Na are constituents of study and are determined in milligrams per litre (mg/l) or in parts per million (ppm).

District Alwar is located in north eastern part of Rajasthan in between 27°40' to 28°40' North latitude and 76°70' to 77°13' East longitude. The length of the district from north to south, it is 137 kms while from east to west, it is 110 kms. The district is surrounded by Gurgaon of Haryana and Bharatpur in north-east side, Mahendragarh of Hariyana from north-west side, Jaipur by south-west and Sawaimadhopur by southern side.

The aquifer water quality of four industrial areas viz. Matsya, Bhiwadi, Neemrana and Behror industrial area were selected for study. Industrial activities generate large number and variety of waste products which were generally discharged in to water streams. Now a day the dispersal of waste waters is of widespread national concern.

MATERIALS AND METHODS

Sampling

Ground water sampling was done from different sites of industrial areas in 1.0 litre polythene bottles for the analysis of chemical parameters, 1.0 litre nitric acid treated samples for trace metal analysis and 2.0 litre for BOD and COD analysis.

Analysis

Chemical parameters like electrical conductivity and pH were determined using conductivity and pH meters. Ca, Mg and total hardness (as $CaCO_3$) was analyzed using EDTA-complexo-metric titrations. Chloride was analyzed by standard $AgNO_3$ as intermediate and K_2CrO_4 as marker (Argento-metric titration). Sulphate was analyzed using back titration method and alkalinity by acidimetric titration. Nitrate was analyzed using UV-Visible spectrophotometer at 220 nm and fluoride at 540 nm wavelengths (APHA, 1989). TDS, total hardness (as $CaCO_3$), *TA, Na%, RSC and SAR* were calculated using suitable formula.

RESULTS AND DISCUSSION

As per WHO and BIS (IS 10500:1991) drinking water specifications, the desirable concentration of TDS is less than 500 ppm and maximum permissible limit in the absence of alternative source is 1500 ppm (2000 ppm as per BIS). Beyond this limits, palatability decreases and may cause gastrointestinal irritation. In the areas under investigation was found that out of 25 water samples 23 water samples having TDS in between 500 to 2000 mg/l (92%). Only 2 water sample ranged within 500 mg/l (8%) and no one sample cross the upper limits of TDS 2000 mg/l. The average TDS in the area was found 1018 mg/l (Figure-1). The desirable Ca^{+2} (as $CaCO_3$) concentration in normal potable ground water should have less than 75.0 mg/l while 200 mg/l set as maximum permissible

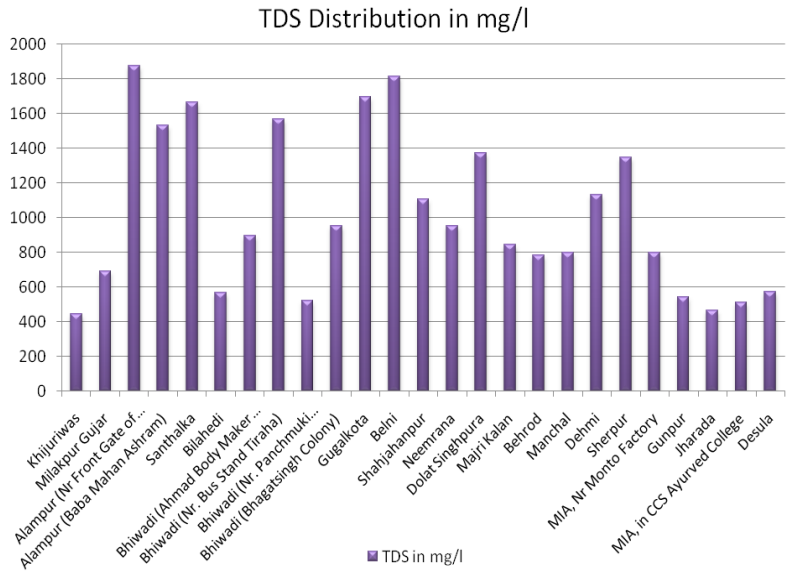

Fig. 1:

Table 1: Chemical quality of the study area

S. No.	Locations	pH	EC	TDS	Na^+	K^+	Ca^{++}	Mg^{++}	Cl^-	SO_4^{--}	CO_3^{--}	HCO_3^-	TA as $CaCO_3$	NO_3^-	F^-	TH as $CaCO_3$	Na%	RSC	SAR
1	S_1	8.8	820	443	77	3	40	47	50	0	24	342	320	31	0.1	295	35.91	0.5	4.13
2	S_2	8.7	1010	689	145	4	38	29	128	91	24	317	300	72	0.48	215	58.88	1.7	8.86
3	S_3	8.5	3560	1874	285	11	102	224	652	293	24	330	310	118	1.07	1175	34.27	0	7.89
4	S_4	8.6	2600	1531	269	4	64	150	376	245	24	513	460	143	0.63	775	42.86	0	9.19
5	S_5	8.5	2940	1663	251	9	126	154	567	211	24	354	330	143	0.17	950	36.19	0	7.50
6	S_6	8.8	970	567	95	6	38	39	106	0	36	452	430	21	0.18	255	44.03	3.5	5.41
7	S_7	8.5	1370	894	120	10	42	79	199	96	24	317	300	167	0.86	430	37.01	0	5.45
8	S_8	8.4	2360	1569	89	7	68	203	475	226	24	281	270	337	1.45	1005	15.96	0	2.70
9	S_9	8.8	870	520	97	9	40	27	92	0	24	415	380	23	0.17	210	48.85	3.4	5.93
10	S_{10}	8.7	1470	954	260	6	30	27	184	101	36	378	370	121	0.48	185	74.59	3.7	17.22
11	S_{11}	8.7	2970	1694	524	5	34	58	567	53	60	732	700	26	0.7	325	77.45	7.5	27.32
12	S_{12}	8.5	3160	1815	549	4	26	74	347	216	84	940	910	44	0.65	370	76.11	10.8	27.45
13	S_{13}	8.6	1870	1107	280	5	30	60	284	48	72	452	490	102	0.64	320	65.17	3.4	14.76
14	S_{14}	8.5	1630	951	251	21	22	51	220	62	24	500	450	50	0.54	265	65.11	3.7	14.69
15	S_{15}	8.7	2370	1374	451	1	30	33	319	62	72	708	700	52	0.67	210	82.28	9.8	28.41
16	S_{16}	8.6	1400	847	260	4	22	29	128	48	84	500	550	22	13.3	175	75.84	7.5	18.20
17	S_{17}	8.5	1350	781	179	4	26	57	262	53	48	293	320	5	0.5	300	56.12	0.4	9.82
18	S_{18}	8.7	1190	798	225	4	24	16	199	48	24	452	410	32	0.56	125	79.03	5.7	17.79
19	S_{19}	8.5	1940	1131	354	3	34	28	248	96	60	452	470	82	0.66	200	79.06	5.4	22.48
20	S_{20}	8.6	2210	1349	299	5	42	89	425	48	24	598	530	118	0.49	470	57.73	1.2	13.06
21	S_{21}	8.8	1210	800	205	2	22	29	71	53	84	647	670	12	0.9	175	71.54	9.9	14.35
22	S_{22}	8.3	870	541	77	3	48	38	142	0	24	378	350	20	0.4	275	37.51	1.5	4.15
23	S_{23}	8.5	710	467	17	2	58	50	106	0	24	403	370	8	0.37	350	9.49	0.4	0.82
24	S_{24}	8.6	950	513	31	7	42	78	106	0	24	415	380	18	0.5	425	13.29	0	1.41
25	S_{25}	8.4	980	575	29	4	46	75	106	0	36	537	500	10	0.5	425	12.6	1.5	1.32

All parameters are in mg/l except EC in µS/cm at 25°C, RSC and SAR in meq/l, pH has no unit.

Locations: S_1 Khijuriwas; S_2 Milakpur Gujar; S_3 Alampur (Nr. Front Gate of Ashram); S_4 Alampur (Baba Mahan Ashram)S_5 Santhalka; S_6 Bilahedi; S_7 Bhiwadi (Nr. Ahmad Body Maker); S_8 Bhiwadi (Near Bus Stand Tiraha); S_9 Bhiwadi (Nr. Panchmuki Hanuman Tample); S_{10} Bhiwadi (Bhagatsingh Colony); S_{11} Gugalkota; S_{12} Belni; S_{13} Shahjahanpur; S_{14} Neemrana; S_{15} Dolat Singhpura; S_{16} Majri Kalan; S_{17} Behrod; S_{18} Manchal; S_{19} Dehmi; S_{20} Sherpur; S_{21} Matsya Industrial Area; S_{22} Gunpur; S_{23} Jharada; S_{24} MIA, Nr. CCS Ayurved College; S_{25} Desula; **Note:** $S_1 – S_{10}$ Bhiwadi Industrial Area; $S_{11} – S_{16}$ Nimrana Industrial Area; $S_{17} – S_{20}$ Behrod Industrial Area; $S_{21} – S_{25}$ Matsya Industrial Area

limit. Beyond this undesirable effects can occur. In the whole study area, the concentration of Ca-H (as $CaCO_3$) ranges between minimum 22 mg/l at Neemrana and near Monto factory, Matsya Industrial Area to maximum 126 mg/l at Santhalka. The average calcium was measured 44 mg/l in and surrounding areas and found soft in nature and fit for drinking as well as bathing, washing, laundering and industrial activities. The concentration of Mg-H is found minimum 16 ppm at Manchal to maximum 224 mg/l at Alampur (near front gate of Ashram) with the average concentration is calculated 70 mg/l, while maximum relaxable level of magnesium in water should be 100 mg/l. (BIS, 1991 and ICMR, 1975). The result shows that the ground water of the area under investigation is safe side with respect to magnesium and suitable for specific purposes. As per BIS standards, the ground water having up to 250 mg/l total hardness (TH) is essential which relaxes up to maximum of 600 mg/l (Table-2). The average

Table. 2: Ground Water Quality Standards for Drinking Purposes

S. No.	Parameters	Units	ISI: 1991	ICMR: 1975	WHO: 2006
1	EC	µS/cm at 25°C	NG	500	600
2	pH	-	6.50-8.50	7.0-8.50	6.50-8.50
3	TDS	mg/L	500	500	500
4	Na^+	mg/L	NG	NG	200
5	K^+	mg/L	NG	NG	NG
6	Ca^{+2}	mg/L	75	75	75
7	Mg^{+2}	mg/L	30	50	30
8	Cl^-	mg/L	250	200	200
9	SO_4^{-2}	mg/L	200	200	200
10	HCO_3^-	mg/L	NG	NG	NG
11	NO_3^-	mg/L	45	20	50
12	F^-	mg/L	1.00	1.00	1.50
13	TH as $CaCO_3$	mg/L	300	300	200

NG-No Guideline

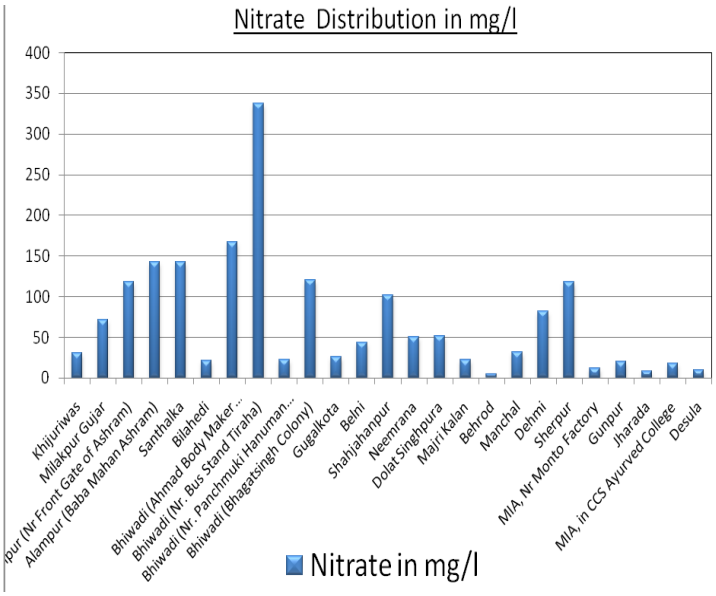

Fig. 2:

total hardness in the area under investigation is measured 396 mg/l, while it is found minimum 125 mg/l at Manchal and maximum 1175 mg/l at Alampur (near front gate of Ashram). It can be concluded that the aquifer water is quite hard in nature and it should be used for any specific purposes after taking suitable measures.

The Cl^- concentration is observed minimum 50 mg/l at Khijuriwas to maximum 652 mg/l at Alampur with an average concentration was measured 254 mg/l. The desirable/essential limit of chloride for drinking water is 250 mg/l and it is relaxed up to 1000 mg/l. Therefore, the chloride concentration was found in between the prescribed limits. The

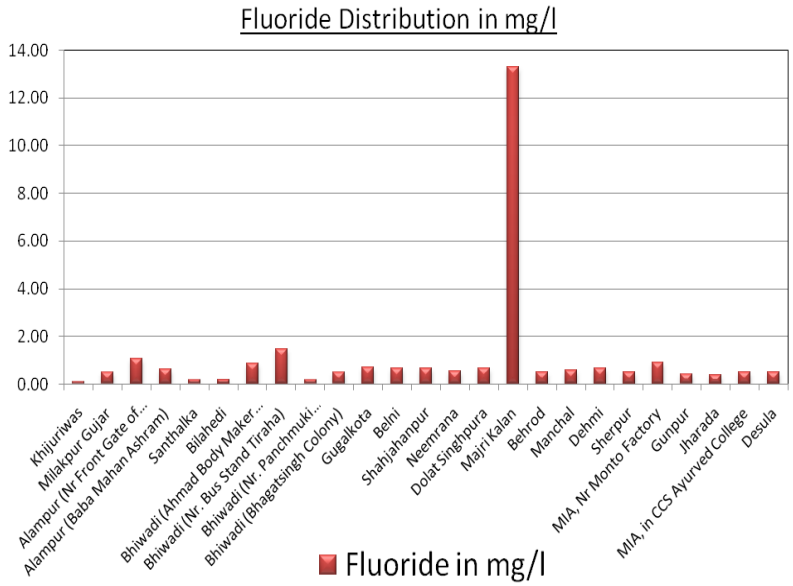

Fig. 3:

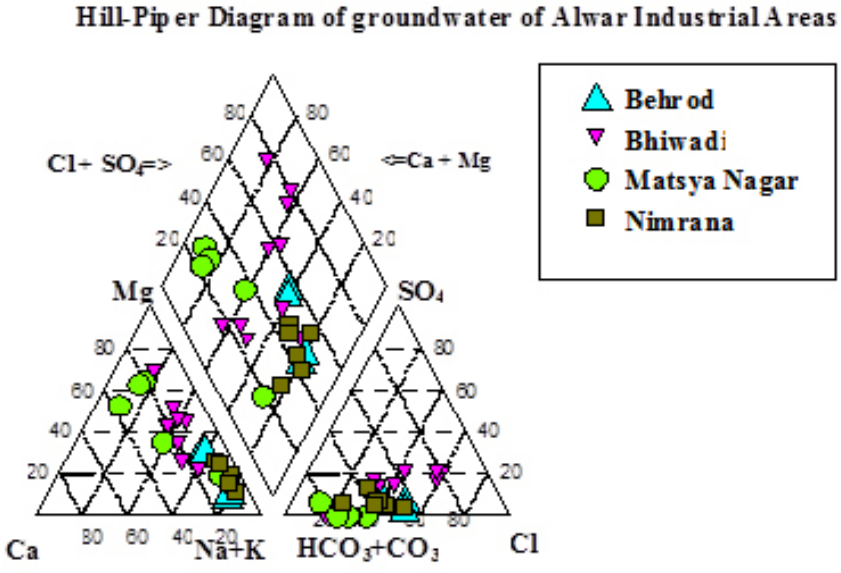

Fig. 4:

SO_4^{-2} concentration in the study area were varies minimum traces at many locations to maximum 293 mg/l at Alampur, while average concentration was measured 82 mg/l. The essential level of sulphate is 200 mg/l while maximum permissible limit for drinking purpose should not be more than 400 mg/l. Therefore, on the basis of these limits and analysis results thereon, it can be said that the ground water in the area was found within limits. More than 200 mg/l sulphate was shown in some locations of Bhiwadi and Neemrana industrial areas (Table-1). As per BIS specifications, the prescribed level of total alkalinity is 200 mg/l, and the higher concentrations make the water unpleasant in taste. Alkalinity relaxes up to 600 mg/l. The water analysis results reveal that the average concentration of alkalinity in the ground water of the area under investigation was measured 468 mg/l ranges from minimum 281 mg/l at near bus stand tiraha of Bhiwadi industrial area to maximum 940 mg/l at Belni of Neemrana industrial area. The BIS sharply relaxed the NO_3^- concentration up to 45 mg/l in drinking water for potability which relaxes up to 100 mg/l. In the study area it was found minimum 5 mg/l at Behrod, while maximum 337 mg/l near bus stand tiraha of Bhiwadi industrial area with average of 71 mg/l indicates the increasing rate of nitrate level in the study areas (Figure-2). The F^- concentration was found minimum 0.10 mg/l at Khijuriwas to maximum 1.45 mg/l near bus stand tiraha of Bhiwadi industrial area. An exceptional fluoride concentration was observed in Majri kala location of Neemrana industrial area. An elevated concentration of fluoride in groundwater is common in rocky areas heaving fluoride minerals (Handa, 1975). The average fluoride concentration was measured 1.08 mg/l. The water quality standards specified by Bureau of Indian standards (BIS) for drinking, F^- concentration should not be more than 1.5 mg/l (Figure-3). Artificial recharge, blending of water, construction of well in the area where the fluoride concentrations are under the safe limits etc. may improve the aesthetic status of community of the area. (Vikasi et al, 1999).

The interpretation of the 'water type' was made using Hill-Piper and Wilcox diagrams. The prominent was Na/Mg-HCO_3 and Na/Mg-Cl type of water. However, a slight variation was observed in the Na-HCO_3 type of water. Sodium (alkali) hazard were observed from low (S1) to high (S3) and salinity hazard is high (C3) to very high (C4) (Figure-4 and 5). The average Na% of the water ranged minimum 9.49 at Jharda to maximum 82.28 in the groundwater of Daulat Singhpura with an average of 51.48 indicates that the groundwater is not fit for excellent irrigation. RSC value <2.0 meq/l put the water bodies in to good category of irrigation water. It was observed nil to 10.8 with an average 3.26 meq/l refers moderately poor quality of irrigation water.

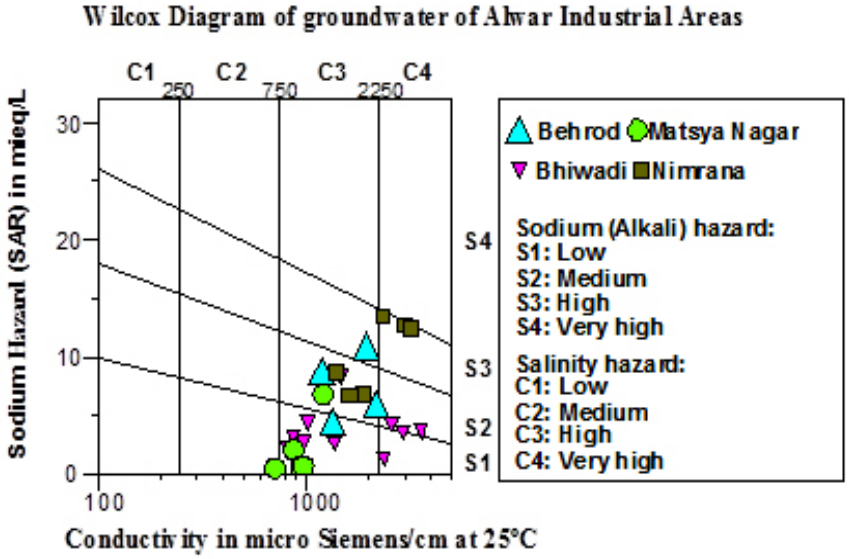

Fig. 5:

SAR reveals the ratio of sodium versus major cations and reflects the irrigation suitability of the water for different agricultural purposes. Water that has an SAR <3.0 meq/l is safe for irrigating turf and other ornamental landscape plants. Greater than 9.0 can cause severe permeability problems when applied to fine textured soils (a silty clay loam) and should be avoided. In the study, the SAR values ranges minimum 0.82 at Matsya industrial area, near CCS Ayurved College to maximum 28.15 meq/l at Dolat Singhpura with an average of 11.61 meq/l. The area fall in high sodium class and it implies that there is alkali hazard anticipated to the crops.

The overall water quality of the area taken under consideration is getting deteriorated. The causes of quality variations may be attributed to the rainfall, drawdown of water and geological formations/structures of the area (Sharma and Agarwal, 2013).

REFERENCES

1. APHA, Standards Methods for Examination of Water and Wastewater, American Public Health Association, Washington DC, edn. 17 (1989).
2. BIS Indian Standard Drinking Water Standard Specification (First Revision). 8th Reprint, Sept. 2008, IS, 10500, (1991).
3. Handa, B.K., Geochemistry and genesis of fluoride containing groundwater in India, *Groundwater,* **13**: 275-281, (1975).
4. ICMR Manual of Standards of Quality for Drinking Water Supplies, spl. Res. S.No. 44, ACMR, New Delhi (India), (1975).
5. Sharma, K.C. and Agarwal, M., Assessment of ground water quality for drinking and irrigation purposes in Banasthali village, district-Tonk, Rajasthan, *Nat. Env. & Poll. Tech.,* **12**(4): 679-684, (2013).
6. Vikasi, C., Kushwaha, R.K. and Pandit, M.K., Hydrochemical Status of Groundwater in District Ajmer (NW India) with Reference to Fluoride Distribution, *J. Geological Soc. of India,* **73**, 773-784 (1999).
7. WHO, International Standards for Drinking Water, World Health Organization, Geneva, (1971).
8. WHO, Fluoride and Fluorides, Environmental Health Criteria, 21-23, 63 WHO, Geneva, Switzerland, (1984).