PREVALENCE OF URANIUM IN GROUND WATER OF 54 VILLAGES OF ROHTAK DISTRICT OF HARYANA INDIA

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Why test for Uranium ?

Uranium doesn’t figure on the list of contaminants monitored under the **Bureau of Indian Standards**’ drinking water specifications.

'Cancer Train‘ Starts from Bhatinda in Punjab around 9.25 pm and covers a distance of about 325 km to reach Bikaner in the Indian state of Rajasthan. The most remarkable feature of this train is that 60% of its passengers are cancer patients of all ages who come from all parts of Punjab.

Gorakhpur Nuclear Power Plant or the Gorakhpur Haryana Anu Vidyut Pariyojana (GHAVP) is a proposed nuclear power plant to be built on a 560 hectares area west of Gorakhpur village of Fatehabad district of Haryana

International and National Stipulated Limits / Guideline values for Uranium in Drinking Water

Sl. No.	Country / Agency / Body	Limit / Guideline Value (µg/l / ppb)
1	**Atomic Energy Regulatory Board (AERB), India**	**60**
2	World Health Organisation (WHO, 2011)	30
3	United States Environmental Protection Agency (US EPA)	30
4	Germany (2001)	10
5	Russian Federation	15
6	Canada (Guidelines for Canadian Drinking Water Quality)	20
7	Australia (Australian Drinking Water Guidelines, 2011)	17
8	Czech Republic	15
9	Switzerland	30

Source of Uranium in Groundwater

- Due to natural erosion and weathering process, uranium mobilized from the rocks to groundwater and surface water.
- Chemical parameters such pH, EC Temp., CO_2, HCO_3-, O_2, ligands, etc. are the conducive conditions for leaching of uranium from the host rock to the groundwater.
- Under reducing condition, U exists as +4 and get precipitated (sandstone type deposit) and under oxidising condition, uranium get oxidised to +6 state and combine with oxygen to form UO_2^+ which is stable and highly mobile.
- Uranium forms different species depending on the pH, E C and ligands such as carbonates, phosphates, vanadates, fluorides, sulphates and silicates present in water
- U(VI) forms different species in an aqueous system. E.g. in a U(VI)-water system,, the dominant species were UO_2^{2+} at pH <5, in the pH range of 5-9, $UO_2(OH)_{2(aq)}$ becomes dominant and pH value above 9, $UO_2(OH)_3^-$ becomes predominating species.
- In more complex chemical system (natural waters), in anoxic condition at pH 6, 7.5 and 8, U(IV) exist as $U(CO_3)_4^{4-}$, U_4O_9 and UO_2, respectively. In oxic water at pH 9.2, $UO_2(CO_3)_3^{4-}$ becomes the predominating species.

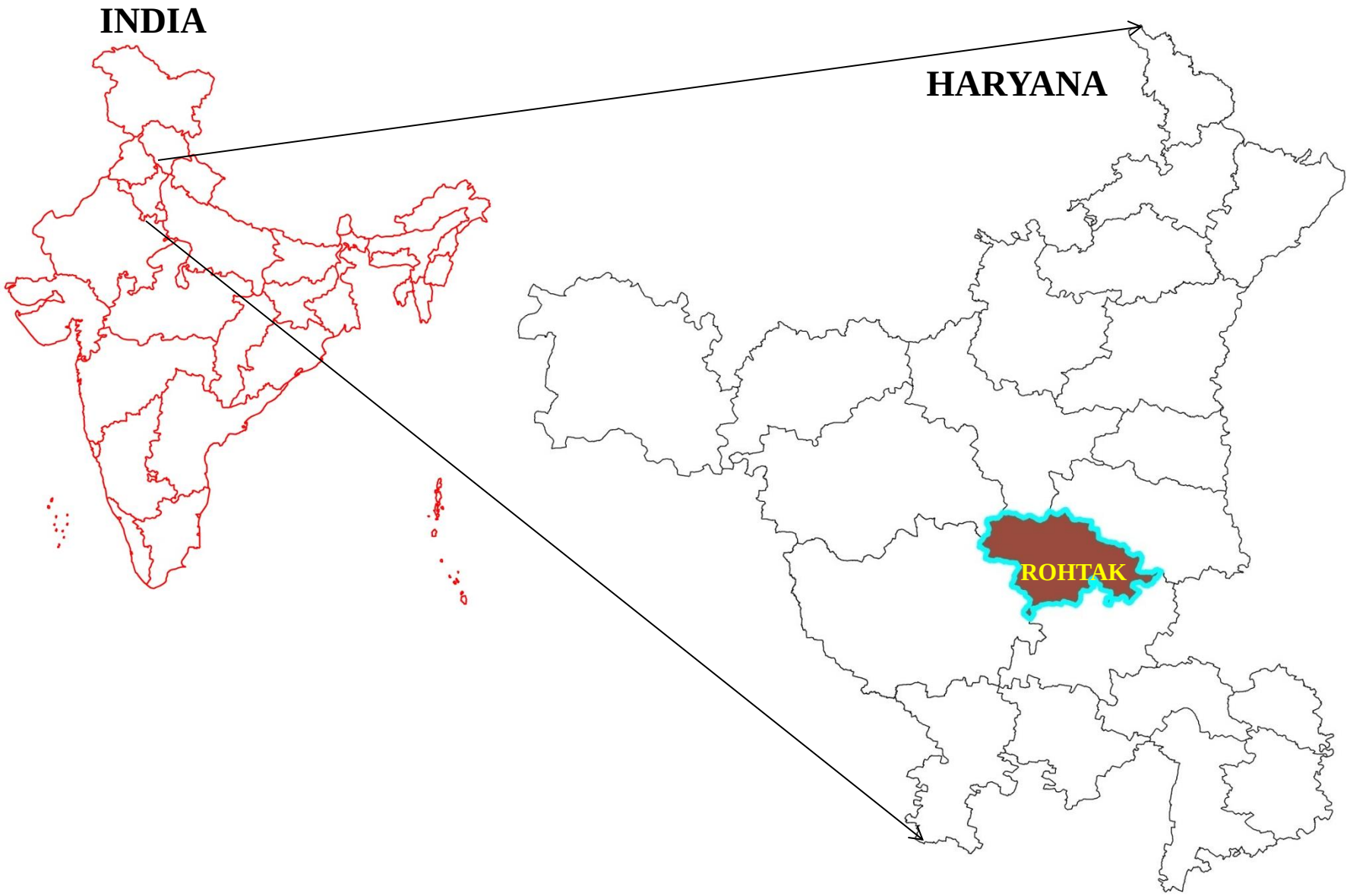
Ref. Wanner & Forest, 1992, Kumar et al., 2011

Health Effects of Uranium

- Uranium is a health hazard only if it is taken into the body as it is an alpha emitter.
- External exposure is generally not a major concern because uranium emits only a small amount of low-energy gamma radiation.
- Primary means of exposure are ingestion of food and water containing uranium isotopes and inhalation of uranium-contaminated dust. Inhalation component is insignificant as the U air activity concentration is very low.

- Major health concern is kidney damage caused by the chemical toxicity of soluble uranium compounds. Uranium is a well known nephrotoxic element.
- Specific activity of uranium found in nature is very small as compared to other natural radionuclides. Therefore, the chemical toxicity supercedes the radiological effect.
- When the pH value is below the normal pH level (~7.3) in kidney, the dissolved uranyl-carbonate complexes decompose in acidic environment to uranyl $(UO_2)^{2+}$ and bicarbonate $(HCO_3)^-$ ions. Uranyl ions depress glomerular function (filtration action), therefore proteinuria or albuminuria is the result.

Map of study area showing Rohtak district of Harayana



STUDY AREA

Rohtak District lies in South-East of Haryana.

PHYSIOGRAPHY-

Climate –

Sub-tropical, Semi-arid, continental and monsoon type.

Rainfall-

Normal annual rainfall- 592 mm.
Normal monsoon rainfall- 499 mm.

Wind velocity –

Maximum in May and June (8-11 km/hr).

Temperature-

Mean maximum- 40 to 50^0c (May & June).
Mean minimum- 7°c (Jan).
Mean annual temperature range- 23°C to 26°C

Total geographical area –

1745 Sq.Km.

Soil- Sandy, Sandy loam

Source- Nina Singh, 2012.http://www.mcrohtak.gov .in/location.htm

Sampling- Grid sampling, grid size 6x6 km,

one sample from each grid

Sampling location- One village in each grid

Sources- Well, hand pump, tube well

Sampling frequency- Pre and post monsoon

Readings taken at each site

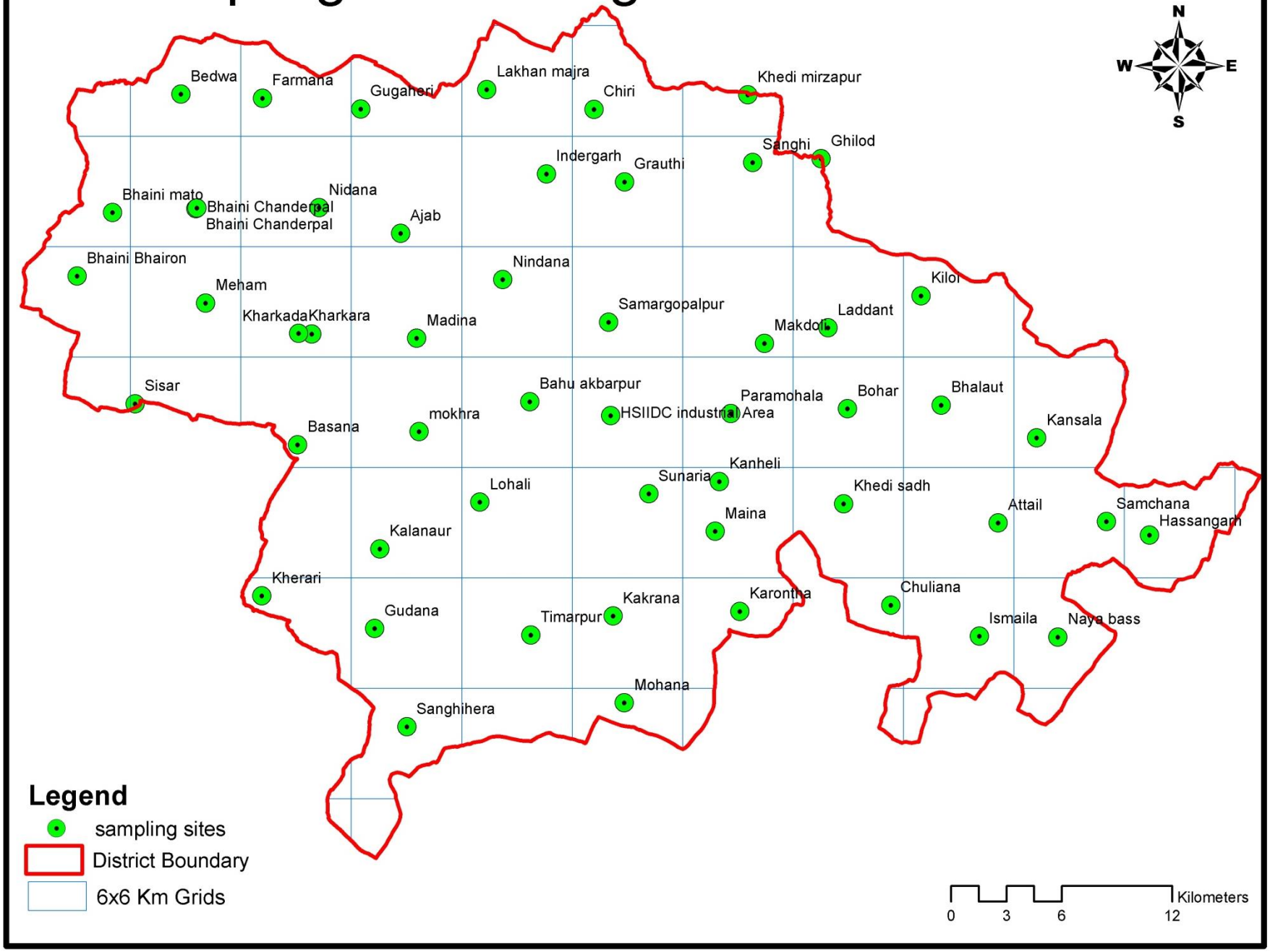
GPS readings

Gama radiation

Insitu water testing for

pH, nitrate, EC, temp

Sampling sites and grids of Rohtak District



Uranium analysis in water samples

Filtration - 0.22 micron nylon syringe filter

Instrument - Pulsed LED fluorimeter

Make – Quantalase Enterprises Pvt. Ltd., India

Model- LF 2

Led bank -400nm

Detector- Photo multiplier tube Green fluorescence

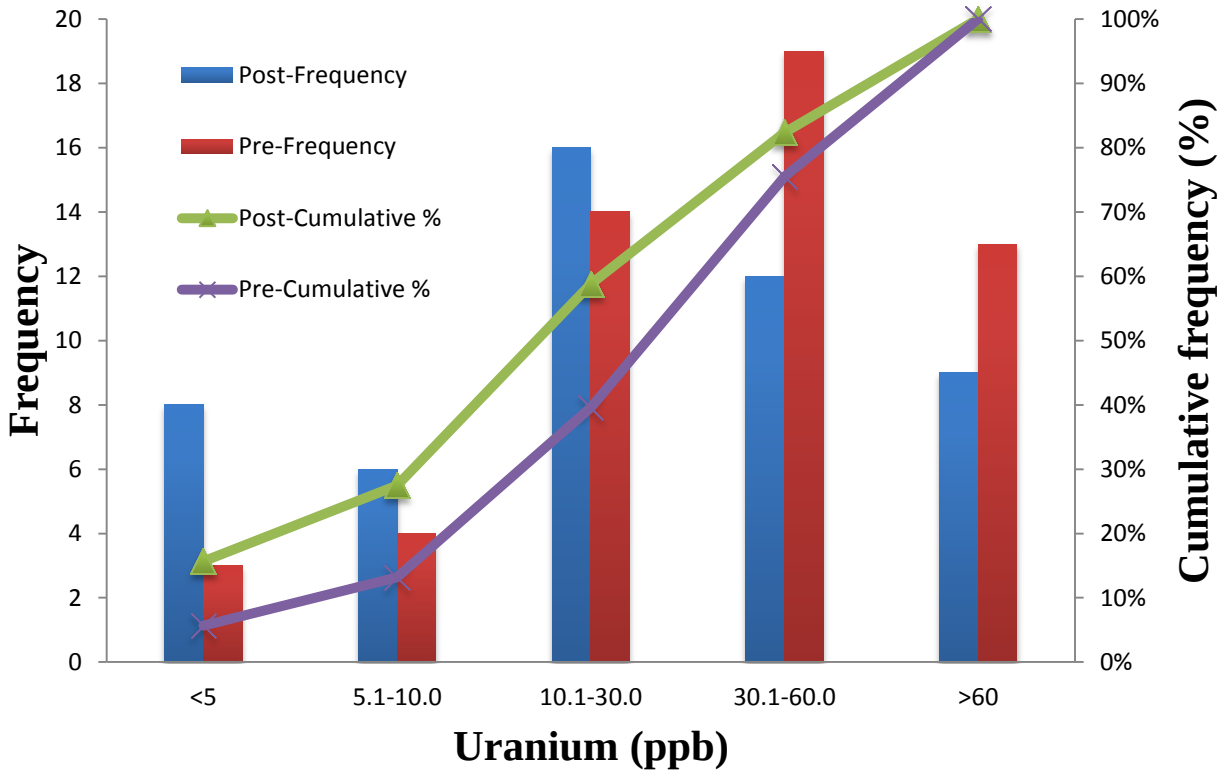
On/off synchronised with LED pulsing.

Minimum detection limit – 0.1 ppb

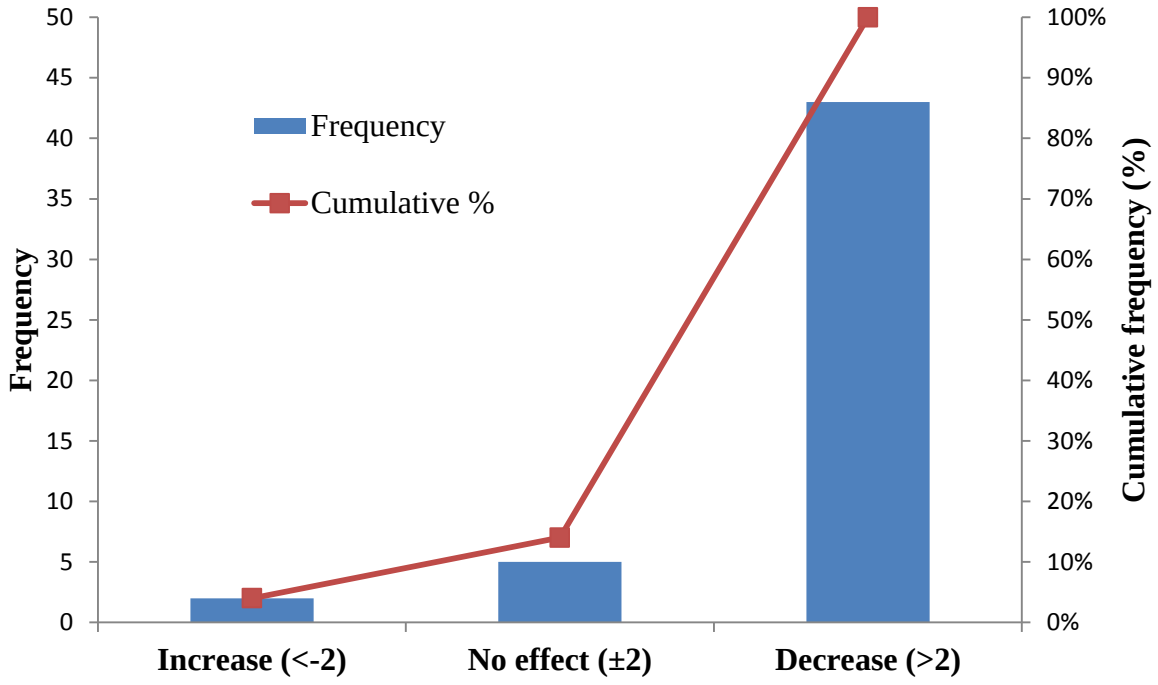
Physico-chemical parameters of groundwater of Rohtak district of Harayana

Water quality parameters	WHO/ BIS/ AERB*		Pre-monsoon			Post-monsoon			% exceeding MAL (Uranium above AERB limit)	
	Most Desirable	Max. allowable limit (MAL)	Range	Median	Mean	Range	Median	Mean	Pre-monsoon	Post-monsoon
pH	6.5-8.5	9.2	5.9-7.9	7.2	7.2	7.0-7.9	7.3	7.4	-	-
TDS (mg/L)	600	1000	162-7208	1352	1839	132-5585	937	1289	50	45
EC (µS/cm)	-	1500	323-14416	2704	3679	254-11147	1968	2616	74	57
TH (mg/L)	300	600	18.2-2765	57.9	240	15.5-1426	57.4	162.6	12	8
Calcium (mg/L)	75	200	12.9-83.9	40.6	41.3	7.6-747.7	44.3	83.2	-	8
Magnesium (mg/L)	50	150	0-2721	8.1	198.9	0.13-919.7	14.2	79.4	16	9
Bicarbonate (mg/L)	-	300	12.5-96	46.5	46.4	9.1-289.6	39.3	57.3	-	-
Chloride (mg/L)	250	1000	51.1-11542	384.3	829.1	38.1-4346	206.3	395.6	16	6
Sulphate (mg/L)	150	400	1-3748	147.7	433.6	2.8-1470	96.2	223.8	32	21
Phosphate (mg/L)	-	-	0.1-0.19	0.08	0.08	0.1-41	<0.1	1.5	-	-
Nitrate (mg/L)	45	-	0.5-57.8	3.6	8.8	0.5-43.2	2.1	6.45	2	-
Fluoride (mg/L)	1.2	1.5	0.14-2.5	1.31	1.26	0.12-9.97	0.85	0.96	34	4
U (µg/L)	-	30/60*	1.9-236	33	53	1.7-199	21	39	24	17

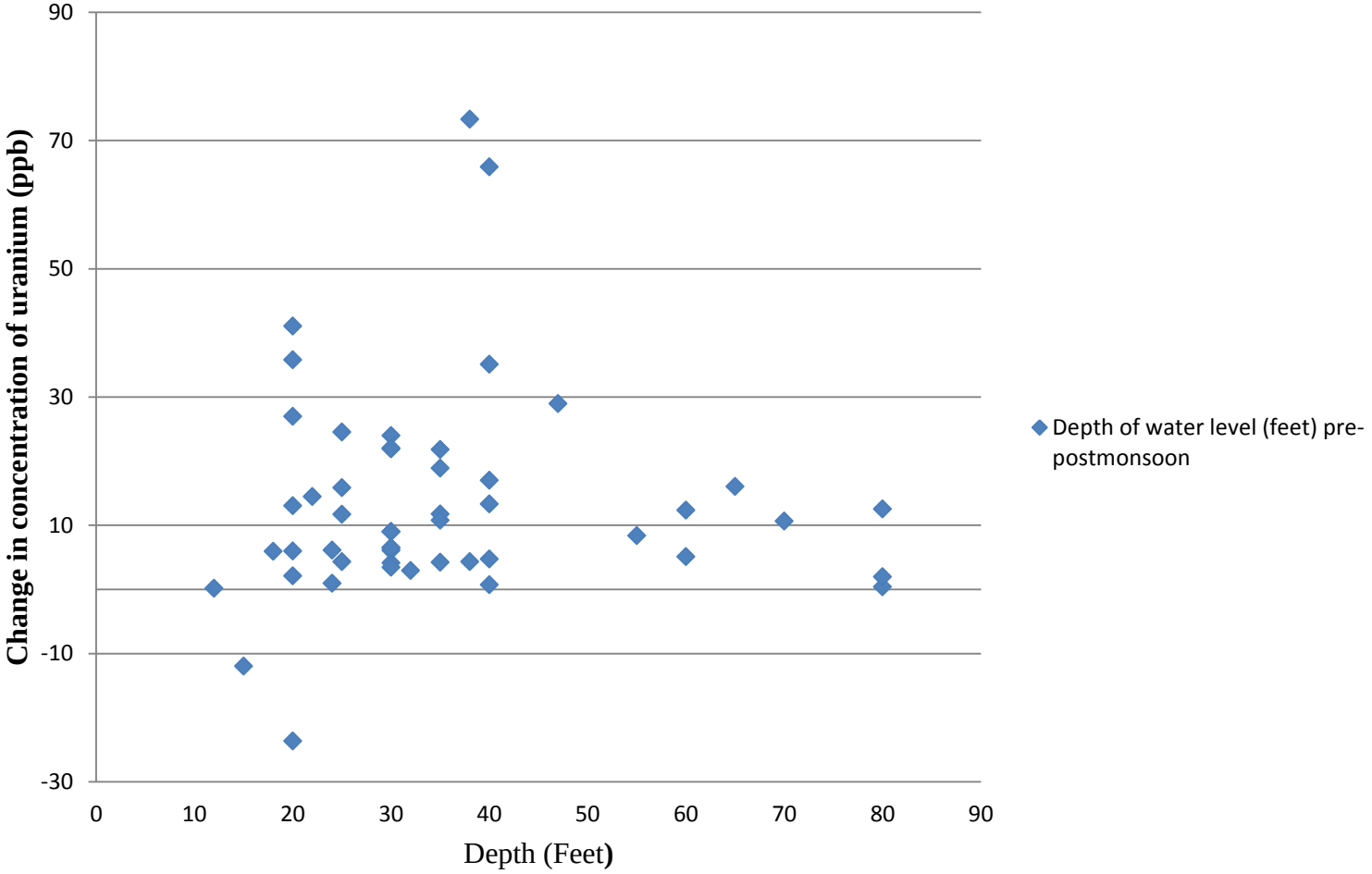
Histogram of frequency distribution uranium concentration in Pre and Post- monsoon of Rohtak district of Haryana.

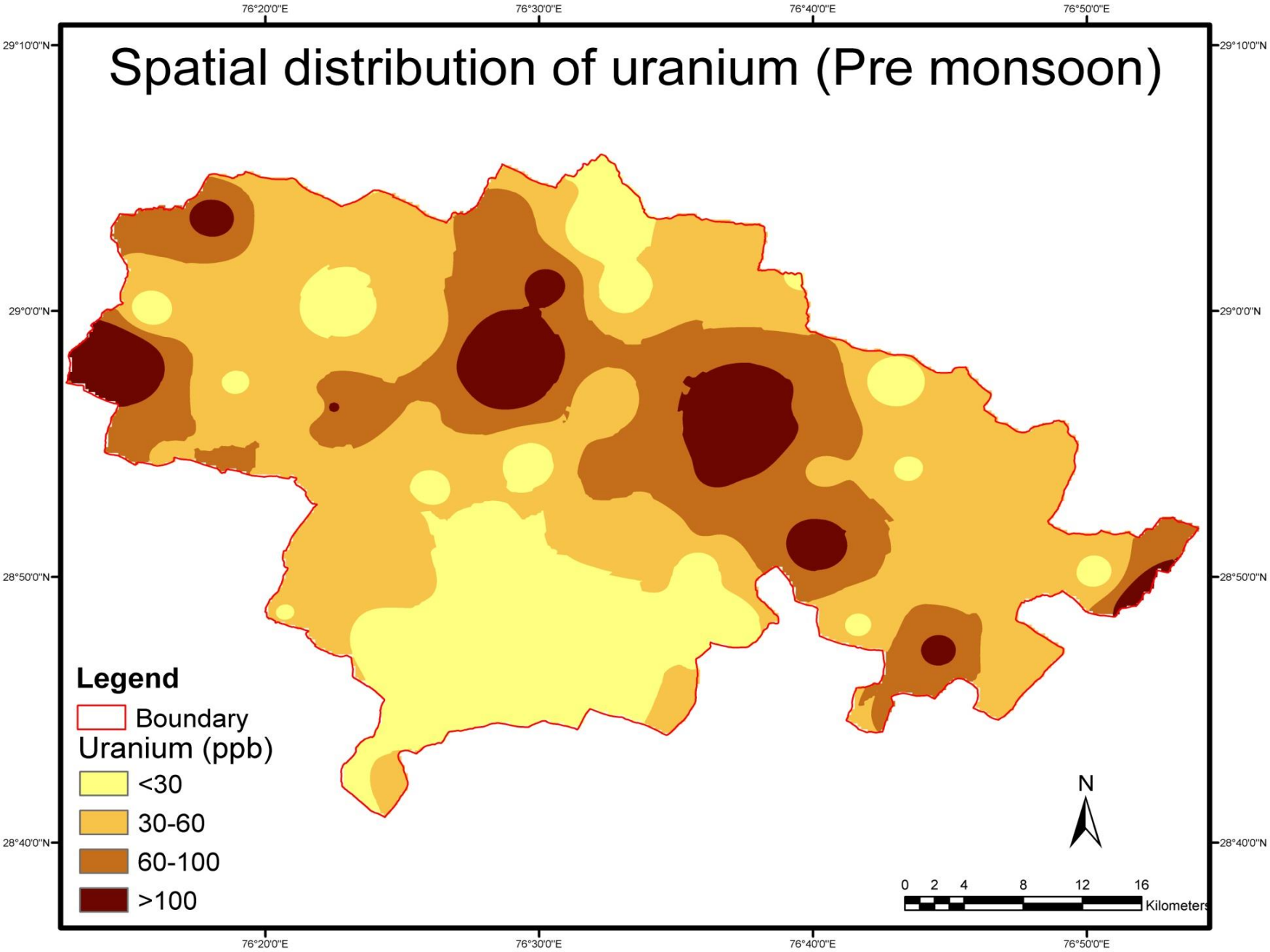


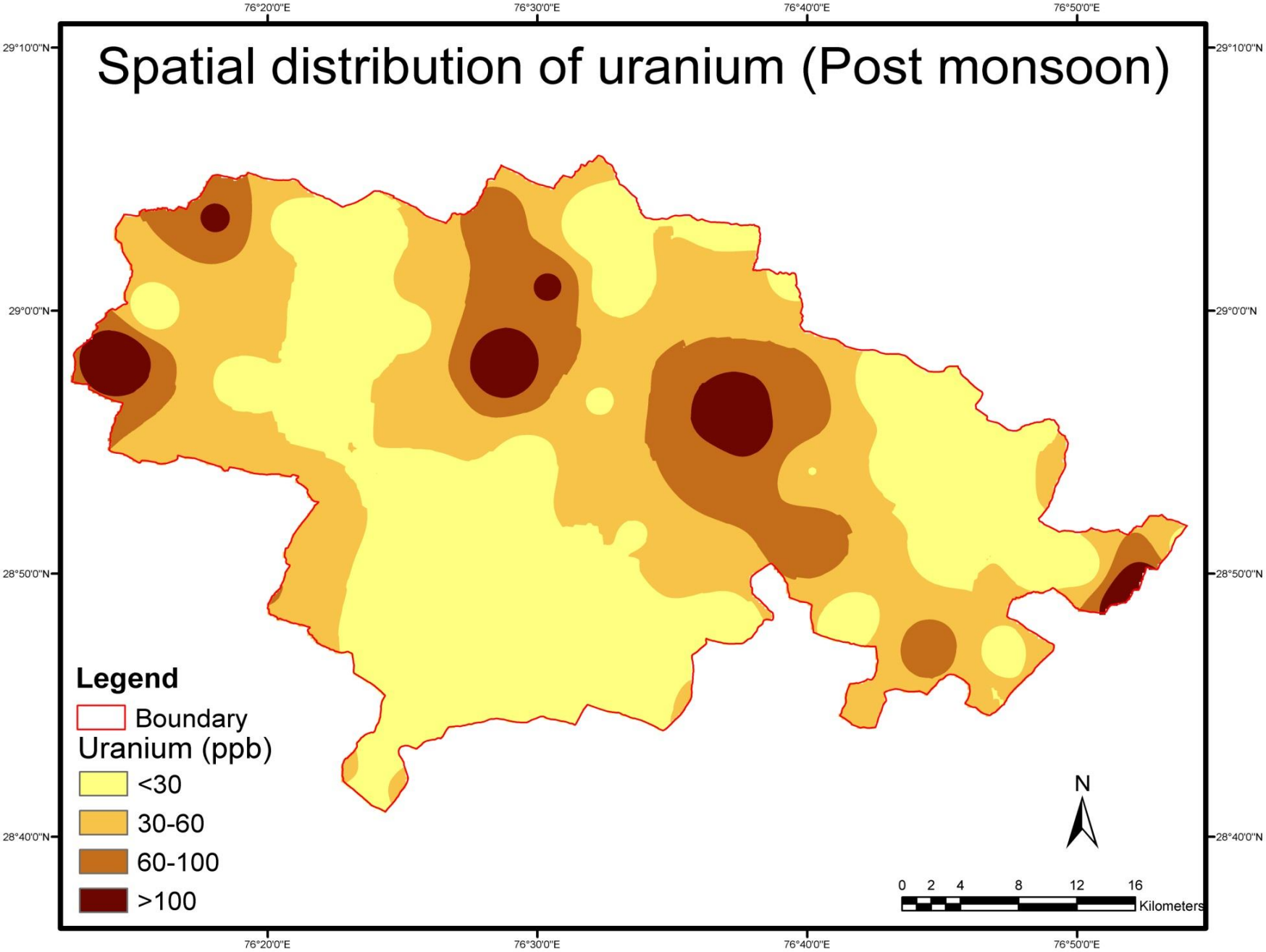
Difference in pre and post monsoon uranium concentration with depth of water table.



Depth of water level (feet) pre-post monsoon

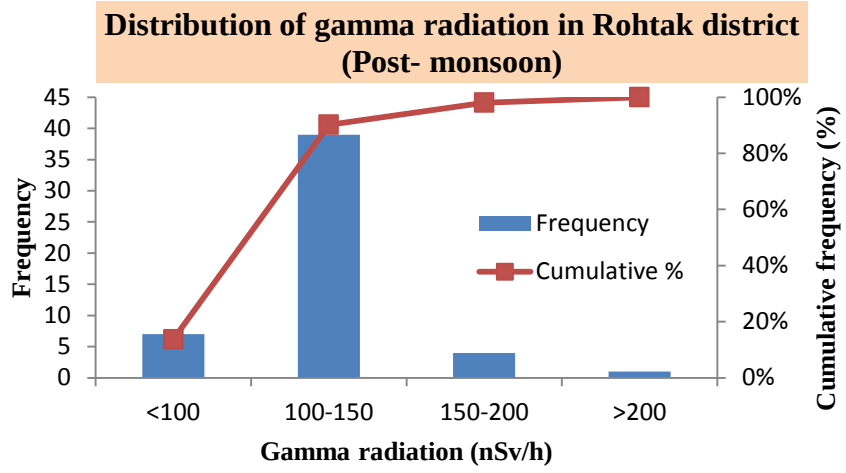


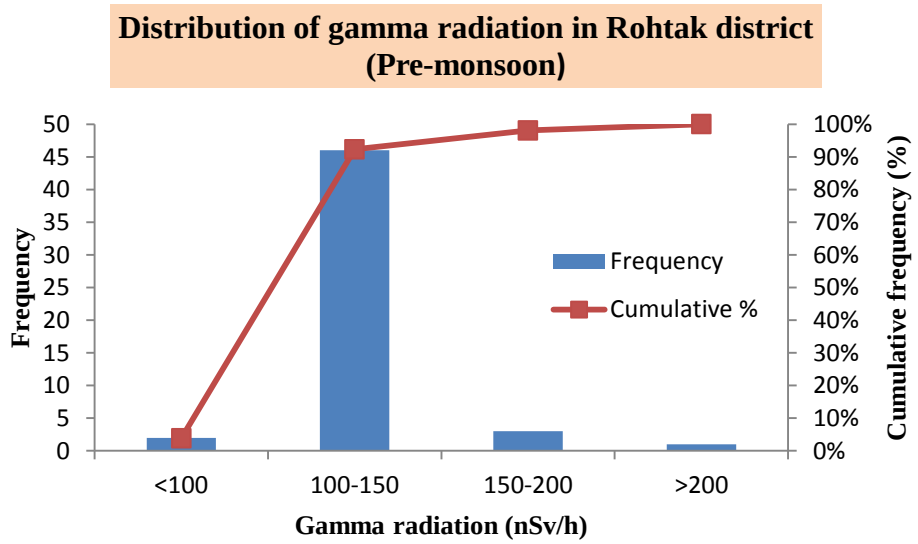

Spatial distribution of uranium (Pre monsoon)
76°20'0"E
76°30'0"E
76°40'0"E
76°50'0"E
29°10'0"N
29°0'0"N
28°50'0"N
28°40'0"N
Legend
Boundary
Uranium (ppb)
<30
30-60
60-100
>100
N
0 2 4 8 12 16
Kilometers


Spatial distribution of uranium (Post monsoon)
76°20'0"E
76°30'0"E
76°40'0"E
76°50'0"E
29°10'0"N
29°0'0"N
28°50'0"N
28°40'0"N
Legend
Boundary
Uranium (ppb)
<30
30-60
60-100
>100
N
0 2 4 8 12 16
Kilometers

CORRELATION URANIUM WITH OTHER PARAMENTERS

	pH	TDS (ppm)	EC (µS/cm)	ORP (mV)	Temp. (oC)	Salinity (ppm)	DO (ppm)	Fluride (ppm)	Chloride (ppm)	Nitrate (mg/l)	Sulphate (mg/L)	Phosphate (mg/l)	Uranium (ppb)
pH	1												
TDS (ppm)	-0.428	1											
EC (µS/cm)	-0.434	0.998	1										
ORP (mV)	-0.183	-0.199	-0.188	1									
Temp. (oC)	-0.116	0.167	0.172	-0.114	1								
Salinity (ppm)	-0.434	0.998	0.999	-0.188	0.173	1							
DO (ppm)	-0.027	-0.090	-0.100	-0.137	0.061	-0.099	1						
Floride (ppm)	0.044	-0.044	-0.043	0.217	-0.076	-0.043	-0.206	1					
Chloride(ppm)	-0.347	0.870	0.870	0.007	0.165	0.870	-0.100	0.014	1				
Nitrate(mg/l)	-0.103	0.281	0.277	0.019	-0.047	0.277	0.135	0.027	0.118	1			
Sulphate (mg/L)	-0.283	0.707	0.704	0.076	0.099	0.704	-0.176	0.018	0.748	0.202	1		
Phosphate (mg/l)	-0.091	-0.100	-0.102	0.171	-0.174	-0.102	-0.113	0.021	-0.052	-0.077	-0.068	1	
Uranium (ppb)	-0.170	0.390	0.386	-0.028	-0.076	0.386	-0.257	-0.089	0.466	-0.064	0.348	0.283	1


Distribution of gamma radiation in Rohtak district (Post- monsoon)
Frequency
Cumulative frequency (%)
Frequency
Cumulative %
45
40
35
30
25
20
15
10
5
0
100%
80%
60%
40%
20%
0%
<100
100-150
150-200
>200
Gamma radiation (nSv/h)


Distribution of gamma radiation in Rohtak district (Pre-monsoon)
Frequency
Cumulative frequency (%)
Frequency
Cumulative %
50
45
40
35
30
25
20
15
10
5
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
<100
100-150
150-200
>200
Gamma radiation (nSv/h)

THANK YOU