Research Article

Distribution of naturally occurring uranium and other heavy toxic elements in selected spring water samples of Pithoragarh District, Uttarakhand, India

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Abstract
The main purpose of this study was to investigate the seasonal variation of the uranium (U) concentration level in natural drinking water. Laser fluorimetry technique has been used for the microanalysis of uranium concentration in water samples collected from different natural sources like springs and subterranean springs of various depths. A total of 23 drinking water samples were collected based on their consumption for drinking purposes from the different areas of Pithoragarh district. Seventeen physico- chemical parameters, six heavy metals and uranium were estimated in the samples. The results showed that the average value of TDS was observed 204.65 mg/L during pre- monsoon season and 213.82 mg/L during post- monsoon season, the uranium concentration in drinking water samples varied from 0.10–9.90 µg L^{-1} in pre-monsoon and 0.10–8.32 µg L^{-1} in post-monsoon seasons. The study revealed that none of the samples had exceeded the guideline values prescribed for concentration of uranium in drinking water by World Health Organization (30 µg L^{-1}) and sources can be considered safe with respect to the level of uranium concentration.

Keywords Uranium concentration · Laser fluorimetry · Natural drinking water · Heavy metals

1 Introduction

Water is a vital component for the survival of life and is a universal solvent that can dissolve many organic and inorganic compounds [1]. The availability of clean and safe drinking water is a basic right of humans, but in the present scenario clean and safe drinking water is in scarcity. Water is an important element for life and has multiple uses especially for drinking purposes. Therefore, clean and safe drinking water is a vital commodity required for humans. Springwater is a common source of public supply in various rural communities [2]. In hills, spring water is frequently used for drinking purposes, therefore, the quality of spring water assumes the highest priority.

Human beings are exposed to natural radioactivity since the inception of the earth which is due to the presence of naturally occurring radionuclides in the surroundings. Exposure to radiation due to natural sources is a continuous and inescapable feature of life on earth [3]. Uranium is one of the radionuclides which is omnipresent and is widely available in the earth's crust. These radionuclides get introduced into the human body through food, water, and air. Uranium is present in rocks and soil and when water passes through and over these formations, it dissolves many compounds and minerals including uranium [4]. Most of the natural water sources contain a detectable concentration of uranium in the soluble or particulate form [5]. Uranium is radiologically toxic as well as chemically toxic and the level of toxicity depends

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upon the concentration, exposure route, chemical nature, exposure period, the solubility of a uranium compound, contact time, and route of elimination from the body [6]. The chronic presence of uranium at higher concentrations in drinking water can cause severe health effects because of its non- biodegradable nature. Uranium congregates in vital human organs and results in toxicity. Along with this, uranium emits alpha particles of high ionizing power, so it may be toxic if inhaled or ingested in excess amount. Eighty five percent of ingested uranium is contributed through drinking water and only 15% is contributed through food [7]. Uranium is a well-known nephrotoxic element and the principal sites of its deposition in the body are the kidney, liver, and bones. Moreover, experimental studies show that the toxic effect of uranium is found on the respiratory and reproductive systems also [8, 9]. Due to all these health hazards, the estimation of uranium in drinking water becomes very important. WHO guidelines have recommended a value of 30 µg/L (chemically) and Atomic Energy Regulatory Board (AERB), Department of Atomic Energy, India has recommended a value of 60 µg/L (radiologically) for the uranium concentration in drinking water [10, 11].

Uranium diffuses readily in oxygenated water due to which uranium is present in most of the surface, underground, and seawater. Studies have shown that weathering of igneous rocks from the earth's original crust results in a higher level of dissolved uranium concentration in comparison to other rock formations [12]. Along with this, combustion of coals, the use of phosphate fertilizers and effluents from the uranium industry are also responsible for the introduction of uranium in the water body [12]. Uranium exists in +4 oxidation state in primary igneous rocks, which further oxidize to +5 and +6 oxidation state. In +6 oxidation state, it is highly stable and soluble in water, while almost all compounds of uranium in +4 oxidation state are relatively insoluble in water. Uranium in +6 oxidation state forms uranyl UO_2^{+2} ions. This ion plays a very important role in transporting uranium through the weathering of rocks [13, 14]. In the last few years, several studies have been undertaken in various states of India including Mansa district of Punjab; Balod district of Chattisgarh; Amritsar, Gurdaspur, and Pathankot districts of Punjab and Kanker district of Chattisgarh for the assessment of uranium concentration in groundwater and varied results were obtained from the studies [15–18].

Springwater is the prime source providing and regulating life at hills and being used as the main source of fresh drinking water at Uttarakhand. Various natural water sources like snow, spring, rain-fed rivers, lakes are a profound source of water in Uttarakhand [19]. Spring is a concentrated discharge of groundwater appearing at the ground surface as a current of flowing water. And when the ground surface intersects the water supply, the springs are formed [20]. Water pollution not only affects water quality but also harms human health, economic development, social structure, etc. During the evaluation of water quality, it also becomes very essential to evaluate the physico-chemical parameters to collect the very first information regarding the potability of water.

Keeping in view, all the health effects caused due to different pollutants in water and toxicity due to uranium, the present research work has been done to evaluate the water quality of the samples. A total of 24 parameters was evaluated in the water samples collected from various regions of Pithoragarh district, which includes physico-chemical properties, uranium concentration as well as detection of the concentration of some other heavy metals. To the best of our knowledge, such type of study has not been conducted earlier in this region specifically for natural water sources only, so this baseline data will serve as reference information to assess any further changes in the concentration of uranium radionuclide as well as other parameters for future studies.

2 Materials and methods

2.1 Geology of the study area

The selected study region of Pithoragarh district covers the area between latitude 29.52–30.11° and longitude 80.04–80.62°. It was situated in elevation of < 1150 m–2300 m. Generally, the major sources of uranium are rocks, combustion of coals, use of phosphate fertilizers, effluents from the uranium industry but in the present study area, the only possible source of uranium can be rocks. The major rock types of the area are igneous, metamorphic, and sedimentary. Out of 23 sampling sites, 4 sites belong to an igneous type of rocks, 10 sites having metamorphic types of rocks, and 9 sites having sedimentary types of rocks. The district is distributed in six tehsils viz., Dharchula, Berinag, Munsyari, Pithoragarh, Gangolihat, and Didihat. The lands in the surroundings of the study area are being used for agricultural purposes throughout the year. The map of the study region and the major rock types of the surroundings of the study area are represented in Table 1 and Fig. 1.

2.2 Experimental techniques

The samples were collected in clean double capped polypropylene 250 mL bottles. 23 samples were collected from various springs and subterranean springs of various depths. The samples were collected in pre-monsoon (PRM) and post-monsoon (POM) seasons. For PRM, the sampling

Table 1 Sampling sites with geological information

Tehsil (T)	Location details	GPS Coordinate (WGS 84, decimal)		
		Latitude	Longitude	Type of rocks
Dharchula (T)	Khet	29.99544	80.56699	Igneous
Dharchula (T)	Baluwakot	29.80225	80.43023	Metamorphic
Dharchula (T)	Pangu	29.98328	80.61628	Sedimentary
Didihat (T)	Borabunga	29.76568	80.21696	Igneous, Plutonic
Didihat (T)	Chana	29.752	80.23682	Metamorphic
Didihat (T)	Tana/ Dugda	29.71035	80.20463	Sedimentary Carbonate
Didihat (T)	Askot	29.76511	80.3313	Igneous
Didihat (T)	Suni	29.74158	80.13281	Metamorphic
Didihat (T)	Sadgad	29.66131	80.27119	Sedimentary Carbonate
Didihat (T)	Tarigaon	29.79071	80.1373	Metamorphic
Berinag (T)	Kotgadi	29.86904	80.07238	Metamorphic
Berinag (T)	Sheridhara/Chormania	29.72466	80.07655	Metamorphic
Munsyari (T)	TallaDhumar	30.10648	80.2506	Metamorphic
Munsyari (T)	Munsyari	30.06572	80.23782	Metamorphic
Munsyari (T)	Birthi	30.03971	80.16334	Metamorphic
Munsyari (T)	Timtia	29.93738	80.14392	Sedimentary Carbonate
Munsyari (T)	Selmali	29.95611	80.24926	Igneous
Pithoragarh (T)	Gethigada(Taleshwar)	29.60914	80.40656	Sedimentary
Pithoragarh (T)	Katiyani	29.60482	80.35062	Sedimentary
Pithoragarh (T)	Mad-Saun	29.52389	80.30561	Sedimentary
Gangolihat (T)	Dubola	29.52303	80.09117	Metamorphic
Gangolihat (T)	Jadapani	29.71321	80.03857	Sedimentary Carbonate
Gangolihat (T)	JahnaviNaula	29.6564	80.04267	Sedimentary Carbonate

was done from April- June 2018 and for POM, the sampling was done from September- November 2017. Samples were stored at 4°C temperature in the laboratory and were analyzed as soon as possible after the collection and the samples collected for the analyses of uranium and other heavy metals concentration were acidified with nitric acid to pH 1-2.

2.2.1 Estimation of physico- chemical parameters

All the techniques which were adopted during the analysis of physico-chemical parameters are discussed here. For the analysis of pH, dissolved oxygen (DO), total dissolved solids (TDS), electrical conductance (EC), oxidation-reduction potential (ORP) and temperature (T), water, and soil analysis kit by ISO- TECH with model no. ITS- 701 was used and suitable probes were used for afore said parameters. All these parameters were measured immediately at the sampling sites in in-situ conditions. Mohr's method was used for the analysis of chloride (Cl^-) concentration in water samples. For the estimation of total hardness (TH), ammonia buffer was added to the samples followed by Eriochrome Black T as an indicator and ethylenediaminetetraacetic acid (EDTA) as titrant. Calcium (Ca) hardness was analyzed by using NaOH, followed by murexide as an indicator and EDTA as titrant. For the estimation of total alkalinity (TA), phenolphthalein and methyl orange were used as indicators. Fluoride (F^-), nitrate (NO_3^-), phosphate (PO_4^{-3}), and sulfate (SO_4^{-2}) were analyzed with the help of a digital multiparameter photometer with model no. HI-83,300 by Hanna. For the determination of F^- concentration in water samples, the SPADNS method was used, for NO_3^- determination, cadmium reduction method, for PO_4^{-3} determination, ascorbic acid method, and for SO_4^{-2} determination, precipitation with barium chloride crystal method was used. Magnesium (Mg), Carbonate (CO_3^{-2}) and bicarbonate (HCO_3^-) were calculated theoretically.

2.2.2 Uranium estimation in water samples using fluorimetry

Laser fluorimeter manufactured by Quantalase Enterprises Pvt. Ltd., Indore, was used for the analysis of uranium in drinking water samples. The analytical procedure for the determination of uranium concentration in water samples was done by adopting the procedure described by Sahoo and co-workers [12]. The source used in the study was LED and the wavelength of the laser was 400 nm. About 5 mL

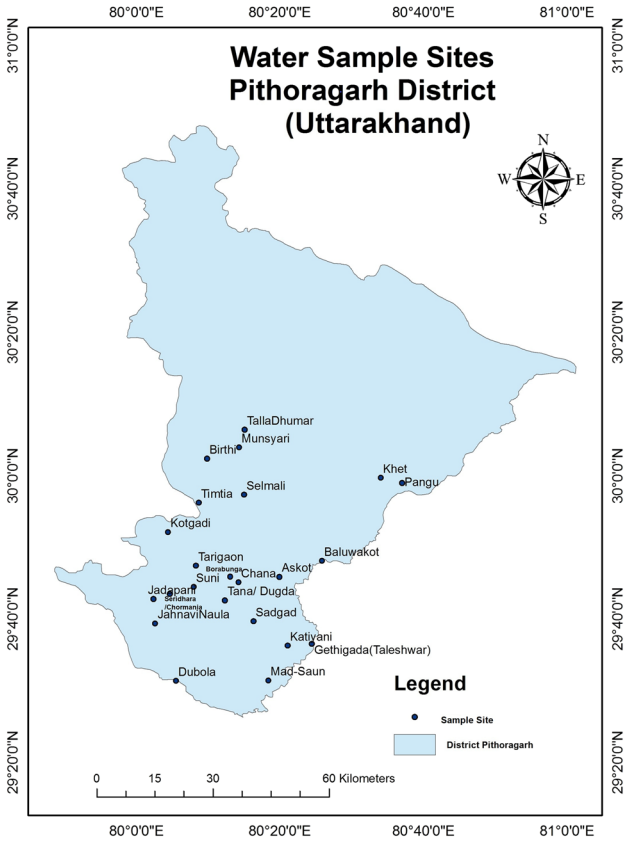

Fig. 1 Map representing sampling locations with elevation

of water sample was placed in a dry and clean cell and 0.5 mL of 5% sodium pyrophosphate (pH 7) was added and measured. The instrument was calibrated with a standard uranium solution of a known concentration. The standard addition method was followed for analysis of field samples to avoid the matrix effect because the samples were from different parts of the district and the chemical constituents may vary significantly. Micropipettes and analytical balance were used simultaneously to avoid any error in pipetting. The concentration of uranium (U) in water samples using Laser fluorimeter was calculated by:

$$\boldsymbol{U(ppb)} = \frac{\boldsymbol{D1}}{\boldsymbol{D2} - \boldsymbol{D1}} \times \frac{\boldsymbol{V1}}{\boldsymbol{V2}} \times \boldsymbol{C}$$

where,D_1 = Fluorescence due to sample only; D_2 = Fluorescence due to sample and U standard spiked; V_1= Volume of U standard added (mL); V_2= Volume of sample taken (mL); C = Concentration of U- standard solution (µg L^{-1})

2.2.3 Heavy metal analysis

Varian AA280Z Zeeman Atomic absorption spectrometer with GTA 120 Graphite Tube Atomizer was used for the metal (copper, lead, iron, manganese, zinc and chromium) analysis. To destroy organic material in the sample, 100 mL aliquot of filtered water sample was taken in duplicate for wet digestion (HNO_3) on hot plates followed by the injection of 25 mL of the prepared sample in the nebulizer-spray chamber-burner system of the Atomic Absorption Spectrophotometer. Atomic Absorption Spectrophotometer was standardized with standard element concentrations in prior and air-acetylene compressed gas has been used as oxidant and fuel.

3 Result and discussion

3.1 Uranium concentration analysis

The samples were collected at PRM and POM seasons. This paper consists of the distribution of uranium concentration based on the tehsils of the Pithoragarh district. The uranium concentration of these 23 sampling sites varied from 0.10 to 9.96 µg L^{-1} in PRM and 0.10 to 8.32 µg L^{-1}in POM which was lower than guideline values of 30 µg L^{-1} by WHO and 60 µg L^{-1} by AERB (India), DAE (India). Three samples were collected from Dharchula tehsil for which the minimum value of uranium concentration was 0.14 µg L^{-1} and the maximum was 9.96 µg L^{-1} for the PRM period. For POM it ranged from 0.10 to 8.32 µg L^{-1}. From Didihat tehsil, seven samples were collected, the uranium concentration ranged from 0.10 to 1.12 µg L^{-1} in the PRM period and 0.10 to 1.20 µg L^{-1} in the POM period. Two samples were collected from Berinag tehsil. The concentration of uranium in the PRM period ranged from 0.25 to 0.54 and 0.12 in the POM period for both the samples. For five samples collected from Munsyari tehsil, the concentration of uranium varied from 0.17 to 2.35 µg L^{-1} for PRM and 0.10 to 2.76 µg L^{-1} for POM. For three samples collected from Pithoragarh tehsil, the PRM concentration of uranium varied from 0.20 to 1.00 µg L^{-1}, and for POM, it varied from 0.11 to 0.30 µg L^{-1}. For three samples collected from Gangolihat tehsil, the uranium concentration varied from 0.10 to 0.22 µg L^{-1} during PRM and 0.10 to 0.23 µg L^{-1} during POM. All the collected samples with their uranium concentration and average values are represented in Table 2, and the distribution of uranium concentration in PRM and POM seasons is represented in Figs. 2 and 3. Among all the samples, the highest value of uranium concentration was obtained from only one sample collected from a specific site in Dharchula tehsil in both PRM and POM seasons; although, this value is still below the prescribed limit of 30 µg L^{-1}. The higher value of uranium in the sample collected from a particular specific site of Dharchula could be due to the presence of igneous rocks in that region

Table 2 Distribution of uranium concentration at different locations of Pithoragarh district

Tehsil (T)	No. of samples	Uranium concentration(μg L^{-1})					
		PRM			POM		
		Min	Max	Average	Min	Max	Average
Dharchula (T)	3	0.14	9.96	3.64	0.10	8.32	3.14
Didihat (T)	7	0.10	1.12	0.37	0.10	1.20	0.26
Berinag (T)	2	0.25	0.54	0.39	0.12	0.12	0.12
Munsyari (T)	5	0.17	2.35	1.03	0.10	2.76	1.06
Pithoragarh (T)	3	0.20	1.00	0.57	0.11	0.30	0.23
Gangolihat (T)	3	0.10	0.22	0.14	0.10	0.23	0.15

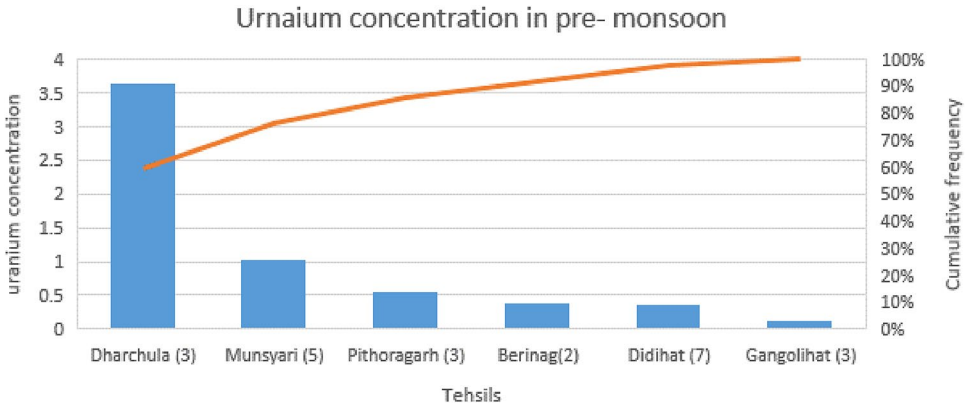

Fig. 2 Distribution of uranium (μg L^{-1}) in pre- monsoon

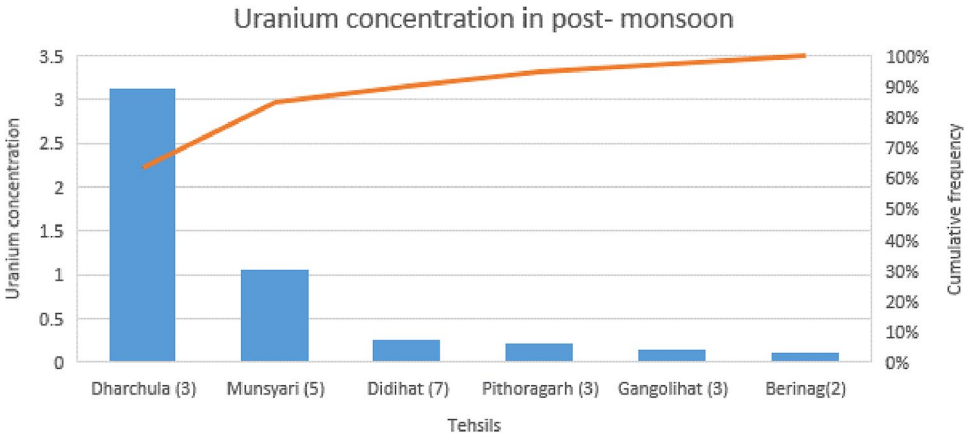

Fig. 3 Distribution of uranium (μg L^{-1}) in post- monsoon. *In both the figures, the number in the bracket represents the number of samples collected from the respective tehsil

because studies have shown that the concentration of radionuclides like uranium in water depends upon its concentration in rocks and soil. Igneous rocks are usually those types of rocks that have a higher concentration of radionuclides like uranium in comparison to other kinds of rocks [7, 21]. Thus, by analysis of different samples collected from different sites in the Tehsils and sub tehsils of Pithoragarh, it was found that the uranium concentration was found to be lower than the guideline values prescribed by both WHO and AERB (India).

3.2 Water quality parameters

The summarized statistical analysis of the physico-chemical parameters of water samples is represented in Table 3. The pH was found to be acidic to alkaline in both seasons. TDS ranged from 30.00 to 624.00 mg/L and 25.70 to 604.00 mg/L during PRM and POM respectively. The maximum value of nitrate was found to be 46.70 mg/L in PRM and 61.50 mg/L in POM which is greater than the prescribed Bureau of Indian Standards (BIS) limit which may be due to leaching from plant

Table 3 The statistical summary of water samples

Parameters	PRM(N=23)					POM (N=23)				
	Min	Max	Average	Standard deviation	Skewness	Min	Max	Average	Standard deviation	Skewness
pH	5.87	8.56	7.39	0.67	−0.36	5.63	8.43	7.29	0.60	−0.85
TDS (mg/L)	30.00	624.00	204.65	169.46	0.69	25.70	604.00	213.82	175.02	0.73
EC (µS/Cm)	34.80	950.00	309.26	254.30	0.72	38.80	909.00	321.63	262.36	0.72
ORP (±mV)	119.00	280.00	214.83	48.38	−0.37	85.00	263.00	152.32	50.01	0.58
T (°C)	16.3	25.3	20.4	2.4	0.33	15.3	26.0	19.8	3.2	0.43
DO(mg/L)	4.8	8.5	6.9	1.3	−0.23	5.4	9.6	7.5	1.4	−0.52
F^-(mg/L)	0.005	1.80	0.22	0.40	3.36	0.005	2.00	0.40	0.54	2.57
Cl^-(mg/L)	42.54	106.35	66.89	16.94	0.81	28.36	99.26	51.33	16.55	1.32
NO_3^-(mg/L)	0.05	46.70	3.00	10.01	4.16	0.05	61.5	6.41	13.07	4.18
SO_4^{-2} (mg/L)	0.5	32.5	5.9	8.1	2.1	1.0	40.0	8.0	10.8	2.1
PO_4^{-3}(mg/L)	0.005	0.70	0.11	0.17	2.39	0.005	0.45	0.14	0.13	1.16
TH(mg/L)	32.00	352.00	155.48	106.59	0.45	24.00	360.00	140.48	106.92	0.73
Ca(mg/L)	3.84	20.52	10.71	5.24	0.31	2.56	33.35	12.62	8.79	1.02
Mg(mg/L)	4.66	74.66	31.29	23.40	0.52	1.94	67.25	26.39	21.85	0.81
TA (mg/L)	48.0	336.0	157.6	85.9	0.39	8.0	376.0	160.9	114.0	0.44
CO_3^{-2} (mg/L)	0	128	13.91	38.38	2.68	0	96	10.24	23.55	3.37
HCO_3^-(mg/L)	32.0	336.0	143.6	86.0	0.63	8.0	376.0	154.6	106.8	0.4

nutrient and use of nitrogen-containing fertilizer. Fluoride in some samples was slightly high in both seasons. High or low concentrations of fluoride in water may be due to natural as well as anthropogenic reasons. Natural causes are associated with the geological, physical, and chemical conditions, soil, and rock types of the study area. Fluoride is a lithophilic element that occurs in many common rock minerals like fluorite, apatite, etc. [22, 23]. Mg was higher in both the seasons which might have been introduced from the dissolution of magnesium calcite, gypsum, and dolomite from the source rock. Total hardness of the water samples ranged from 32.00 to 352.00 mg/L with the average value of 155.48 mg/L in PRM and 24.00 to 360.00 mg/L with the average value of 140.48 mg/L in POM.

3.3 Heavy metal analysis

Heavy metals are toxic elements that are bioaccumulative. These can be toxic if taken in the excess amount than the required concentration and can enter the body through drinking, inhalation, ingestion, and skin absorption [24]. Different metals like copper, lead, iron, manganese, zinc, and chromium were evaluated in the collected water samples and the evaluated concentration of the samples is given in Table 4 and their seasonal variation is shown in Figs. 4 and 5.

Copper is an essential metal for humans but if taken in excess, it causes anemia, stomach, and intestinal irritation. Along with this, it can also cause liver and kidney problems. In the present study, the concentration of

Table 4 Seasonal representation of metals

Metals	PRM	POM	Desirable limit(mg/L)	
			(Recommended by BIS) [28]	Permissible limit(mg/L) (Recommended by BIS)
Copper (Cu)(mg/L)	< 0.00001*–0.0031	< 0.00001–0.0031	0.05	1.5
Lead (Pb)(mg/L)	< 0.00001–0.012	< 0.010–0.010	0.01	No relaxation
Iron (Fe) (mg/L)	< 0.01–0.80	< 0.01–0.64	0.3	No relaxation
Manganese (Mn) (mg/L)	0.002–0.010	0.002–0.010	0.1	0.3
Zinc(Zn)(mg/L)	0.01–0.22	0.01–0.12	5	15
Cromium (Cr) (mg/L)	< 0.01	< 0.01	0.05	No relaxation

< 0.00001 indicates all those values which were below detection limit

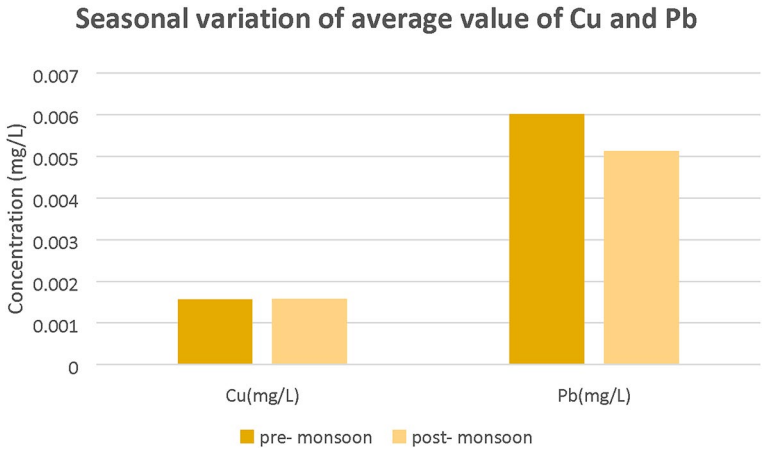

Fig. 4 Seasonal variation of Cu and Pb (mg/L)

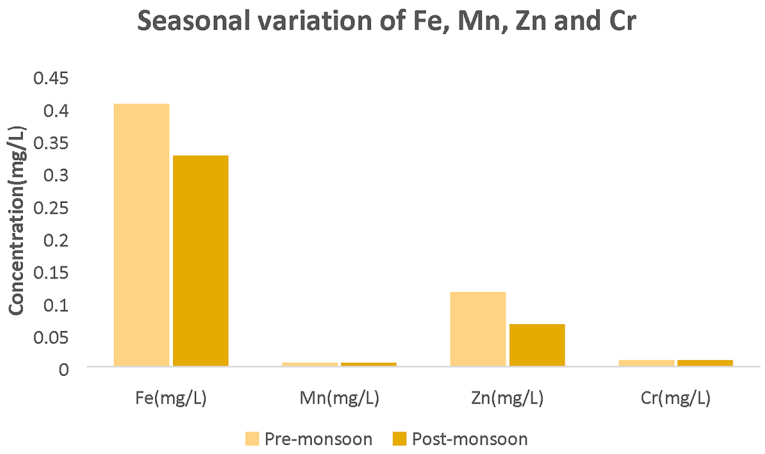

Fig. 5 Seasonal variation of Fe, Mn, Zn and Cr (mg/L)

Cu ranged between < 0.00001 and 0.0031 mg/L. Acute or chronic complications can occur in the nervous system of human beings due to long-lasting exposure to lead. The highest concentration of Pb observed was 0.012 mg/L in PRM and 0.010 mg/L in POM respectively which was below the prescribed standard limit. The Highest Fe concentration was found to be 0.80 mg/Lin PRM and 0.64 mg/Lin POM. Out of 23 samples, 6 samples had higher iron concentrations than the desirable limit of 0.3 mg/L in both seasons. In an earlier investigation also, a high concentration of iron in rivers of Uttarakhand was reported [25]. This increase in the value may be due to geological reasons [26]. Weathering of rocks can be one of the reasons for iron contamination. High iron content in drinking water may cause 'Haemosiderosis' [27]. Mn was found to be 0.002–0.010 mg/L in both the seasons. Zinc concentration in water varied from < 0.01 to 0.22 mg/L in pre-monsoon and from 0.01 to 0.12 mg/L in post-monsoon season. Long-term exposure to chromium is carcinogenic and can cause respiratory

Table 5 Correlation table between uranium and metals during pre- monsoon season

	Cu (mg/L)	Pb (mg/L)	Fe (mg/L)	Mn (mg/L)	Zn (mg/L)	Cr (mg/L)	U (µg/L)
Cu (mg/L)	1						
Pb (mg/L)	0.23	1					
Fe (mg/L)	0.18	0.12	1				
Mn (mg/L)	0.14	−0.10	0.64**	1			
Zn (mg/L)	0.28	0.15	0.55**	0.67**	1		
Cr (mg/L)	0.00	0.00	0.00	0.00	0.00	1	
U (µg/L)	−0.15	−0.04	−0.13	−0.18	−0.16	0.00	1

** Correlation is significant at the 0.01 level (2-tailed)

Table 6 Correlation table between uranium and metals during post- monsoon season

	Cu (mg/L)	Pb (mg/L)	Fe (mg/L)	Mn (mg/L)	Zn (mg/L)	Cr (mg/L)	U (µg/L)
Cu (mg/L)	1						
Pb (mg/L)	−0.02	1					
Fe (mg/L)	0.08	0.44*	1				
Mn (mg/L)	0.04	0.43*	0.62**	1			
Zn (mg/L)	0.12	0.16	0.48*	0.68**	1		
Cr (mg/L)	0.00	0.00	0.00	0.00	0.00	1	
U (µg/L)	−0.15	−0.08	0.00	−0.02	−0.05	0.00	1

*Correlation is significant at the 0.05 level (2-tailed)

**Correlation is significant at the 0.01 level (2-tailed)

problems. In the present study, chromium was recorded below the detection limit in both seasons.

3.4 Correlation analysis between uranium concentration and metals

Correlation analysis was done to assess the correlation between various metals analyzed here and uranium concentration. The correlation table for both the pre-monsoon and post-monsoon seasons are given in Tables 5 and 6. A negative correlation has been exhibited by uranium with most of the metals with Cu (−0.15), Pb (−0.04), Fe (−0.13), Mn (−0.18), Zn (−0.16) during pre-monsoon and with Cu (−0.15), Pb (−0.08), Mn (−0.02) and Zn (−0.05) during post-monsoon.

4 Conclusion

The chemical composition of water is strongly influenced by the geology of the surroundings, weathering and leaching actions of water, and the use of fertilizers. The above study gives an overview of the quality of water samples collected from the Pithoragarh district. Physico-chemical parameters and heavy metals were also found to be within the range except for a few parameters (F–, NO_3^-, Mg, and Fe). The pH of some of the samples was a little acidic which can be easily treated by using alkaline methods for drinking purposes. It was found that the uranium concentration level in all the samples was within WHO guideline values (30 µg L^{-1}) and indicates that there is a natural distribution of uranium in water. Along with this, the correlation study of uranium with different metals suggests that there is no significant relationship between the uranium concentration and presence of metals in the sampling sites. Although the samples don't have a very high concentration of the parameters studied, there is a great urge to monitor these sources from time to time to confirm the potability status of water because if the concentration of these parameters increases continuously, it will cause severe health effects to the local population.

Compliance with ethical standards

Conflicts of interest The authors declare that they have no conflict of interest.

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