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Hydrochemical Analysis of Drinking Water Quality of Alwar District, Rajasthan

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ABSTRACT: Hydrochemical study of 13 ground water samples of Alwar district was done. Alwar districts lies in the eastern plains of Rajasthan State, covers an area 8,380 km^2 and lies between 27°-57' N latitude and 76°-6'E longitude. Different sampling stations were selected for the study purpose in the district. Sample collected from the Bore-wells and hand pumps were analyzed for the various physicochemical parameters like pH, electrical conductivity (EC), sodium(Na), potassium (K), Calcium (Ca^{+2}), magnesium (Mg^{+2}), fluoride (F^-), chloride (Cl^-), sulphate (SO_4^{-2}), nitrate (NO_3^-), total dissolved solids (TDS) and total hardness (TH). The results revealed that most of the water samples were out of limit according to the WHO standards (1996). The potability of ground water is going to be deteriorate. There is a rigorous fluoride problem in various parts of Alwar region. The results revealed that the values of pH were found to be ranging between 7.18-7.86, EC ranged from 592 to 1810 μs/cm and chloride content differed from 69.98 to 299.91 mg/l and total hardness varied from 295.23 to 865.70 msg/l. The most important parameter fluoride was found to be 0.45 to 3.6 ppm, which is more than the permissible limit in most of the samples studied. The results revealed that the quality of drinking water of Alwar region is very poor, which can be used for drinking and cooking only after prior treatment. [Nature and Science. 2009;7(2):30-39]. (ISSN: 1545-0740).

Keywords: Ground water, Alwar district, Fluoride, Total dissolved solids, WHO

INTRODUCTION

One of the most important crises of the twenty-first century is the scarcity of drinking water. Most freshwater bodies the world over are becoming increasingly polluted, thus decreasing the potability of water (Dixit et al.,2005). Increasing urbanization is taking place along coastlines and estuaries and causing increased use of groundwater that will have a large impact on the quality and quantity of aquifer water (Campbell et al, 1992). Water is also one of the most convenient of the natural resources as it is capable of diversion, transport, storage, and recycling. All these properties have great utility for human beings(Kumar et al.,2005). According to National Water Policy (2002) in the planning and operation of systems, water allocation priorities should be broadly as: (i) drinking water, (ii) irrigation, (iii) hydropower, (iv) ecology, (v) agro-industries and non-agricultural industries, and (vi) navigation.

Water pollution is a serious problem in India. The contamination of groundwater due to the human activities can lead to adverse effects on human health and ecosystem(Al-Khashman, 2007). Two types of water pollutants exist; point source and non point source. Point sources of pollution occur when harmful substances are emitted directly into a body of water. A nonpoint source delivers pollutants indirectly through environmental changes. Nearly 70% of surface water resources and a large number of groundwater reserves of India are already contaminated by biological, organic and inorganic pollutants. The difference of dissolved ions concentration in groundwater are generally governed by lithology, velocity and quantity of groundwater flow, nature of geochemical reactions, solubility of salts and human activities (Bhatt et al. 1996; Karnath, 1997). Water is often is contaminated by pollutants like excess amount of fertilizers, pesticides, effluents, discharged from industries, sewage and so on. Near about 70% rivers and stream of world contain polluted water because of disposal of sewage, industrial waste, radioactive waste etc. It is reported that 15 out of 1000 children born in the developing countries die before the age of five from diarrhoea caused by drinking polluted water (UNESCAP, 2000). The evaluation of water quality in developing countries has become a critical issue in recent years, especially due to concerned that freshwater will be a scare resource in the future. Various workers in our country have carried out extensive studies on water quality. Groundwater and wastewater quality for irrigation purpose and various studies on wastewater and groundwater of Jaipur City have also been study in our laboratory(Sharma et al., 1988,1989).

At present there is no major industry in and around the study area, yet household waste water and garbage (municipal sewage) are directly discharged into water bodies. The water supply for human consumption is often directly sourced from ground water without biochemical treatment and the level of pollution has become a cause for major concern. The water used for drinking purpose should be free from toxic elements, living and non-living organisms and excessive amount of minerals that may be harmful to health. Suitable quality of groundwater become a more crucial alternative resource to meet the drastic increase in social, agricultural, and industrial development and to avoid the expected deterioration of groundwater quality due to heavy abstraction for miscellaneous uses. Hence, hydrochemical investigations are the main objectives for the groundwater quality.

The purpose of this study is to monitor the hydrochemical characteristics of groundwater in Alwar. The data will be used to characterize the groundwater. This will help water resource planning in the area and will provide a baseline for future studies of water quality and trends. Therefore, in the present study an attempt is made to evaluate the the suitability of the groundwater of Alwar city, Rajasthan for the purposes of drinking and irrigation, with reference to recommended limits set by WHO.

MATERIAL AND METHODS

Alwar district (27°-57' N latitude and 76°-6'E longitude), which is located in the eastern part of Rajasthan State, covers an area 8,380 km^2, is undergoing rapid urbanization and industrialization. Ground water sample collected from the Bore-wells and hand pumps of fifteen sampling stations were analysed during pre monsoon session (Table 1). Samples were collected in clean Teflon bottles of 1 L capacity. Analysis was done during pre monsoon session (March 2008 to June 2008). High pure quality chemicals and double distilled water was used for preparing solutions for analysis.

Physical parameters like pH, TDS and EC were measured using digital meters immediately after sampling. The concentration of major cations and anions were analysed in the laboratory using the standard methods (Grasshoff et al., 1983; APHA, 1985).

- Sodium and potassium in groundwater samples were analysed using Flame photometer.
- Calcium and magnesium were estimated by EDTA titrimetric method.

- chloride was determined by Mohr's argentometric titration using standard silver nitrate as reagent.
- Carbonate and bicarbonate concentrations of the groundwater were determined titrimetrically.
- Sulphate concentration was carried out following turbidity method using double beam UV-Visible spectrophotometer.
- Nitrate and Fluoride concentration was determined by spectrophotometer.

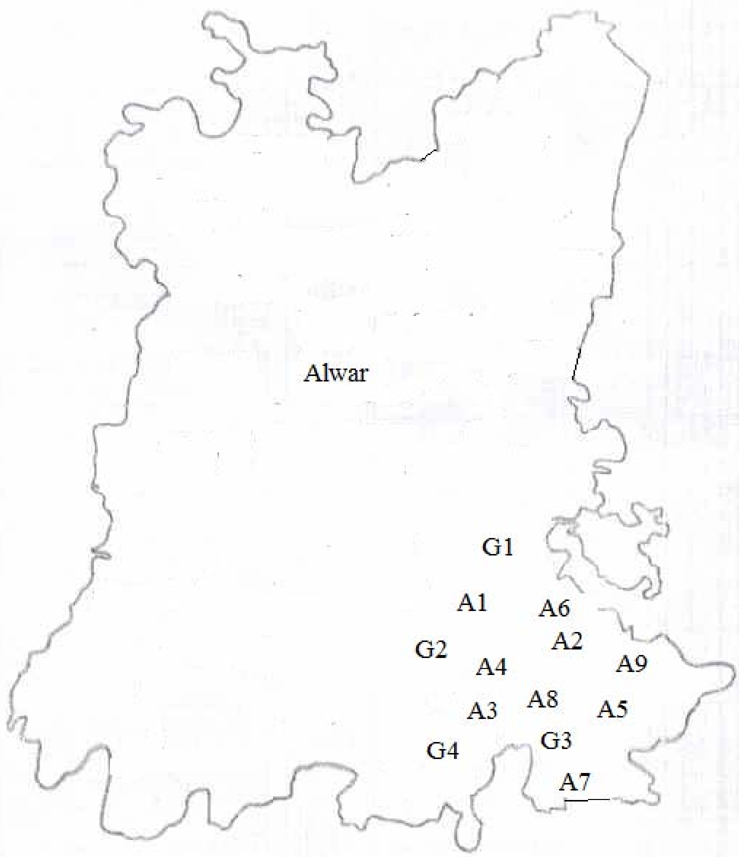

Figure 1 : A map view of study site

RESULT AND DISSCUSSION

Table 1 presents an overview Ionic Variation of groundwater in study area during pre monsoon season. The Values of TDS, TA, TH, RSC, SAR and Na% of groundwater are presented in Table 2. Permissible limit of parameters are described in Table 3. Table 4 illustrate Correlation Matrix among 13 water quality parameters of groundwater of Alwar City.

Chemistry of groundwater

In the studied localities groundwater samples were free from color and odor. The pH values of groundwater were varied from 7.18 to7.86 indicating slightly alkaline nature. The slight alkaline nature of groundwater may be due to the presence of fine aquifer sediments mixed with clay and mud. In general the pH was within the limits of the standard values (APHA 1985). For drinking water, a pH range of 6.0-8.5 is recommended (De 2002). EC and TDS show the inorganic load in water. EC is a numerical expression of ability of an aqueous solution to carry electric current. WHO recommended permissible limit for electrical conductivity (EC) is 1400 µmhos/cm. The values of EC ranged from 592 to 1810 µmhos/cm. Minimum and maximum EC was reported from A7 and G3 water samples respectively.

Some of the water samples showed EC higher than permissible limit (Table 2). EC signifies the amount of TDS in water. The total dissolved solids (TDS) in drinking water reveal the saline behaviour of water. According to classification by (Rabinove et al., 1958), only one sample was slightly saline category (TDS value range between 1,000 and 3,000 mg l^{-1}). TDS ranged from 360.02 to 1085.63 mg/l. Minimum (360.02 mg/l) and maximum (1085.63 mg/l) concentration of TDS was observed in A7 and G3 samples respectively (Table 1). According to WHO (2000), TDS should be 600 mg/l.

CO_3^{-2} was absent in most of the water samples. The concentration of HCO_3^- ion in groundwater of study area varied from 110.2 (A7) to 597.8 mg l^{-1} (G3) which is quite high. CO_3^{2-} and HCO_3^- together make total alkalinity. The value of Total Alkanility (as $CaCO_3$) of water samples ranges from 90.33 (A7) to 535 (G3) mg l^{-1}(Table 2). Alkalinity was higher than permissible limit i.e. (200 mg/l) in more than 50% samples (Table 2).

Calcium hardness (Ca-H) ranged from 40.08 to 194.39 mg/l. Minimum Ca-H (40.08 mg/l) was observed in A7 sample whereas maximum Ca-H (194.39 mg/l) was reported in G3 sample. Magnesium hardness (Mg-H) ranged from 34.05 to 92.42 mg/ l. Minimum (34.05 mg/l) and maximum (92.42 mg/l) values were reported A9 and G3 samples respectively. High concentration may cause laxative effect, while deficiency may cause structural and functional changes. Ca-H and Mg-H combined to form total hardness. TH varied from 295.23 to 865.70 mg/l. Minimum (295.23 mg/l) and maximum (865.70 mg/l) was reported from A9 and G3 water samples respectively (Table 2). WHO recommended safe permissible limit for hardness i.e. 500 mg/l (Table 3). Water hardness in most groundwater is naturally occurring from weathering of limestone, sedimentary rock and calcium bearing minerals. Hardness can also occur locally in groundwater from excessive application of lime to the soil in agricultural areas. Very hard groundwater results in urinary concretions, diseases of kidney or bladder or stomach disorder.

Chloride (Cl^-) varied from 69.98 to 299.91 mg/l. Minimum (69.98 mg/l) was reported in A7 and maximum (299.91 mg/l) was observed in A4 water samples (Table 1). The chloride values in the water samples due to dissolution of rocks surrounded the aquifer and probably due to leakage of sewage and anthropogenic pollution (agricultural activities). High concentration of chloride gives salty taste to water and may result in hypertension, osteoporosis, renal stones and asthma (McCarthy 2004). Sulphate concentration is varying from 22 to 137 mg/l and these values are within permissible limits prescribed by ISI, ICMR and WHO. Minimum (22 mg/l) and maximum (137 mg/l) sulphate (SO_4^{2-}) content was observed from A1 and G3 samples respectively.

Minimum (24 mg/l) and maximum (158 mg/l) Sodium (Na^+) content was observed from A8 and A9 samples respectively (Table 1). More than 50% samples contained higher concentration of Na^+. The higher concentration of Na^+ may pose a risk to the persons suffering from cardiac, renal and circulatory diseases.The acceptable limit for Na^+ is 50 mg/l according to WHO (Table 3). Potassium (K^+) content of water samples varied from 0 to 5 mg/l. Minimum (0 mg/l) and maximum (5.0 mg/l) K^+ content were observed from A3 and G4 samples respectively (Table 1). All the water samples (100%) contained K^+ content lower than permissible limit i.e. 20 mg/l (Table 2).

Minimum (12 mg/l) and maximum (87 mg/l) nitrate (NO_3^-) content was observed from G3 and G2 samples respectively. Due to its solubility and anionic form, nitrate is very mobile and can easily leach into the water table (Fetter, 1988). The most common sources of nitrate in groundwater are atmospheric fallout, sanitation facilities, irrigational activities and domestic effluents (Ritzi *et al*., 1993). WHO recommended safe permissible limit for nitrate i.e. 50 mg/l (Table 3). Almost 50% water samples had NO_3^- concentration higher than permissible limit. Higher concentration of NO_3^- in water causes a disease called “Methaemoglobinaemia” or known as “Blue-baby Syndrome”. It is particularly infant disease upto 6 months of child. The concentration of F^- in the studied water samples ranged from 0.4 to 3.6 mg/l . Minimum (0.4 mg/l) and maximum (3.6 mg/l) fluoride (F^-) content was observed from A8 and A2 samples respectively (Table 1). F^- at low concentration (1 mg/l) in drinking water has been considered beneficial but high concentration may causes dental fluorosis (tooth mottling) and more seriously skeletal fluorosis (Ravindra et al., 2006).

Correlation:

Correlation is a method used to evaluate the degree of interrelation and association between two variables (Nair et al, 2005). A correlation of +1 indicates a perfect positive relationship between two variables. A correlation of –1 indicates that one variable changes inversely with relation to the other. A correlation of zero indicates that there is no relationship between the two variable. Table 4 represents the Correlation Matrix among thirteen Water Quality Parameters of Groundwater of Study Area. EC and TDS showed good positive correlation with major water quality parameters. The correlation($r = 0.9848$) between these two parameters for the analyzed samples in this study showed a linear correlation. Some of the other highly significant correlation at $p = < 0.001$ were found between EC and Ca^{2+} ($r = 0.8867$) and between TDS and Ca^{2+} ($r = 0.8881$)also showed linear correlation. Some of the negative correlations were found between calcium and pH ($r = -0.1060$), between chloride and pH ($r = -0.2015$), between nitrate and pH ($r = -0.2158$), between calcium and nitrate ($r = -0.1378$), between carbonate and nitrate ($r = -0.4872$), between potassium and carbonate ($r = -0.0511$), between fluoride and nitrate ($r = -0.0032$). E.C. is solely a function of the major ion concentrations (Ca^{2+}, Mg^{2+}, Na^+, K^+, HCO_3^-, Cl^-, SO_4^{2-} and NO_3^-), the multiple regression model can be applied between EC and the ion concentrations expressed (in mg/L), as follows in equation:

$$EC = -8.03 + 5.05\,Ca + 9.0\,Mg + 4.33\,Na + 2.37\,K + 0.05\,HCO_3 - 0.09\,CO_3 + 0.23\,Cl - 0.43\,SO_4 - 0.48\,NO_3$$

Table 1: Ionic Variation of Groundwater in Study Area during Pre Monsoon Season:

CODE	pH	EC	TDS	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	NO_3^{-}	F^{-}
A1	7.60	948	535.79	80.16	43.78	75	1.2	0	231.8	164.95	22	33	1.2
A2	7.30	975	548.98	84.17	49.86	36	2.4	0	189.10	172.45	86	24	3.6
A3	7.76	963	544.93	42.08	85.12	48	0	0	146.6	232.43	25	39	2.1
A4	7.18	1478	829.09	146.29	71.74	60.7	2.1	0	164.7	299.91	111	54	1.6
A5	7.62	1324	772.42	102.20	62.02	92	3.1	0	280.6	214.9	98	60	3.2
A6	7.40	1104	703.10	124.25	68.1	36	1	0	213.5	222.43	122	22	0.6
A7	7.74	592	360.02	40.08	49.86	36	2	0	110.2	69.98	60	47	1.1
A8	7.45	925	513.53	52.10	72.96	24	1.8	0	268.4	112.47	42	74	0.4
A9	7.53	1175	729.87	62.12	34.05	158	4.1	0	195.2	204.94	104	66	2.7
G1	7.69	1368	797.43	116.23	83.9	53	1.1	0	244.0	269.20	112	40	1.2
G2	7.58	1518	838.71	160.32	60.8	45	3.2	0	420.9	199.94	72	87	1.4
G3	7.86	1810	1085.63	194.39	92.42	81	2	18	597.8	249.92	137	12	0.8
G4	7.24	1198	734.65	136.27	42.56	63	5	0	292.80	247.42	35	59	0.45

All values are in mg/L. except pH and EC

Table (2). The Values of TDS, TA, TH, RSC, SAR and Na% in the Study Area

CODE	TDS	TA	TH	RSC	SAR	Na%
A1	535.79	190	380.31	-	1.67	30.20
A2	548.98	155	415.35	-	0.77	16.39
A3	544.93	120.16	455.34	-	0.98	18.66
A4	829.09	135	660.50	-	2.1	16.95
A5	772.42	230	510.41	-	1.77	28.56
A6	703.10	175	590.48	-	0.64	11.88
A7	360.02	90.33	305.25	-	0.9	20.95
A8	513.53	220	430.32	-	0.50	11.25
A9	729.87	160	295.23	-	4.0	54.18
G1	797.43	200	635.47	-	0.91	15.52
G2	838.71	345	650.51	-	0.77	13.56
G3	1085.63	535	865.70	-	1.20	17.12
G4	734.65	240	515.40	-	1.21	21.78

Table 3 : Standards for Drinking Water Quality

S. No.	*Parameters*	*BIS: 1999*	*ICMR: 1975*	*WHO: 2000*
1.	pH	6.5–8.5	7.0–8.5	6.5–9.5
2.	EC (µseimens/cm)	–	–	1400
3.	TDS	2000	500	600
4.	Na^{+}	–	–	–
5.	K^{+}	–	–	20
6.	Ca^{2+}	200	200	100
7.	Mg^{2+}	100	200	150
8.	Cl^{-}	1000	200	250
9	CO_3^{2-}	–	–	–
10	HCO_3^{-}	–	–	–
11	SO_4^{2-}	400	200	250
12	NO_3^{-}	100	50	50
13	TH	600	600	500

Note: All values except pH and EC are expressed in mg/l.

TDS = Total Dissolved Solids

EC = Electrical Conductance

TH = Total Hardness

Table 4: Correlation Matrix among thirteen Water Quality Parameters of Groundwater of Study Area :

	pH	EC	TDS	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	NO_3^{-}
EC	0.0572											
TDS	0.0680	0.9848										
Ca^{2+}	-0.1060	0.8867	0.8881									
Mg^{2+}	0.3986	0.4479	0.4111	0.3306								
Na^{+}	0.1300	0.3016	0.3648	0.0361	-0.3692							
K^{+}	-0.3999	0.2171	0.2542	0.2485	-0.6241	0.4669						
CO_3^{2-}	0.4654	0.5919	0.6288	0.5671	0.4883	0.1620	-0.0511					
HCO_3^{-}	0.3237	0.7634	0.7626	0.7558	0.3698	0.1154	0.2173	0.7938				
Cl^{-}	-0.2015	0.7517	0.7577	0.6462	0.3910	0.2681	0.0486	0.2158	0.2557			
SO_4^{2-}	0.0275	0.6217	0.6759	0.5602	0.3240	0.2702	0.0434	0.4475	0.3322	0.4558		
NO_3^{-}	-0.2158	-0.0128	-0.0780	-0.1378	-0.3089	0.1183	0.5103	-0.4872	-0.0645	-0.1673	-0.3057	
F^{-}	-0.0420	-0.0480	-0.0821	-0.2681	-0.2615	0.3767	0.1301	-0.2208	-0.2793	0.0406	0.1456	-0.0032

Conclusion:

Total hardness of the groundwater of the most of the study area fall in the hard category. Higher concentration of EC, TDS, Cl^{-}, F^{-} and NO_3^{-} in the study area indicates sign of deterioration, which calls for at least primary treatment of groundwater before being used for drinking. The groundwater quality improves with the increase in depth and distance of the well from the pollution source. Although, the concentrations of few contaminants do not exceed drinking water standard even then the ground water quality represent a significant threat to public health.

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