

Ground water quality deterioration in and around of Jaipur (Rajasthan)

Dr. Akhalesh Kumar

Lecturer in Chemistry, Govt. R. R. College, Alwar, Rajasthan

ABSTRACT

Water is the most essential thing for any kind of life. In recent years, due to population growth, industrialization and unsafe use of fertilizers, water is getting highly polluted in the state of Rajasthan. Rajasthan is the driest state of India and out of total 15 basins only 2 basins (Chambal and Mahi) are perennial. Due to unavailability of surface water and lack of rainfall, ground water plays an important role in this state for all uses especially as a source of drinking water. The ground water scenario of the capital city of Rajasthan has come under alarming situation due to over exploitation of ground water resources, unsafe waste disposal practices, urbanization etc. In this paper, fifty samples of groundwater were collected from in and around the Jaipur city area and were analyzed in order to find out the causes of groundwater quality deterioration due to pollution and impact on ground water resources. The physicochemical analyses results of the parameters, pH, EC and the major ions (Na^+ , K^+ , Ca^{2+} , Mg^{2+} , Cl^- , HCO_3^- , CO_3^{2-} , F^- & NO_3^-) revealed that the study area is most affected by salinity, high Fluoride and high Nitrate problems. The heavy metal analysis for these samples showed that Pb and Fe are also present beyond permissible limits. The remedial measures have also been discussed in this paper to control this type of ground water pollution.

1. INTRODUCTION

The demand of fresh water has been increasing day by day due to growing population. Where surface water is not available in sufficient quantity, groundwater is the main resource as fresh water and widely used by industries, irrigation and for domestic purposes (Usha et al, 2011). The development of industries and agriculture created a number of environmental problems including air and water pollution with their serious effects on human health (Wang et al., 2010; Patrick, 2003). Pollution free water is the only hope for the healthy life. The polluted water is the root cause of no. of deadly diseases. The polluted water not only affects the life of present generation but it can also destroy the life of upcoming generations due to its long lasting effect in the water resources. The present study was carried out for qualitative analysis based on physico-chemical parameters of groundwater.

II STUDY AREA

Jaipur popularly known as Pink city, is the capital of Rajasthan. It covers about 480 sq. km. of geographical area and is bounded by 26°44'32" & 27°03'13" North latitudes and 73°35'34" & 73°56'55" East longitudes. The city falls in the parts of Amber, Jaipur and Sanganer Tehsils and forms the part of Amber, Jhotwara and Sanaganer Bocks

(Panchayat Samitis). For the present study, the area comprising Jaipur Urban area and surrounding Rural/sub-urban area has been selected. The total population of city is approximately 30.47 lakh (2011) consisting of 16.0 lakh males and 14.47 lakh females. The Location of the study area along with ground water sampling sites is given below in Figure 1.

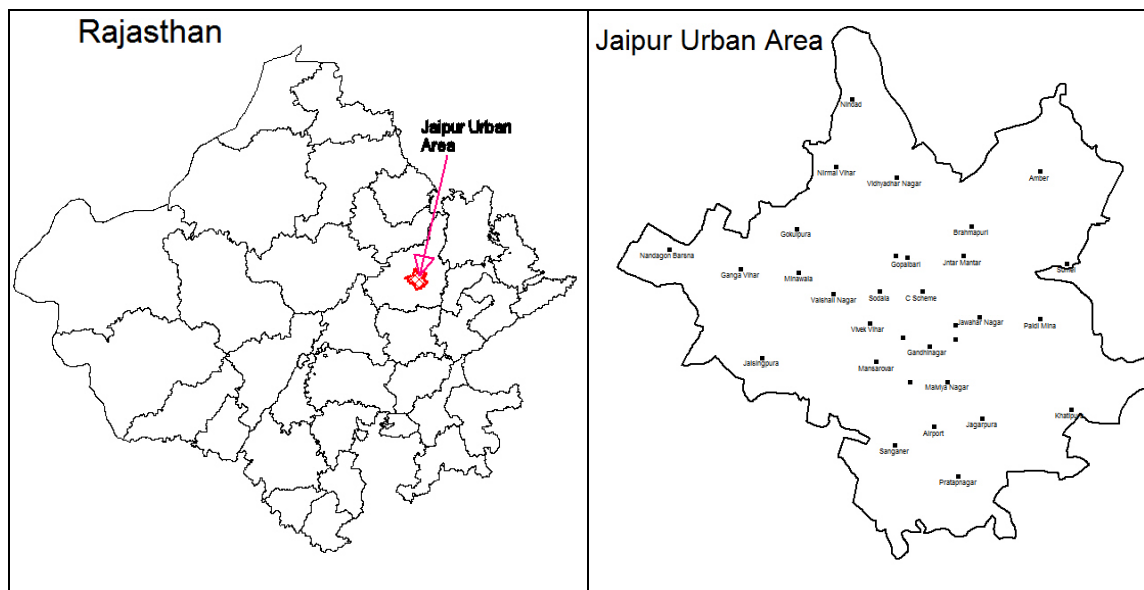


Fig.1: Location map along with Ground water sampling sites

Physiographically, the city area is characterized by wide variety of features like sandy plains, hills, intermontane-valleys, pediments, etc. The major part of the city is covered by alluvial sandy plains which are dissected at places. In the northern and eastern parts, the Aravalli Hill ranges, trending NE-SW alternating with intermontane-valleys, are the significant features. The elevation of plain area ranges from 350 m amsl in the southern part of the area to 470 m amsl in the northern part and highest peak of 602 m AMSL. In the entire area, Amanishahnallah is the main surface water carrier and it joins the Dhund river towards south which is a tributary of Morel river. The climate of the city is hot & semi-arid and the average annual rainfall is about 650 mm, most of which occurs during monsoon months (June to September). During the monsoon there are frequent, heavy rains and thunderstorms, but flooding is not common. Temperatures remain relatively high during summer from April to early July with average daily temperatures of about 30°C. The winter months of November to February are mild and pleasant, with average temperatures ranging from 10–15°C.

III MATERIALS AND METHODS

Fifty samples were collected from the study area in June 2011 comprising 13 samples from rural and 37 samples from urban area of Jaipur. From the same sites, 50 no. of samples were also collected for heavy metal analysis. The water sampling was carried out following the standard procedures. Good quality air tight plastic bottles with cover lock were used for sample collection and safely transferred to the laboratory for analysis. These were analyzed in

laboratory of Central Ground Water Board, Western Region, Jaipur. The analysis were done for physico-chemical parameters, i.e., pH, EC and the major ions (Na^+ , K^+ , Ca^{2+} , Mg^{2+} , SO_4^{2-} , Cl^- , HCO_3^- , CO_3^{2-} , F^- and NO_3^-) using standard methods (APHA, 2012) and heavy metals, i.e., Zn, Mn, Ni, Cu, Fe&Pb. Also, Temperature, pH & EC were determined in the field at the time of sampling. Bicarbonate analysis was carried out using acid titration method, Cl by AgNO_3 titration method and Ca&Mg by EDTA titration method. Na and K were analysed using flame photometer, NO_3^- and F by UV-Visible spectrophotometer. The heavy metals were analysed by Atomic absorption spectrophotometer. The data was subjected to various mathematical and statistical analysis. The ionic balance error for studied ions was within $\pm 5\%$.

IV RESULTS AND DISCUSSION

4.1 Physico-chemical Parameters

A total of 50 groundwater samples were collected from the study area for physico-chemical parameters. The results have been presented in Table 1 and standard guideline values for the analysed parameters as recommended by WHO and BIS for drinking water are depicted in Table 2.

Table 1. Results of Physio- chemical Parameters

S. No.	Location	pH	EC in $\mu\text{S}/\text{cm}$	HCO_3	Cl	NO_3	TH	Ca	Mg	Na	K	F
S1	Bhakrota	7.78	840	171	142	85	210	48	22	96	1	1.07
S2	Murlipura	7.95	220	61	28	12	80	16	10	13	0	1.76
S3	Kalwar	8.28	1780	439	320	45	290	56	36	275	3	2.195
S4	Harmada	8.02	1100	268	180	50	240	44	32	140	2	0.212
S5	Hathoj	8.15	680	220	67	60	70	16	7	125	1	2.11
S6	Chomu	8.56	685	110	110	20	120	28	12	102	1	1.81
S7	Jhotwara	8.35	575	98	115	31	120	24	15	75	2	2.04
S8	M.I. Road	7.76	1220	220	178	190	390	84	44	100	4	0.415

S9	Nindar	7.9 4	1349	281	220	90	420	12 0	29	115	4	2.12
S10	Jobner	7.7 4	1125	195	227	70	200	40	24	166	3	1.79
S11	Vaishali	7.4 7	704	85	128	100	200	36	27	68	1	0.39
S12	Shyamnagar	8.1 3	3110	683	532	150	240	28	41	600	5	1.07
S13	Chitrakoot	7.8 7	750	122	163	25	210	32	32	72	4	0.73
S14	Malviya Nagar	7.3 1	450	85	99	2	110	20	15	51	3	0.45
S15	Chaksu	7.5 4	3300	732	603	16	340	40	58	600	2	5.3
S16	Balawala	7.5 6	3150	159	400	930	340	48	53	570	0	2.45
S17	Jagatpura	8.1 1	790	220	99	80	270	64	28	62	3	0.27 5
S18	Gopalpura	7.8	1140	183	156	210	380	92	36	86	3	0.32 5
S19	Bassi	8.3 3	1408	390	224	45	160	24	24	255	2	1.14
S20	Gujar Ki Thadi	7.9 1	460	85	92	2	140	20	22	39	3	0.79 5
S21	Malpura	7.9	1610	305	292	125	500	13 2	41	140	3	0.18 5
S22	Khatipura	7.8 2	461	73	92	6	160	28	22	35	3	0.61
S23	Mansarovar	8.0 6	430	98	78	3	130	24	17	38	2	0.73
S24	VKAI	7.5 6	450	61	110	4	140	20	22	36	3	0.63
S25	Kanota	7.8	1369	305	210	130	260	48	34	195	1	1.57
S26	Jhalana	8.1 9	990	146	241	17	400	10 4	34	42	3	0.19 5

S27	Jaisinghpura	8.2 9	610	98	135	20	210	52	19	44	1	0.76
S28	Kukas	7.6 2	1790	329	327	140	610	16 8	46	130	3	0.79 5
S29	Govindpura	8.1 1	2200	354	410	210	580	16 4	41	240	3	0.13
S30	Sukehdopura	7.9 4	1450	366	220	85	400	10 0	36	150	2	0.53 5
S31	Brahampuri	8.2 4	460	61	106	3	130	32	17	35	2	0.61
S32	Shivdaspura	8.2 4	2750	610	554	30	370	88	36	450	2 2	3.68
S33	Sanganer	8.0 6	1960	195	358	360	500	12 8	44	220	2	1.88
S34	Shastrinagar	8.0 8	535	122	99	8	190	32	27	34	2	0.71 5
S35	Balawala Stand	7.2 2	2960	97	345	105 0	510	13 2	44	445	2	1.26
S36	Amer	7.1 9	6800	866	134 9	235	118 0	32 8	99	950	4 1	0.99 5
S37	Durgapura	8.1 7	690	110	118	65	250	64	22	42	2	0.71 5
S38	Lalkothi	8.0 2	430	49	80	55	150	28	19	30	2	0.62
S39	Bajajnagar	7.8 3	470	49	106	3	150	24	22	36	3	0.49
S40	Khatipura	7.8 3	2825	708	450	155	270	72	22	525	2	1.6
S41	University of Rajasthan	8.1	760	130	65	170	260	48	34	56	1	0.85 5
S42	Sethi Colony	8.1 1	435	125	71	3	180	32	24	22	2	0.74 5
S43	Tilak Nagar	7.5	440	73	85	6	160	36	17	26	2	0.73
S44	Dudu	8.0 9	4100	1013	667	75	410	12 0	27	750	3	10.4

S45	Bichun	8.0 2	2300	671	334	50	610	16 8	46	250	1	10.7
S46	MotiDungri	8.0 5	460	73	85	32	150	32	17	35	2	0.52 5
S47	Chandpole	8.3 3	6400	1037	156 2	8	480	12 4	41	125 0	3	0.34
S48	Banipark	7.8 6	580	61	138	5	220	56	19	32	2	0.46 5
S49	Vidhyadhar Nagar	7.7 1	600	110	99	55	240	60	22	30	2	0.15 2
S50	C Scheme	7.6 4	320	61	64	4	120	20	17	19	1	0.65 5

Table 2. Standards for drinking water quality as recommended by WHO and BIS

S. No.	Parameters	BIS	WHO: 2011
1.	pH	6.5-8.5	6.5-8.5
2.	EC (μ S/cm)	-	1500
3.	TH (mg/l)	200	500
4.	Cl (mg/l)	250	200
5.	NO ₃ (mg/l)	45	45
6.	F (mg/l)	1.0	1.5
7.	Ca (mg/l)	75	75
8.	Mg (mg/l)	30	50
10	Zn (mg/l)	5.0	3.0
11.	Mn (mg/l)	0.5	0.5
12.	Ni (mg/l)	0.02	0.02
13.	Cu (mg/l)	0.05	2.0
14.	Fe (mg/l)	0.3	1.0
15.	Pb (mg/l)	10.0	10.0

The brief details of quality parameters are discussed below:

4.1.1 pH

The pH value depicts the balance between acids and bases in water. The pH value of groundwater samples collected from the study area varies between 7.19 to 8.56 with a mean value 7.94 indicating slightly alkaline in nature but suitable for drinking purposes.

4.1.2 Electrical Conductivity (EC)

Electrical Conductivity is a measure of capacity of water to convey the electrical current and is a function of temperature, type of ions present and concentration of various ions (Walton, 1970). The ground water samples having EC values less than 2000 $\mu\text{S}/\text{cm}$ at 25°C is generally considered as fresh water. In present study area, EC values are ranging from 220 to 6800 $\mu\text{S}/\text{cm}$ at 25°C with average mean value of 1370 $\mu\text{S}/\text{cm}$ at 25°C. TDS concentrations in the groundwater vary from 225mg/l to 5549mg/l with an average value of 1149mg/l in the study area.

4.1.3 Bicarbonate (HCO_3)

Most surface streams contain less than 200mg/l of carbonate and bicarbonate, but in groundwater it is quite higher. The bicarbonate concentration varying from 49.0 to 1037.0 mg/l with average value of 251.0 mg/l. has been observed in the study area.

4.1.4 Chloride (Cl)

Chloride is one of the major and extremely stable inorganic anion in fresh water and waste water. Mostly, chloride anion makes salt with sodium cation that decides the salinity of water. In drinking water, the acceptable limit of Chloride is 250 mg/l and permissible limit in the absence of alternative source of water is 1000 mg/l as per BIS (2012). The chloride ion in the ground water samples of the study area ranges between 28 to 1562 mg/l with an average value 251.70 mg/l.

4.1.5 Nitrate (NO_3)

Nitrate is one of the dominant anion in the ground water as well as surface water. In Jaipur urban area, it is observed that Jhotwara block is highly affected (Sample No. S5, S9, S22, S29) with high Nitrate problem. In the central part of city, some locations have very high Nitrate values, e.g. 100-350 mg/l at S6, S11, S12, & S18. This may be due to dense population. Apart from this, Sanganer (S33) and Malpura (S21) are highly polluted due to leaching of Nitrate from Amanishahnala.

4.1.6 Fluoride (F)

As per drinking water specification (BIS 2012), the acceptable limit of Fluoride is 1.0 mg/l and permissible limit in the absence of alternative source of water is 1.5 mg/l. The values of Fluoride range from 0.13 to 10.74mg/l with average value 1.43mg/l in the study area.

4.1.7 Calcium and Magnesium (Ca and Mg)

Calcium and Magnesium are the most abundant alkaline-earth metals and are major constituent of many common rocks minerals. The amount of calcium in groundwater of the study area ranges from 16.0 to 328.0 mg/l with average value 64.60 mg/l.

In case of magnesium, the acceptable limit is 30.0 mg/l and permissible limit in the absence of alternative source of water is 100.0 mg/l. It has been observed that all the samples are within permissible limit in the study area

4.1.8 Sodium and Potassium (Na and K)

The most significant and important source of sodium in groundwater are the precipitates of sodium salts impregnating the soil in shallow water tract, particularly in arid and semi-arid regions. BIS (2012) and WHO have not given any guideline limits for sodium and potassium for drinking water. Sodium concentration in the samples is varying between 13.0 to 1254.0 mg/l with mean value 184.0 mg/l in the study area.

Potassium is essential element for plants and animals. But very high concentration may be harmful to human nervous system. The concentration of potassium is very low in the study area and ranges from 0.00 to 41.0 mg/l with mean value 3.53 mg/l.

4.1.9 Hardness (TH)

Hard water is unsuitable for domestic use. As per drinking water specification (BIS 2012), the permissible limit in the absence of alternative source of water is 600 mg/l. The degree of hardness of water can be categorized in four classes in terms of the equivalent CaCO_3 ; (i) Soft -0-75 mg/l, (ii) Moderate 75-150 mg/l, (iii) Hard 150-300 mg/l, Very hard >300 mg/l. Out of 50 ground water samples, only one sample falls under soft category, 12 samples under moderate hard class, 21 samples under hard and 16 sample fall under very hard class of permanent hardness.

4.2 Heavy Metals

50 no. of groundwater samples were collected from the study area for six major heavy metal analysis and their results have been presented in table 5. The brief discussion of results is discussed below.

4.2.1 Zinc (Zn)

As per BIS specification, the maximum acceptable limit of Zn is 5.0 mg/l. In present study area, the value of Zn varies from 0.0 to 2.0 mg/l with mean value 0.259 mg/l. The maximum value has been observed in Jhotwara (H22).

4.2.2 Copper (Cu)

The value of Cu ranges from 0.0 to 0.07 mg/l with mean value 0.012 mg/l in the samples.

4.2.3 Manganese (Mn)

In present study area, the value of Mn varies from 0.0 to 2.0 mg/l with mean value 0.055 mg/l. All samples are within the permissible limit of BIS.

4.2.4 Nickle (Ni)

Ni concentrations in the groundwater of study area ranges between 0.0 to 0.092mg/l with mean value 0.016 mg/l. Out of 50 samples, 16 samples are beyond the BIS limit.

4.2.5 Iron (Fe)

The value of iron content in the study area ranges between 0.0 to 2.28mg/l with average value 0.313mg/l. One sample (S6) has value beyond the acceptable limit and four samples (H12, H27, H40 &H50) showvalue beyond permissible limit.

4.2.6 Lead (Pb)

Lead is highly toxic metals and normally it should be present only in traces. In the present study, the values of lead are very high than the maximum permissible limit of BIS(0.01mg/l) and range from 0.0 to0.104mg/l with mean value0.025mg/l. The maximum concentration of lead is found in sample S11.

V STATISTICAL SUMMARY OF RESULTS

The basic statistics of the analysed water quality parameters are summarized in Table 3.

The table indicates that pH values of almost all 50samples are within the range. About one fourth of the total water samples have high EC. Because of strong correlation between EC and chloride, about 25% of ground water samples have high salinity. Nitrate and Fluoride are of great concern in the study area because about half (49%) of the total ground water samples have Nitrate concentrations beyond the permissible limitsand one third (34%) of the total samples have Fluoride above permissible limits.

Table 3: Statistical parameters of the different chemical constituents of groundwater samples
Correlation Matrix

S. No.	Parameters	Minimum	Maximum	Average	Standard Deviation	Coefficient Variance
1.	pH	7.19	8.56	7.94	0.29	3.61
2.	EC (μS/cm)	220	6800	1370	1425	104.00
3.	TH (mg/l)	70.0	1180	278.72	193.88	69.56
4.	Cl (mg/l)	28.0	1562.0	251	299.0	118.93
5.	NO ₃ (mg/l)	2.0	235.0	63.51	65.14	102.57
6.	HCO ₃ (mg/l)	49.0	1037.0	270.47	265.66	98.19
7.	F (mg/l)	0.13	10.74	1.43	2.16	151.44
8.	Ca (mg/l)	16.0	328.0	64.60	57.82	89.50
9.	Mg (mg/l)	7.0	99.0	28.81	15.06	52.82
10.	Na (mg/l)	13.0	1250.0	184.0	261.49	141.89
11.	K (mg/l)	0.0	41.0	3.53	6.36	180.02

The correlation coefficients have been computed between all the ions and the correlation matrix is given below in Table 4.

Table 4: Correlation Matrix of the hydrochemical parameters

	<i>EC</i>	<i>HCO₃</i>	<i>Cl</i>	<i>NO₃</i>	<i>TH</i>	<i>Ca</i>	<i>Mg</i>	<i>Na</i>	<i>K</i>	<i>F</i>
<i>EC</i>	1.000									
<i>HCO₃</i>	0.932	1.000								
<i>Cl</i>	0.979	0.870	1.000							
<i>NO₃</i>	0.399	0.335	0.291	1.000						
<i>TH</i>	0.757	0.632	0.709	0.623	1.000					
<i>Ca</i>	0.716	0.590	0.672	0.599	0.983	1.000				
<i>Mg</i>	0.752	0.629	0.702	0.587	0.903	0.812	1.000			
<i>Na</i>	0.971	0.938	0.962	0.273	0.581	0.536	0.606	1.000		
<i>K</i>	0.607	0.417	0.591	0.346	0.683	0.659	0.694	0.490	1.000	
<i>F</i>	0.339	0.556	0.232	-0.055	0.220	0.224	0.157	0.350	0.024	1.000

The correlation matrix describes the interrelationship between variables. The results for 10 hydrochemical parameters show that very high positive correlation exists between EC-Cl (0.98), EC-Na (0.97), EC- HCO₃ (0.93), Na-Cl (0.96), Na-HCO₃ (0.94), TH-Ca (0.98) & TH-Mg (0.90). High positive correlation exists between Cl-HCO₃ (0.87) & Ca-Mg (0.81). From table, it is quite clear that most of the parameters significantly correlate with HCO₃. It may indicate that the aquifer system may have experienced various processes such as ion exchange, water rock interaction and weathering of the aquifer's parental material. Similarly good correlation of EC, Na & Cl shows salinity problem in study area. The poor correlation of NO₃ with all other parameters shows that it has some anthropogenic source.

VI CONCLUSION

On the basis of the field observations and results of study area, it may be concluded that high pH can be due to anthropogenic activities like sewage disposal, decomposition of organic matter, improper irrigation and weathering processes. Electrical conductivity is higher in small pockets in densely populated urban Jaipur. In rural Jaipur, it may be higher due to the excess irrigation. Like EC, high chloride is noticed in small patches in central part and most of the rural area of Jaipur. The chloride in ground water may be from diverse sources such as weathering, leaching of sedimentary rocks & soil, domestic & municipal effluents and lack of underground drainage system. In Jaipur urban area, it is observed that Jhotwara block is polluted by high nitrate. This may be due to septic and sewage discharge and by percolating water through leaching from cess pools & soak pits. The high value of Nitrate in the central part of the city might be due to dense population, human & animal refuge, garbage, poor sanitation system and shallower water level. The western part of city (Sanganer and Malpura) is highly polluted due to leaching of

Nitrate from Amanishahnala. The Jaipur rural area is worst affected from fluoride contamination especially at Bichun, Dudu and Chaksu which may be attributed due to geogenic conditions and use of fluoride rich fertilizers in cultivation. The Sanganer is famous for block printing, and it is worst polluted from high fluoride due to such type of dying industries situated in this area. The ground water of study area is mainly contaminated from high nitrate and fluoride along with high salinity. For removal of the above, following processes can be used as remedial measures:

1. Precipitation process, including coagulation assisted micro filtration and lime softening;
2. Adsorptive processes, including adsorption on to activated alumina, activated carbon coated filter media;
3. Ion exchange processes specifically anion exchange;
4. Membrane processes, including nano-filtration, reverse osmosis and electro dialysis.

Along with these processes, Domestic sewage disposal should be strictly monitored. Agricultural practices should be modified to prevent water pollution. Good sanitation measures in villages and cities will prevent ground water as well as surface water pollution. We should aware and adopt the remedial measures for treatment of polluted water.

Table 5. Results of Heavy Metal Analysis

S. No.	Location	Zn	Ni	Mn	Cu	Fe	Pb
H1	Bhakrota	0.650	0.020	0.002	0.008	0.169	0.036
H2	Murlipura	0.030	0.000	0.000	0.049	0.047	0.000
H3	Kalwar	0.300	0.020	0.221	0.017	0.265	0.025
H4	Harmada	0.075	0.021	0.006	0.011	0.158	0.025
H5	Hathoj	0.023	0.000	0.000	0.002	0.020	0.000
H6	Chomu	0.149	0.010	0.008	0.016	0.759	0.028
H7	Jhotwara	0.026	0.010	0.002	0.005	0.123	0.011
H8	M.I. Road	0.129	0.011	0.011	0.014	0.137	0.035
H9	Nindar	0.575	0.026	0.007	0.001	0.097	0.005
H10	Jobner	0.032	0.022	0.014	0.000	0.117	0.000
H11	Vaishali	0.074	0.013	0.001	0.010	0.070	0.104
H12	Shyamnagar	0.575	0.031	0.010	0.008	1.767	0.041
H13	Chitrakoot	1.005	0.007	0.022	0.006	1.740	0.018
H14	Malviya Nagar	0.021	0.000	0.003	0.030	0.083	0.002
H15	Chaksu	0.061	0.040	0.004	0.024	0.101	0.045
H16	Balawala	0.010	0.023	0.000	0.005	0.051	0.022
H17	Jagatpura	0.000	0.000	0.000	0.002	0.000	0.000
H18	Gopalpura	0.054	0.020	0.112	0.011	0.119	0.029
H19	Bassi	0.675	0.021	0.008	0.015	0.258	0.037
H20	Gujar Ki Thadi	0.038	0.011	0.030	0.006	0.237	0.022
H21	Malpura	0.450	0.018	0.005	0.006	0.086	0.030

S. No.	Location	Zn	Ni	Mn	Cu	Fe	Pb
H22	Khatipura	0.184	0.002	0.005	0.004	0.006	0.000
H23	Mansarovar	0.175	0.006	0.007	0.007	0.154	0.022
H24	VKAI	0.183	0.002	0.005	0.010	0.052	0.011
H25	Kanota	0.202	0.017	0.002	0.014	0.123	0.017
H26	Jhalana	0.875	0.016	0.003	0.004	0.080	0.024
H27	Jaisinghpura	0.350	0.004	0.005	0.011	1.639	0.017
H28	Kukas	0.500	0.025	0.016	0.015	0.235	0.050
H29	Govindpura	0.400	0.038	0.003	0.010	0.131	0.060
H30	Sukehdopura	0.148	0.013	0.001	0.008	0.081	0.017
H31	Brahampuri	0.188	0.001	0.001	0.002	0.047	0.002
H32	Shivdaspura	0.059	0.029	0.002	0.010	0.058	0.039
H33	Sanganer	0.136	0.005	0.032	0.012	0.245	0.040
H34	Shastrinagar	0.325	0.000	0.003	0.004	0.067	0.010
H35	Balawala Stand	0.004	0.030	0.000	0.007	0.050	0.011
H36	Amer	0.016	0.063	0.011	0.015	0.164	0.077
H37	Durgapura	0.153	0.010	0.005	0.017	0.251	0.036
H38	Lalkothi	0.102	0.006	0.010	0.008	0.232	0.016
H39	Bajajnagar	0.094	0.005	0.007	0.027	0.077	0.007
H40	Khatipura	2.000	0.042	0.038	0.071	2.002	0.061
H41	University of Rajasthan	0.070	0.002	0.000	0.003	0.032	0.002
H42	Sethi Colony	0.077	0.000	0.000	0.009	0.058	0.017
H43	Tilak Nagar	0.162	0.009	0.047	0.005	0.194	0.035
H44	Dudu	0.151	0.035	0.027	0.012	0.209	0.026
H45	Bichun	0.036	0.029	0.005	0.009	0.262	0.037
H46	MotiDungri	0.148	0.000	0.006	0.044	0.013	0.008
H47	Chandpole	0.106	0.092	0.017	0.027	0.169	0.086
H48	Banipark	0.375	0.000	0.004	0.005	0.267	0.016
H49	Vidhyadhar Nagar	0.560	0.018	2.000	0.005	0.090	0.036
H50	C Scheme	0.225	0.000	0.019	0.014	2.277	0.000

REFERENCES

1. APHA "Standard methods for the examination of water and wastewater (22nd ed.). Washington D.C.", American Public and Health Association.
2. BIS "Bureau of Indian Standards IS: 10500", ManakBhavan, New Delhi, India.
3. Development Plan of Jaipur City, Jaipur Urban Development Authority
4. WHO (2011) WHO Guidelines for Drinking-water Quality, fourth ed. World Health Organization.
5. .Rai, J.P.N. and Sharma, H.C., Impact of industries on the quality of surface and ground waters in the north-west region of U.P., National symposium on protection of environment of city water fronts, CWC, New Delhi, 11 (1990).
6. Forstner, U. and Wittman, G.T.W., Metal Pollution in the aquatic environment Springer Verlag (1983).
7. Klein, L.A., Long, M., Nash, N., Kirschner, S.L., J.W.P.C.E. 46, 2653 (1974), Hunt, D.T. and A.L. Wilson. The chemical analysis of water, General Principles and Techniques, Royal Society of Chemistry, U.K. 2nd edition (1986).
8. Ghose, N.C. and Sharan, C.B. Effect of drain water on the Physico-chemical and bacteriological characters of river Ganga, Ecology and Pollution of Indian river, 255 (1988).
9. Chandini, T., Regulation & Control of generation and discharge of industrial wastes, National Symposium on Protection of Environment of City Water Fronts, New Delhi, II, 37 (1990).
10. Kumar, S., Kushwaha, R. et al. "Impact of textile industry on ground water quality of Sanganer, Jaipur", IWWA 4, 321 (2001).
11. Majumdar, D. and Gupta, N., Nitrate pollution of ground water and associated with human health disorders, Indian J. Env'tl. 42, 28 (2000).
12. Abhay Kumar Singh "Quality assessment of surface and subsurface water of Damodar river basin", IJEH, 44, 41 (2002).
13. Samal, U.N., Dental fluorosis in school children in the vicinity of an aluminium factory in India 21, 137 (1988).
14. Dutta Ira & Mookerjee Anjali, Heavy metal pollution in grass, solid around factory in West Bengal, Indian J. Environ. Hlth. 22(3), 220 (1980).
15. Council for Agricultural Science and Technology, "Application of sewage sludge to cropland, appraisal of potential hazards of the heavy metals to plants and animals", report no. 64, council for agricultural science and technology, Ames IA (1976).
16. Madhavan, N. and Subramanyam, V., Fluoride concentration in river water of South Asia, Current Science, 80, 1312 (2001).
17. Choubisa, S.L., Choubisa Leela, et al., "Endemic Fluorosis in Rajasthan", IJEH, 43, 177 (2001).
18. Das, S., Menta, B.C., Samanta, S.K., Das, P.K. and Srivastava, S.K., Fluoride hazards in ground water of Orissa, India. Indian J. Environ. Hlth., 1, 40 (2002).

19. Bulusu, K.P. and Pathak, B.N., Discussion on paper water defluoridation with activated Alumina by yeon C. Wu and Anan Nitya, Proc. Paper 14544, The Journal of Env. Engg. Divn. ASCE 2, 466 (1980).
20. Choudhary, M. and Syed Sattar, S.D., Domestic water treatment for developing countries in crution A. Mc. Feters. Drinking water microbiology Springer Vellay New York, 160 (1990).
21. Agrawal, V., Vaish, A.K. and Vaish, P. "Ground water quality focus on fluoride and fluorosis in Rajasthan", Current Sci., 73(9), 743 (1987).
22. Kumar, S. and Gopal, K., A review of fluorosis and its preventive strategies, Indian J. Envnt. Prot. 20, 430 (2000).