



## SPATIAL ASSESSMENT OF GROUNDWATER QUALITY FOR DRINKING PURPOSE IN KAITHAL DISTRICT, HARYANA

Anup Kumar<sup>1\*</sup>, Baru Ram<sup>2</sup>, Naresh Kumar<sup>2</sup> and V.S.Arya<sup>3</sup>

<sup>1</sup>Front Office-HARSAC, DST, Bays 35-38, Sector-2, Panchkula

<sup>2</sup>Deptt. of Geology, Kurukshetra University, Kurukshetra

<sup>3</sup>Haryana Space Applications Centre (HARSAC), Hisar

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### Abstract

Water is important for sustaining life. Presently the demand of water is increased for drinking, irrigation and industrial purposes. Excessive use of water leads to the depleting of aquifer as well as deterioration of quality. In these days many techniques are available for searching of groundwater and quality establishment. In the present study Geographical Information System (GIS) has been used to study spatial groundwater quality in Kaithal district, Haryana. Kaithal district is located between the latitudes 29°30" North to 30°11 North and longitudes 76°090 East to 76°41 East and covering area 2,317 sq. km. In the study 62 groundwater samples were collected during field in the month of February 2019. All the groundwater samples were analyzed using Field Water Testing Kit prepared by Tamilnadu Water Supply and Drainage Board, Chennai for twelve chemical parameters-pH, alkalinity, hardness, chloride, total dissolved solids, fluoride, iron, ammonia, nitrite, nitrate, phosphate and residual chlorine. Results of chemical analysis of groundwater samples were put in GIS environment and inverse distance weighted interpolation technique applied to get spatial scenario of each chemical parameter in the study area. Chemical results were categorized in desirable, permissible and non-potable drinking water class as per BIS drinking water standards and area under each drinking water class was calculated. In the study area pH covers 97.45% area under desirable and 2.55% area under non-potable, alkalinity is desirable in 0.18% area, permissible in 99.14% area and non-potable in 0.68% area, hardness covers 63.15% area under desirable, 34.94% area under permissible and 1.91% area under non-potable, chloride is desirable in 85.32 % area and permissible in 14.68% area, total dissolved solids cover 0.15% area under desirable, 98.83% area under permissible and 1.02% area under non-potable, fluoride is desirable in 4.79% area, permissible in 18.88% area and non-potable in 76.33% area, iron is desirable in 94.48% area and non-potable in 5.52% area, ammonia covers 55.29% area under desirable and 44.71% area under non-potable, nitrate covers 100% area under non-potable and nitrite, phosphate and residual chlorine cover 100% area under desirable drinking water class. The spatial groundwater quality scenario in the study area is highly useful for planning, monitoring and management of groundwater for drinking purpose.

### Keywords

Groundwater, quality, spatial, Kaithal, Haryana.

### INTRODUCTION

Water is important for survival of living beings. Groundwater is utmost importance because of easily available for drinking, irrigation and industrial uses. But the excessive use of

groundwater leads depleting and quality deterioration. Groundwater quality is important for drinking purpose because poor quality drinking water leads to many health problems. Knowledge of spatial distribution of chemical

parameters in an area helps to locate a well at good groundwater quality site. Geographical Information System (GIS) plays vital role in displaying spatial distribution of chemical parameters in an area from point groundwater sample. Many workers have studied groundwater quality using GIS in various types of areas for drinking and industrial purposes (Asadi et al. (2007), Singh and Lawrence. (2007), Arumugam and Elangovan (2009), Balakrishnan et al. (2011), Deshpande and Aher (2012), Krishnaraj et al. (2015), Singhet al. (2015), Ambiga (2016), Nelly et al. (2016), Pandian and Jeyachandran (2014)).

### STUDY AREA

The study area Kaithal district lies between latitudes 29°30" North to 30°11 North and longitudes 76°090 East to 76°41 East and covers 2,317 sq.km area. Slope of the district is from north-east to south-west. Geologically in the district alluvium of Quaternary age and geomorphologically alluvial plain is present.

### OBJECTIVE

The main objective was to study spatial groundwater quality in Kaithal district using GIS technique.

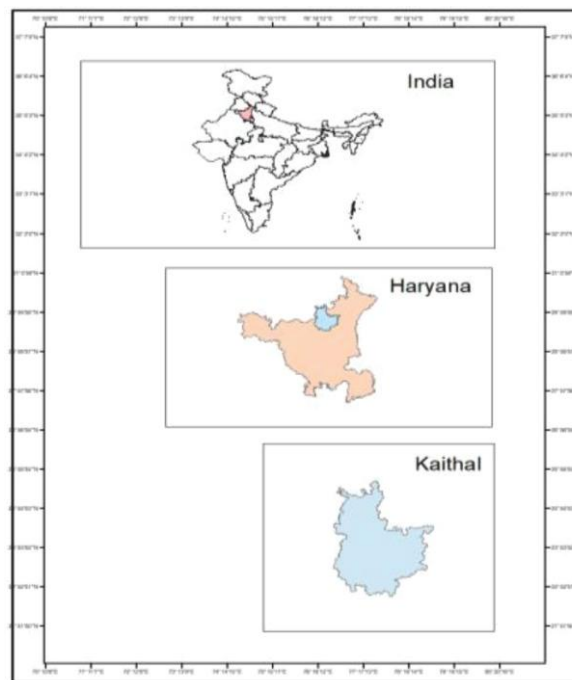


Fig. 1: Location map of the study area.

Table 1: Result of chemical analysis of groundwater samples.

S.I. No.	Sample	Latitude	Longitude	Source	pH	Alkalinity (mg/l)	Hardness (mg/l)	Chloride (mg/l)	TDS (mg/l)	Fluoride (mg/l)	Iron (mg/l)	Ammonia (mg/l)	Nitrite (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	Residual Chlorine (mg/l)
1	Simla	29.63874	76.21864	Tubewell	7	200	140	50	468	5	0	0	0.5	100	0	0
2	Batta	29.6963	76.29694	Tubewell	8	390	480	500	1371	5	0	2	1.0	100	0	0
3	Kurar	29.72024	76.19895	Tubewell	7.5	310	300	100	852	5	0	1	0.2	45	0	0
4	Dubbal	29.74313	76.22141	Tubewell	7.5	280	200	300	936	3	0	0	0.2	75	0	0.2
5	Kailram	29.7105	76.36057	Tubewell	8	380	390	180	1140	3	0	0.5	0.5	75	0	0
6	Mator	29.62334	76.26354	Tubewell	8	600	1120	700	2904	1	0	1	0.5	75	0	0
7	Vajir Nagar	29.67591	76.34291	Handpump	6.5	150	150	30	396	2	0	1	0.5	100	0	0
8	Kheri Lamba (I)	29.69788	76.23436	Tubewell	7	200	970	730	2280	1.5	0	0.5	0.2	45	0	0
9	Kheri Lamba (ii)	29.69788	76.23436	Tubewell	9	550	300	400	1500	5	0	0	0.5	75	0	0
10	Kharondhi	30.0138	76.29592	Tubewell	7.5	400	270	110	936	2	2	0.5	0.2	100	0	0.2
11	Baupur	30.11075	76.38177	Tubewell	8	370	130	110	732	2	0.3	1	0.5	100	0	0.2
12	Cheeka	30.02875	76.33693	Tubewell	8	330	200	30	672	2	0	0.5	0.5	75	0	0
13	Kangthali	29.96862	76.3512	Tubewell	8	550	220	20	948	2	0	1	0.5	75	0	0
14	Malikpur	30.12894	76.23066	Tubewell	7.5	450	420	50	1104	0	0	0.5	0.5	100	0	0
15	Balbehra	30.03338	76.39411	Tubewell	8.5	570	400	30	1200	1	0	0.5	0.5	150	0	0
16	Bhagal	30.0588	76.41847	Tubewell	7.5	270	280	50	720	1.5	0	0.5	0.5	100	0	0
17	Arnoli	30.17489	76.40315	Tubewell	8	390	270	70	876	1.5	0	1	0.2	45	0	0
18	Peedal	29.99565	76.36029	Tubewell	9	430	270	80	936	1.5	0	0	0.5	75	0	0
19	Nagal	29.89185	76.27684	Tubewell	7	330	230	50	732	1.5	0	0	0.2	75	0	0
20	Sontha	29.92306	76.33577	Tubewell	7.5	290	240	50	696	1	0	0.5	0.5	75	0	0
21	Attela	29.84867	76.29293	Tubewell	8	370	270	70	852	1	0	0	0.5	100	0	0
22	Kasour	29.96419	76.2222	Tubewell	7.5	270	270	70	828	1.5	0	0	0.5	75	0	0
23	Andhli	29.90531	76.25165	Tubewell	7.5	260	200	70	624	1.5	0	0.5	0.5	75	0	0
24	Dohar	29.87388	76.4319	Tubewell	8	510	140	70	864	5	0	0.5	0.5	75	0	0
25	Rasulpur	29.92041	76.4155	Tubewell	7	290	70	70	480	1.5	0	0	0.2	75	0	0

26	Kheri Gulamali	29.88164	76.30083	Tubewell	7.5	420	340	70	996	2	0	0.5	0.2	75	0	0
27	Padla	29.80266	76.28128	Tubewell	7.5	370	570	380	1584	2	0.3	0.5	0.5	75	0	0
28	Budha Khera	29.83435	76.25236	Tubewell	8	570	400	50	1224	0.5	0	1	0.5	100	0	0
29	Titram	29.72043	76.40235	Tubewell	7.5	370	550	420	1340	1	0	0.5	0.2	100	0	0
30	Sangan	29.81144	76.22894	Tubewell	7.5	310	330	50	828	2	0	0.5	0.5	100	0	0.2
31	Deod Kheri	29.76101	76.44096	Tubewell	7	270	190	50	612	2	0	0.5	0.2	75	0	0
32	Sismore	29.7207	76.48488	Tubewell	7	350	260	150	912	1.5	0	0.5	0.5	100	0.5	0
33	Sajuma	29.73822	76.2584	Tubewell	8	420	340	100	1032	3	0	1	0.5	150	0	0
34	Nauch	29.93504	76.4458	Tubewell	8	400	400	90	1068	2	0	0.5	0.2	100	0	0
35	Titram Mod	29.73387	76.40363	Tubewell	8	400	260	90	900	2	0	0	0.5	100	0	0
36	Bhani Majra	29.79622	76.46212	Tubewell	7.5	300	100	60	552	1.5	0	0	0.5	75	0	0
37	Kithana (I)	29.53525	76.38503	Tubewell	8	400	370	490	1512	5	0	5	1.0	150	0	0.2
38	Kithana (ii)	29.55712	76.39981	Tubewell	6.5	340	50	60	540	3	0	0	1.0	100	0	0.2
39	Jakhauli	29.65868	76.43861	Tubewell	8	480	540	420	1725	5	0	1	1.0	100	0	0.2
40	Dudana (I)	29.52993	76.4767	Tubewell	8	530	650	300	1776	3	0	1	0.5	75	0	0.2
41	Dudana (ii)	29.52993	76.4767	Tubewell	8	550	400	200	1380	3	0	0.5	0.5	100	0	0
42	Rohera	29.56386	76.41762	Tubewell	7.5	280	120	140	648	3	0	0	1.0	100	0	0
43	Rajound	29.57551	76.48926	Tubewell	8	380	90	80	660	1.5	0	1	1.0	100	0	0.2
44	Kukarkanda	29.62532	76.51557	Tubewell	7	210	400	450	1272	3	0	1	0.5	100	0	0
45	Barsana	29.71078	76.59603	Tubewell	7.5	650	300	100	1224	1.5	0	0.5	0.5	75	0	0
46	Bakal	29.63015	76.58091	Tubewell	7.5	410	270	130	972	3	0	0	0.2	100	0	0
47	Buchi	29.75846	76.6422	Tubewell	8	450	360	60	1044	0	0	0.5	0.5	100	0	0.2
48	Sirsal	29.69477	76.66947	Tubewell	9	520	340	110	1164	1.5	0	2	0.5	100	0	0.2
49	Pai	29.69989	76.52781	Tubewell	9	680	200	100	1176	5	0	0.5	0.5	100	0	0
50	Pundri	29.77195	76.58157	Tubewell	8	540	350	100	1188	1	0	0.5	0.5	75	0	0.2
51	Rashina (Ahmedpur)	29.76204	76.65521	Tubewell	8	310	230	50	708	2	0	0.5	0.5	75	0	0
52	Bhana	29.66497	76.52564	Tubewell	9	240	250	190	816	2	0	0.5	0.5	100	0	0
53	Sakra	29.8124	76.68484	Tubewell	7.5	350	450	190	1028	0.5	0	0	0.5	100	0	0
54	Kaul	29.83569	76.6246	Tubewell	7.5	450	250	50	900	1.5	0	0	0.2	45	0	0
55	Kheri Matwa	29.8184	76.60165	Tubewell	7	220	250	30	600	1.2	0	0	0.5	100	0	0.2
56	Meoli	29.81701	76.5673	Tubewell	7.5	550	250	250	1260	1.5	0	0.5	0.5	100	0	0
57	Faral	29.83816	76.58477	Tubewell	7	230	270	30	636	1	0	0	0.5	75	0	0
58	Ahun	29.77973	76.67493	Tubewell	7.5	300	200	30	636	1.5	0	0.5	0.5	45	0	0
59	Dhand	29.87659	76.60654	Tubewell	7	200	130	50	456	0.5	0	0.5	0.5	75	0	0
60	Bandrana	29.87637	76.54446	Tubewell	7.5	650	350	150	1380	0.5	0	0.5	0.2	45	0	0
61	Dherdu	29.8278	76.64606	Tubewell	8.5	350	350	50	900	3	0	0	0.2	45	0	0
62	Sangroli	29.801	76.62802	Tubewell	8.5	550	250	70	1044	0.5	0	0				

## MATERIALS AND METHODOLOGY

In the study area 62 groundwater samples were collected in the month of February 2019 in 250 ml plastic water bottle. Geo-coordinates of groundwater sample and location name were noted with the help of mobile GPS. All the 62 groundwater samples were analyzed using Field Water Testing Kit prepared by Tamilnadu Water Supply and Drainage Board, Chennai for twelve chemical parameters-pH, alkalinity, hardness, chloride, total dissolved solids (TDS), fluoride, iron, ammonia, nitrite, nitrate, phosphate and

residual chlorine (Table 1). Results of chemical analysis of groundwater samples were put in ArcGIS 10.4.1 software and inverse distance weighted (IDW) interpolation technique applied to get spatial scenario of each chemical parameter in the study area. Chemical analysis results were categorized in three desirable, permissible and non-potable drinking water class as per BIS drinking water standards (IS 10500:2012) (Table 2) and area under each drinking water class was calculated and prepared maps for each chemical parameter.

**Table 2: Drinking water parameters (BIS: 10500:2012).**

Sl. No.	Parameters	Potable		Non potable
		Desirable	Permissible	
1	pH	6.5-8.5	-	<6.5 and >8.5
2	Alkalinity	200	200-600	>600
3	Hardness	200	200-600	>600
4	Chloride	250	250-1000	>1000
5	TDS	500	500-2000	>2000
6	Fluoride	<1.0	1.0-1.5	>1.5
7	Iron	<0.3	-	>0.3
8	Ammonia	<0.5	-	>0.5
9	Nitrite	<0.1	-	>1.0
10	Nitrate	<45	-	>45
11	Phosphate	<1.0	-	>1.0
12	Residual Chlorine	0.2	0.2-1.0	>1.0

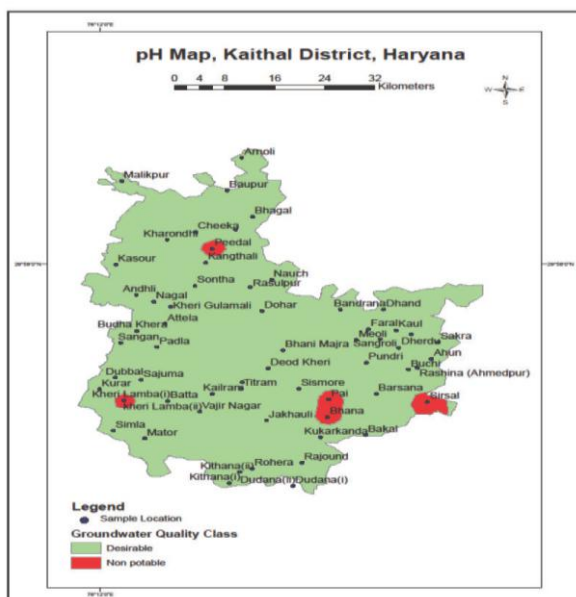
## RESULTS AND DISCUSSION

### i. pH

pH is desirable in 97.45% area and non-potable in 2.55% area (Table 3, Fig.2). As per BIS drinking water standards pH is desirable 6.5 to 8.5 and non-potable < 6.5 and > 8.5 (Table 2).

**Table 3: pH area covered under drinking water class in the study area.**

S. No.	pH Drinking Water Class	Area Covered (Km <sup>2</sup> )	Percentage of Total Area
1	Desirable	2257.88	97.45
2	Permissible	-	-
3	Non-Potable	59.12	2.55
	<b>Total</b>	<b>2317.00</b>	<b>100.00</b>

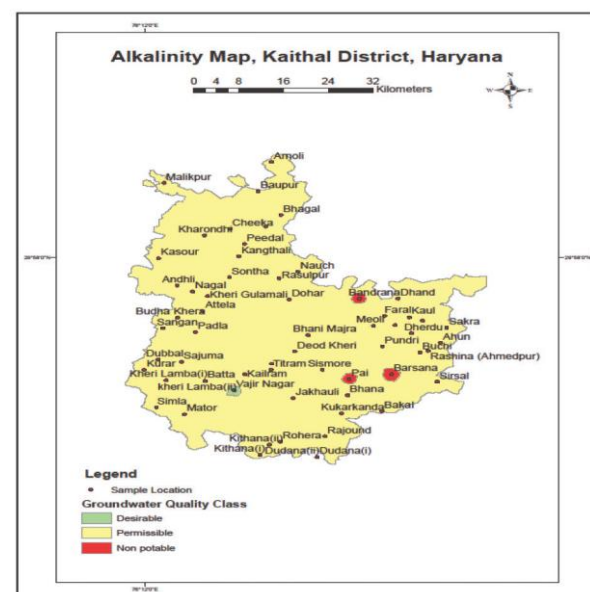
**Fig. 2: Spatial distribution of pH in the study area.**

### ii. Alkalinity

In the study area alkalinity is desirable in 0.18% area, permissible in 99.14% area and non-potable in 0.68% (Table 4, Fig.3). As per BIS drinking water standards alkalinity is desirable < 200 mg/l, permissible 200 mg/l - 600 mg/l and non-potable > 600 mg/l (Table 2).

**Table 4: Alkalinity area covered under drinking water class in the study area.**

S. No.	Alkalinity Drinking Water Class	Area Covered (Km <sup>2</sup> )	Percentage of Total Area
1	Desirable	4.17	0.18
2	Permissible	2296.93	99.14
3	Non-Potable	15.90	0.68
	<b>Total</b>	<b>2317.00</b>	<b>100.00</b>

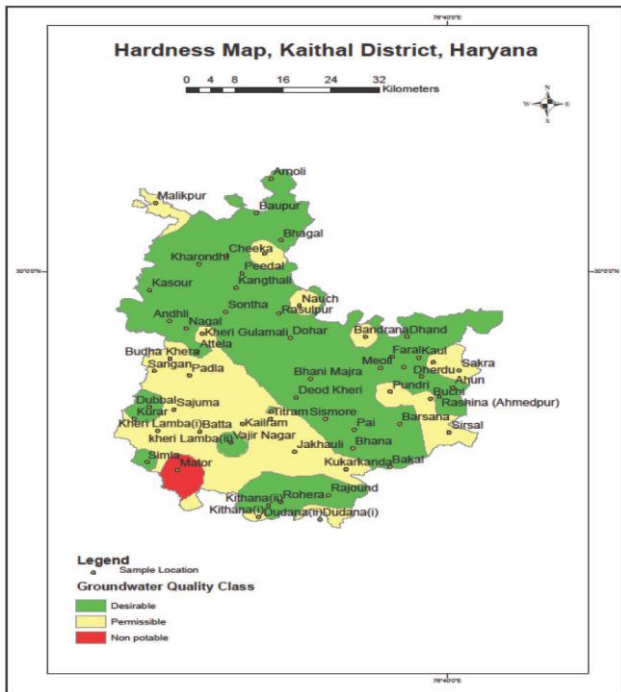
**Fig.3: Spatial distribution of alkalinity in the study area.**

**iii. Hardness**

Hardness is desirable in 63.15% area, permissible in 34.94% area and non-potable in 1.91% area (Table 5, Fig.4). As per BIS drinking water standards hardness is desirable < 200 mg/l, permissible 200 mg/l - 600 mg/l and non-potable > 600 mg/l (Table 2).

**Table 5: Hardness area covered under drinking water classes in the study area.**

S. No.	Hardness Drinking Water Class	Area Covered (Km <sup>2</sup> )	Percentage of Total Area
1	Desirable	1463.28	63.15
2	Permissible	809.45	34.94
3	Non-Potable	44.27	1.91
	<b>Total</b>	<b>2317.00</b>	<b>100.00</b>



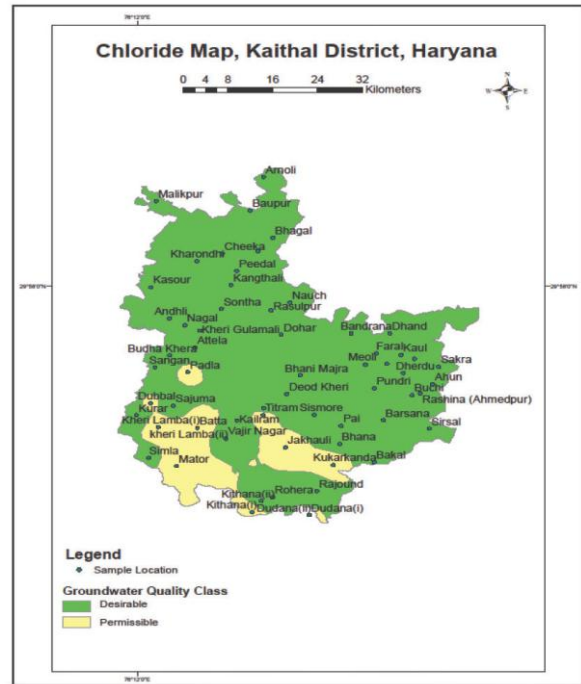
**Fig.4: Spatial distribution of hardness in the study area.**

**iv. Chloride**

Chloride is desirable in 85.32 % area and permissible in 14.68% area (Table 6, Fig.5). As per BIS drinking water standards chloride is desirable < 250 mg/l, permissible 250 mg/l - 1000 mg/l and non-potable >1000 mg/l (Table 2).

**Table 6: Chloride area covered under drinking water classes in the study area.**

S. No.	Chloride Drinking Water Class	Area Covered (Km <sup>2</sup> )	Percentage of Total Area
1	Desirable	1976.97	85.32
2	Permissible	339.93	14.68
3	Non-Potable	-	-
	<b>Total</b>	<b>2317.00</b>	<b>100.00</b>



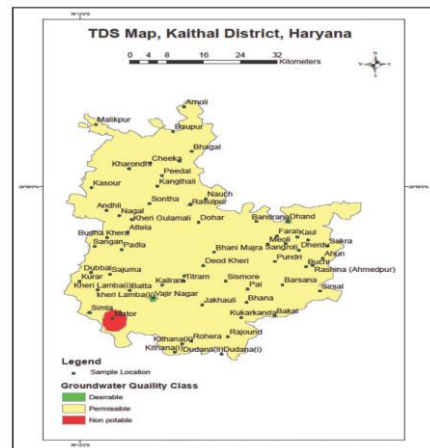
**Fig. 5: Spatial distribution of chloride in the study area.**

**v. Total Dissolved Solids**

Total dissolved solids (TDS) cover 0.15% area under desirable drinking water class, 98.83% area under permissible drinking water class and 1.02% area under non-potable drinking water class (Table 7, Fig.6). As per BIS drinking water standards TDS is desirable < 500 mg/l, permissible 500 mg/l -2000 mg/l and non-potable >2000 mg/l (Table 2).

**Table 7: TDS area covered under drinking water classes in the study area.**

S. No.	TDS Drinking Water Class	Area Covered (Km <sup>2</sup> )	Percentage of Total Area
1	Desirable	3.48	0.15
2	Permissible	2289.86	98.83
3	Non-Potable	23.66	1.02
	<b>Total</b>	<b>2317.00</b>	<b>100.00</b>



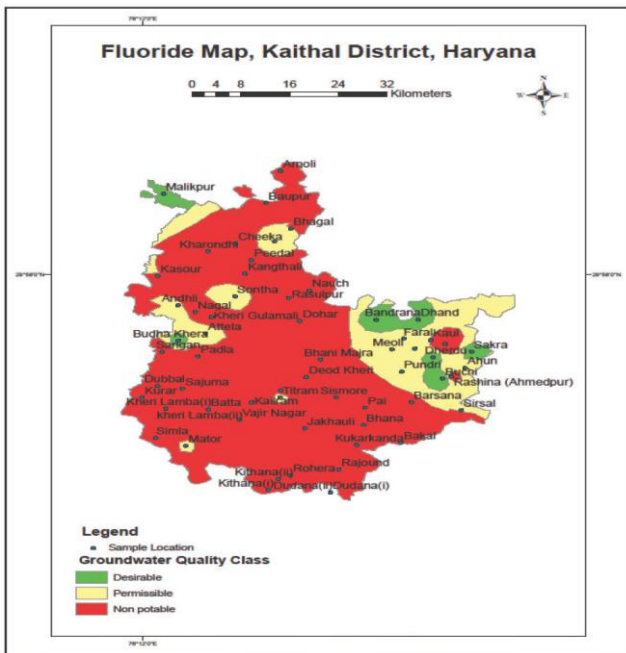
**Fig.6: Spatial distribution of TDS in the study area.**

**vi. Fluoride**

Fluoride covers 4.79% area under desirable drinking water class, 18.88% area under permissible drinking water class and 76.33% area under non-potable drinking water class (Table 8, Fig.7). As per BIS drinking water standards fluoride is desirable <1.0 mg/l, permissible 1.0 mg/l -1.5 mg/l and non-potable >1.5 mg/l (Table 2).

**Table 8 : Fluoride area covered under drinking water classes in the study area.**

S. No.	Fluoride Drinking Water Class	Area Covered (Km <sup>2</sup> )	Percentage of Total Area
1	Desirable	110.92	4.79
2	Permissible	437.49	18.88
3	Non-Potable	1768.59	76.33
	<b>Total</b>	<b>2317.00</b>	<b>100.00</b>



**Fig. 7: Spatial distribution of fluoride in the study area.**

**vii. Iron**

Iron is desirable in 94.48% area and non-potable in 5.52% area under drinking water class (Table 9, Fig.8). As per BIS drinking water standards iron is desirable < 0.3 mg/l and non-potable >0.3 mg/l (Table 2).

**Table 9: Iron area covered under drinking water classes in the study area.**

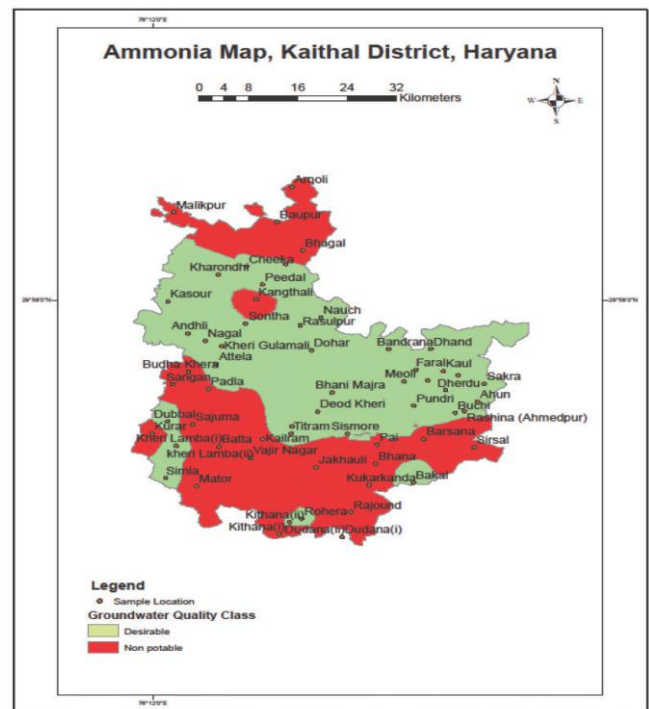
S. No.	Iron Drinking Water Class	Area Covered (Km <sup>2</sup> )	Percentage of Total Area
1	Desirable	2189.08	94.48
2	Permissible	-	-
3	Non-Potable	127.92	5.52
	<b>Total</b>	<b>2317.00</b>	<b>100.00</b>

**viii. Ammonia**

Ammonia covers 55.29% area under desirable drinking water class and 44.71% area under non-potable drinking water class (Table 10, Fig.9). As per BIS drinking water standards ammonia is desirable < 0.5 mg/l and non-potable > 0.5 mg/l (Table 2).

**Table 10: Ammonia area covered under drinking water classes in the study area.**

S. No.	Ammonia Drinking Water Class	Area Covered (Km <sup>2</sup> )	Percentage of Total Area
1	Desirable	1281.18	55.29
2	Permissible	-	-
3	Non-Potable	1035.82	44.71
	<b>Total</b>	<b>2317.00</b>	<b>100.00</b>



**Fig.9: Spatial distribution of ammonia in study area.**

**ix. Nitrite**

Nitrite covers 100% area under desirable drinking water class (Table 11, Fig.10). As per BIS drinking water standards nitrite is desirable <1.0 mg/l and non-potable >1.0 mg/l (Table 2).

**Table 11: Nitrite area covered under drinking water classes in study area.**

S. No.	Nitrite Drinking Water Class	Area Covered (Km <sup>2</sup> )	Percentage of Total Area
1	Desirable	2317.00	100.00
2	Permissible	-	-
3	Non-Potable	-	-
	<b>Total</b>	<b>2317.00</b>	<b>100.00</b>

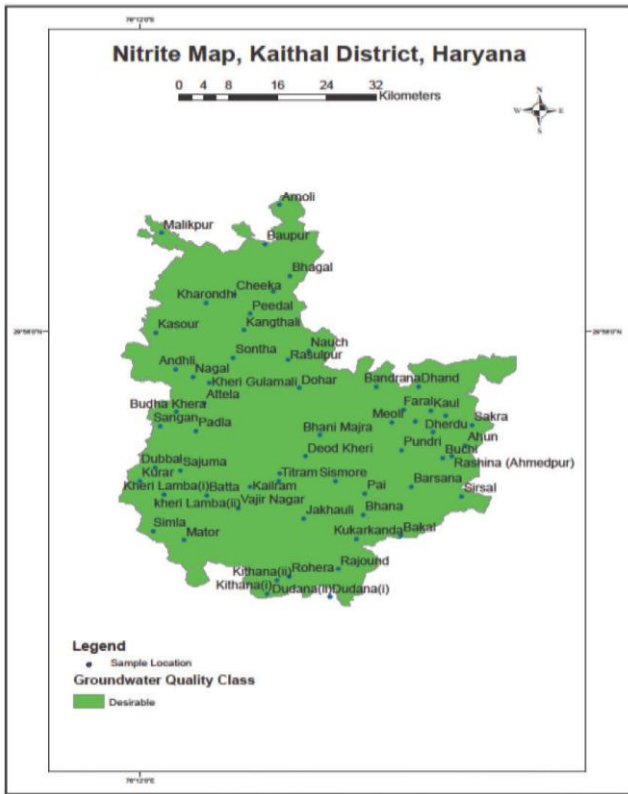


Fig.10: Spatial distribution of nitrite in the study area.

**x. Nitrate**

Nitrate covers 100% area under non-potable drinking water (Table 12, Fig.11). As per BIS drinking water standards nitrate is desirable <45 mg/l and non-potable >45 mg/l (Table 2).

Table 12: Nitrate area covered under drinking water classes in the study area.

S. No.	Nitrate Drinking Water Class	Area Covered (Km <sup>2</sup> )	Percentage of Total Area
1	Desirable	-	-
2	Permissible	-	-
3	Non-Potable	2317.00	100.00
	<b>Total</b>	<b>2317.00</b>	<b>100.00</b>

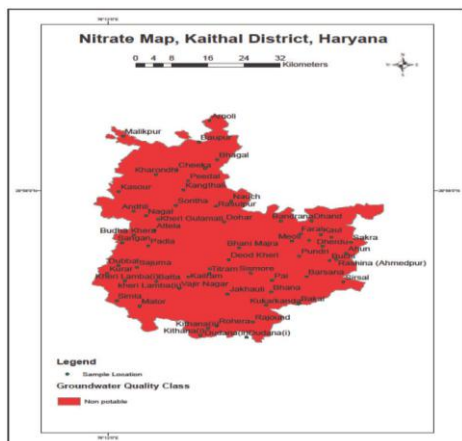


Fig. 11: Spatial distribution of nitrate in the study area.

**xi. Phosphate**

Phosphate covers 100% area under desirable drinking water class in the study area (Table 13, Fig.12). As per BIS drinking standards phosphate is desirable <1.0 mg/l and non-potable >1.0 mg/l (Table 2).

Table 13: Phosphate area covered under drinking water class in the study area.

S. No.	Phosphate Drinking Water Class	Area Covered (Km <sup>2</sup> )	Percentage of Total Area
1	Desirable	2317.00	100.00
2	Permissible	-	-
3	Non-Potable	-	-
	<b>Total</b>	<b>2317.00</b>	<b>100.00</b>

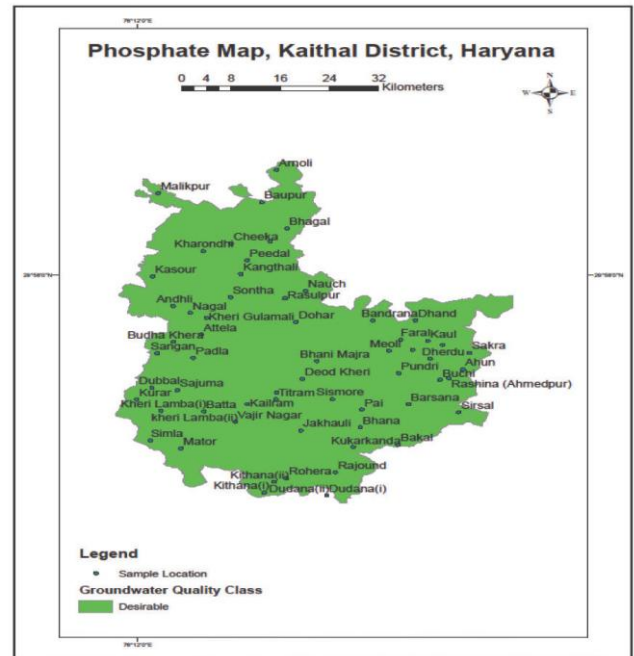


Fig.12: Spatial distribution of Phosphate in the study area.

**xii. Residual Chlorine**

Residual Chlorine covers 100% area under desirable drinking water class (Table 14, Fig.13). As per BIS drinking water standards residual chlorine is desirable < 0.2 mg/l, permissible 0.2 mg/l-1 mg/l and non-potable >1.0 mg/l (Table 2).

Table 14: Residual Chlorine area covered under drinking water classes in the study area.

S. No.	Residual Chlorine Drinking Water Class	Area Covered (Km <sup>2</sup> )	Percentage of Total Area
1	Desirable	-	-
2	Permissible	-	-
3	Non-Potable	2317.00	100.00
	<b>Total</b>	<b>2317.00</b>	<b>100.00</b>

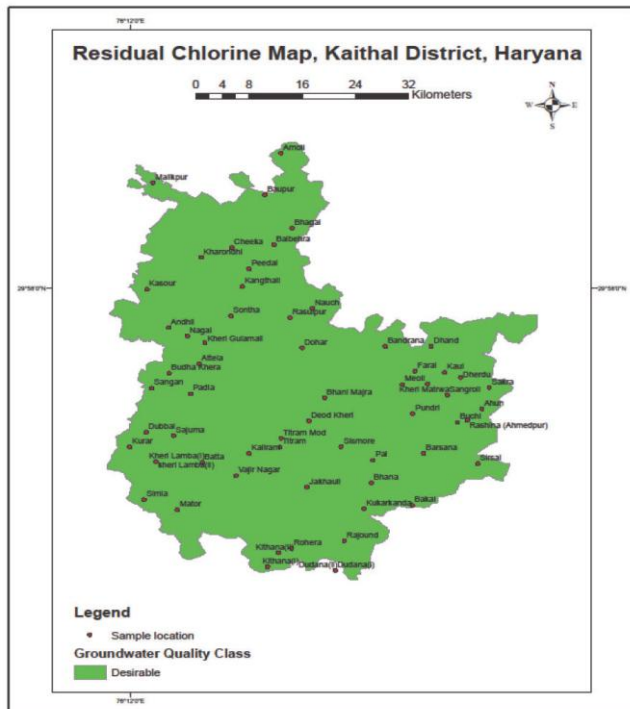


Fig. 13: Spatial distribution of Residual Chlorine in the study area.

## CONCLUSIONS

In the study area pH is desirable in 97.45% area and non-potable in 2.55% area, alkalinity is desirable in 0.18% area, permissible in 99.14% area and non-potable in 0.68% area, hardness is desirable in 63.15% area, permissible in 34.94% area and non-potable in 1.91% area, chloride is desirable in 85.32 % area and permissible in 14.68% area, total dissolved solids cover 0.15% area under desirable, 98.83% area under permissible and 1.02% area under non-potable drinking water class, fluoride is desirable in 4.79% area, permissible in 18.88% area and non-potable in 76.33% area, iron is desirable in 94.48% area and non-potable in 5.52% area, ammonia covers 55.29% area under desirable drinking water class and 44.71% area under non-potable drinking water class, nitrate covers 100% area under non-potable drinking water class and nitrite, phosphate and residual chlorine cover 100% area under desirable drinking water class in the study area. The study is highly useful for planning, monitoring and management of groundwater for drinking purpose in the study area.

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